Global Inflation-Linked Products

A User's Guide

A handbook to understand, navigate and find value in the global inflation-linked bond and derivatives markets.

FOCUS

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INTRODUCTION

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The Bloomberg Barclays World Government Inflation-Linked Bond index has increased by about $300mn, to $3.1trn, since we last published the *Global Inflation-Linked Products: A User's Guide*, in October 2016, and has more than doubled since the financial crisis. At more than $1.4trn, the US remains the largest on a market value basis, but the UK index, which has a duration of over 22 years, is larger in risk-adjusted terms. The Emerging Market Government Inflation-Linked Bond index remains at $400-550bn, where it has been since 2011, with most of the volatility due to yield changes.

Inflation, more than breakevens, in most markets has recovered from the oil-induced lows of 2015 and 2016; but both remain lower than pre-crisis averages. The exception has been the UK, which continues to be dominated by Brexit-related uncertainty and a renewed discussion of a shift away from RPI in its current form. With inflation having generally been lower than central bank targets and relatively stable, markets appear to be questioning the willingness and/or ability of central banks to generate inflation, even if non-traditional policy tools proved useful in avoiding deflation post-crisis. Inflation risk premiums have declined, and in the US, EUR and Japan, most evidence suggests that inflation expectations have fallen to levels inconsistent with central bank credibility. These may return to historical levels, but a rise in realized inflation and credibility in the effectiveness of monetary policy may be needed first.

With structurally low real yields and breakevens, central banks are more likely to reach the effective nominal lower bound more often in downturns, leading policy arguably to be more effective in bringing inflation down than pushing it up. To gain credibility back, some central banks, in particular the Fed, are openly rethinking policy frames, especially concerning inflation targets. If rhetoric leads to structurally dovish change, it could lead to a regime shift in inflation markets as well.

While longer breakevens have fallen, shorter ones, especially in the US, have become less structurally cheap as more investors focus on alpha opportunities. This trend has also shown up in an increased search for relative value and the use of linear inflation-linked derivatives. As such, we have updated and expanded our RV frameworks since the Guide was last published, adding a strategic indicator, based on spreads to an option and seasonally adjusted fitted curve, to our US RV framework, for example.

As with past versions, the main goal of the *Global Inflation-Linked Products: A User's Guide* is education. The first section explains the products within the inflation-linked universe and how they work, including a detailed section on linear and non-linear inflation-linked derivatives. The second outlines the features of each country's individual market. Last, we address key issues for the asset class, including monetary policy frameworks, modelling and understanding inflation dynamics, and present an overview of inflation-linked resources on Barclays Live.

This is the eighth guide with which I have had the privilege of being involved. With each new version, we have tried to make inflation-market fundamentals and frameworks more accessible and provide new ways to find opportunities. We are proud of its history and hope you find this latest one useful for navigating global inflation markets in the coming years.

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INFLATION PRODUCTS

Linker cash flows and yields

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Inflation-linked bonds can trade in different formats, but the so-called "Canadian model" has been widely accepted as the standard framework. The indexation of cash flows in such bonds adds a level of complexity relative to the nominal market, although the pricing principles, or "bond maths", are generally similar.

Inflation-linked bonds (or "linkers", as they are often called) trade in various formats. A common feature of sovereign linker markets, though, is that cash flows are based on a variable principal adjusted for inflation, ie, indexed to the growth of the linking price index, over the life of the bond. In all cases, this indexation contains a lag mechanism, given that inflation data for any period are published with a delay. Indexation methods differ across markets, with the applied lag also varying. However, there has been, in the developed markets at least, a tendency for harmonization, with the so-called "Canadian model" now established as the standard trading format, given its simplicity. Additionally, in many markets, particularly developed ones, linkers contain an embedded floor such that the principal repayment at maturity cannot be below par.

The Canadian model

We start with a simple illustration of the concept of indexation. We ignore indexation lags and deflation/par floors for now. We consider a newly issued 2y inflation-linked bond. Its principal is therefore still at par (at 100), as inflation has not yet started to accrete on the bond. The principal is adjusted for inflation, ie, for the growth of the linking price index, over the life of the bond, with annual coupon payments at a rate of 3% calculated off this adjusted principal. We assume that the value of the index is currently 125 and that at the end of the first year, its value is 130; inflation over the first year is therefore 4%. The indexed principal becomes 104 (ie, 100 * 130 ÷125). The coupon paid at the end of that first year is therefore calculated as 3% * 104 = 3.12. At the end of the second year, the index is 133, so inflation over the second year is 2.31%. Inflation over the two-year period, measured by the index increase from 125 to 133, is 6.4%. At the end of that second year, the indexed principal, which is reimbursed, is thus 106.4 (ie, 100 * 133 ÷ 125) and the coupon paid is 3% * 106.4 = 3.192.

For longer-dated bonds, the same principle would apply. For simplicity, we assume that we are looking at a new bond that is being issued now; ie, inflation has not yet accreted on the principal. We also assume, for now, that there is no lag in the indexation mechanism. In general, if we assume such a linker with annual coupons, we can write its future cash flows as follows:

Cash flow at end of year t = cash flow before adjustment for inflation $* \frac{I_t}{I_0}$,

Where:

I_t is the price index value at the end of year t

I_0 is the price index value at present

So we can write, for a principal of 100:

Coupon at end of year t = 100 * IC% * $\frac{I_t}{I_0}$

Principal repayment at maturity = 100 * $\frac{I_m}{I_0}$,

Where:

IC% is the linker's coupon rate

m is the year of maturity

By definition, future inflation is unknown; therefore, the future cash flows formulated above are unknown. Nevertheless, these cash flows are expressed in nominal terms. Therefore, if we take one of these coupon payments, its present value can be represented by:

Present value of coupon at end of year t = 100 * IC% * $\frac{I_t}{I_0} * \frac{1}{(1+N_t)^t}$

Where: $\frac{1}{(1+N_t)^t}$ is the nominal discount factor for a cash flow at the end of year t.

Similarly, we can write:

Present value of the principal repayment at maturity = 100 * $\frac{I_m}{I_0} * \frac{1}{(1+N_m)^m}$

These are familiar concepts that are analogous to the pricing principles of a common nominal bond where the price represents the sum of discounted future cash flows. In practice, for a nominal bond, a nominal yield to maturity can be found such that the sum of future cash flows discounted using that nominal yield equals the price of the nominal bond. This is the widely known present value formula for a nominal bond:

$$\text{Invoice price of nominal bond} = \sum_{t=1}^{m} \frac{100 * C\%}{(1+N_t)^t} + \frac{100}{(1+N_m)^m}$$

$$= \sum_{t=1}^{m} \frac{100 * C\%}{(1+NY)^t} + \frac{100}{(1+NY)^m},$$

Where:

C% is the nominal bond's coupon rate

NY is the nominal yield to maturity on the nominal bond

For a linker, the full invoice price (which we note P^F) also represents the sum of discounted cash flows, and given the above, the formula is expressed as:

$$P^F = \sum_{t=1}^{m} \left[\frac{I_t}{I_0} * \frac{100 * IC\%}{(1+N_t)^t} \right] + \frac{I_m}{I_0} * \frac{100}{(1+N_m)^m} \qquad (1)$$

Clearly, this formula, in that form, is not useful for a linker. Indeed, given that future values of I_t are unknown, an average yield to maturity cannot be calculated. To circumvent this, we define the concept of a real return on an asset, which is its nominal return adjusted for inflation. For example, we assume that average annual nominal return over three years is 5% and that the price index increases from 125 to 140 over that period. The factor representing the growth, in nominal terms, is given by $(1+5\%)^3$. To get the change in "real" terms, the growth in the price index has to be accounted for. We get $(1+5\%)^3 \div (140 \div 125) \approx (1+1.107\%)^3$, where 1.107% represents the average annualised real return.

In the same way, $(1+N_t)^t$ in the nominal discount factor term above implicitly represents the nominal growth of a cash flow from now to the end of year t. Divided by $\frac{I_t}{I_0}$, it therefore represents the growth in real terms, ie, adjusted for inflation. We write it as:

$$(1+N_t)^t \div \frac{I_t}{I_0} = (1+R_t)^t$$

We can therefore reformulate expression (1) as:

$$P^F = \sum_{t=1}^{m} \frac{100 * IC\%}{(1+R_t)^t} + \frac{100}{(1+R_m)^m} \qquad (2)$$

The term $\frac{1}{(1+R_t)^t}$ can be interpreted as a "real" discount factor for a cash flow occurring at the end of year t. Expressed this way, the price formula is more useful; the (unknown) values of I_t have been eliminated and an average "real yield to maturity" can then be found such that the sum of cash flows (before adjustment for inflation) discounted using that real yield is equal to the linker's price.

$$P^F = \sum_{t=1}^{m} \frac{100 * IC\%}{(1+RY)^t} + \frac{100}{(1+RY)^m} \qquad (3)$$

Where:

RY is the real yield to maturity of the linker.

This is the general principle of the Canadian model. Its simplicity lies in the fact that there is no need to make any assumption about future inflation. To calculate yield metrics, the usual and familiar present value framework is used, but with everything expressed in "real" terms. This real yield can intuitively be interpreted as a yield that is earned above inflation if the linker is held to maturity.

So far, for the sake of simplicity, we have considered a bond that is being issued now so that the principal has no inflation accretion and is at par. We generalise the framework to the case of a "seasoned" bond, where the principal has already started to be adjusted with the growth of the linking price index. In that case, and following on the formulation above, the cash flow at the end of year t is rewritten as:

Cash flow at end of year t = cash flow before adjustment for inflation $* \frac{I_t}{I_{base}}$,

Where: I_{base} corresponds to the value of the price index at the point in time when indexation of the principal starts. We refer to that time as the base index date.

Therefore, we modify the price formula (1) to get:

$$P^F = \sum_{t=1}^{m}\left[\frac{I_t}{I_{base}} * \frac{100 * IC\%}{(1+N_t)^t}\right] + \frac{I_m}{I_{base}} * \frac{100}{(1+N_m)^m}$$

However, we can break down $\frac{I_t}{I_{base}}$ as a combination of the index growth from the base index date until now and from now until the end of year t. So we write:

$$\frac{I_t}{I_{base}} = \frac{I_0}{I_{base}} * \frac{I_t}{I_0}$$

Consequently, we have:

$$P^F = \sum_{t=1}^{m}\left[\frac{I_0}{I_{base}} * \frac{I_t}{I_0} * \frac{100 * IC\%}{(1+N_t)^t}\right] + \frac{I_0}{I_{base}} * \frac{I_m}{I_0} * \frac{100}{(1+N_m)^m}$$

If we divide both sides of the expression by $\frac{I_0}{I_{base}}$, we get:

$$P^F \div \frac{I_0}{I_{base}} = \sum_{t=1}^{m}\left[\frac{I_t}{I_0} * \frac{100 * IC\%}{(1+N_t)^t}\right] + \frac{I_m}{I_0} * \frac{100}{(1+N_m)^m} \qquad (4)$$

The right-hand sides of expressions (1) and (4) are the same. Therefore, in the same way that we moved from expression (1) to (2), we have:

$$P^F \div \frac{I_0}{I_{base}} = \sum_{t=1}^{m}\frac{100 * IC\%}{(1+R_t)^t} + \frac{100}{(1+R_m)^m} \qquad (5)$$

Note that the right-hand sides of expressions (2) and (5) are the same. This is very convenient, as it means that, as in expression (3), we can reformulate the expression using a real yield to maturity:

$$P^F \div \frac{I_0}{I_{base}} = \sum_{t=1}^{m}\frac{100 * IC\%}{(1+RY)^t} + \frac{100}{(1+RY)^m} \qquad (6)$$

Expression (6) represents a general case where the linker's principal has already started accreting inflation. Expression (3) refers to a special case where the base index date is the current date, such that $\frac{I_0}{I_{base}}$=1.

Intuitively, $P^F \div \frac{I_0}{I_{base}}$ represents a price from which inflation that has already accreted has been extracted. It represents a price unadjusted for past inflation accretion and in the Canadian model, prices are quoted on that unadjusted basis. In that case, as per expression (6), the framework allows a real yield to maturity to be easily calculated from the quoted price. Clearly, when a linker is bought, this unadjusted quoted price will need to be adjusted for accreted inflation to determine the effective price paid, as we shall see shortly.

With the general principles of the Canadian model laid out, we look at how they are applied in practice. In particular, the indexation of the principal is always done with a lag. This is because price index data are not available in “real time”. For example, on 11 March 2019, the latest euro HICPx index value available was for January 2019, which was released on 22 February 2019. Moreover, consumer price data typically have a monthly frequency, whereas linkers trade daily. Reference values of the linking index therefore need to be computed so that the principal can be adjusted for every trading day. In the Canadian model, a daily reference index (DRI) is calculated for each settlement date. It is usually computed as a linear interpolation between the published CPI values for two consecutive months in the past. Typically, the DRI is calculated as follows (the result is usually truncated to six decimal places first and then rounded to five decimal places):

$$DRI_{d,m} = CPI_{m-3} + \frac{(d-1)}{D_m} * (CPI_{m-2} - CPI_{m-3})$$

Where:

CPI_{m-2} is the price index for month m-2

CPI_{m-3} is the price index for month m-3

D_m is the number of days in month m

m is the month in which settlement takes place

d is the day of the month on which settlement takes place

The base index value of a linker is the DRI that is calculated for the date from which inflation accretes on the bond. This "base date" does not always correspond to the initial settlement date of the bond. For example, in France, the accrual date of the first coupon is typically before the initial settlement date of the bond; ie, at issuance, the bond already has an accrued coupon element. In that case, the base date would be the same as the accrual date of the first coupon. In other words, even at issuance, the bond's principal would already have accrued some inflation.

For every settlement date, an index ratio (IR) is calculated to measure the inflation adjustment for the principal. This is usually truncated to six decimal places first and then rounded to five decimal places.

$$IR_{d,m} = \frac{DRI_{d,m}}{DRI_{base}}$$

Cash flows are calculated based on the IR. We take a US linker, the TIII 0.625% 15 January 2024 (noted TIIJan24), as an example. It pays coupons semi-annually, where the annual coupon rate is 0.625%, linked to the US City Average All Items Consumer Price Index for all Urban Consumers (CPI-U). We calculate the semi-annual coupon paid on 15 January 2019:

DRI_{base} = 233.33058 (which is the DRI for 15 January 2014, the base date of the bond)

CPI-U October 2018 = 252.885

CPI-U November 2018 = 252.038

$$\boldsymbol{DRI}_{15\ January\ 2019} = 252.885 + \frac{(15-1)}{31} * \ (252.038 - 252.885)$$

$$= 252.50248\ \ (truncated\ to\ 6dp\ and\ rounded\ to\ 5dp)$$

$$\boldsymbol{IR}_{15\ January\ 2019} = \frac{252.50248}{233.33058}$$

$$= 1.08217\ (truncated\ to\ 6dp\ and\ rounded\ to\ 5dp)$$

The DRI and IR calculations above are truncated to six decimal places and rounded to five decimal places, as per the calculation rules for TIIS.

So the semi-annual coupon paid on 15 January 2019 on a principal of $1mn was:

$$\frac{0.625\%}{2} * 1.08217 * \$1mn = \$3{,}381.78$$

Similarly, the principal repayment at maturity for a linker is determined by the IR corresponding to that date. For example, the OAT€i18 (French linker linked to Euro HICPx) matured on 25 July 2018 and the IR corresponding to that date was 1.07451. On a €1mn principal, the principal repayment was therefore €1,074,501.

In the Canadian model, the IR is also used to calculate the full settlement price (ie, the total monetary price that is actually paid to the seller) when a linker is traded, as the price which is quoted is unadjusted for past inflation accretion. Note that, as for nominal bonds, prices are quoted in "clean terms", ie, without accrued coupon. Thus, in general, the settlement price for settlement day *d* of month *m* is calculated as follows:

$$P^{F}_{d,m} = IR_{d,m} * \left(P^{cu}_{d,m} + AC_{d,m}\right), where\ we\ can\ note\ P^{cu}_{d,m} + AC_{d,m} = P^{du}_{d,m}$$

where:

$P^{cu}_{d,m}$ is the quoted "screen" clean price, unadjusted for past inflation accretion and without accrued coupon

$AC_{d,m}$ is the accrued real coupon, before adjustment for inflation, on the settlement date

$P^{du}_{d,m}$ is the "dirty" price, unadjusted for past inflation accretion with accrued real coupon

We illustrate the calculation of the settlement price in the Canadian model for the TIIJan24.

Bond: TIII 0.625% 15 January 2024

Real coupon rate: 0.625%, paid semi-annually

Trade date: 11 March 2019

Settlement date: 12 March 2019

Assumed quoted price $\left(P^{CU}_{11\ March\ 2019}\right)$=100-12 (i.e 100.375)

Previous coupon date: 15 January 2019

Next coupon date: 15 July 2019

Number of days between last coupon date and settlement date: 56

Number of days between last and next coupon date: 181

Real accrued coupon $= AC_{11\ March\ 2019}$

$$= \frac{0.625\%}{2} * \frac{56}{181}$$

$$= 0.096685 \ldots \%$$

DRI_{base} = 233.33058 (which is the DRI for 15 January 2014, the base date of the bond)

CPI-U December 2018 = 251.233

CPI-U January 2019 = 251.712

The DRI and IR calculations are truncated to six decimal places and rounded to five decimal places. We have:

$$DRI_{12\ March\ 2019} = 251.233 + \frac{(12-1)}{31} * (251.712 - 251.233)$$

$$= 251.40297$$

$$IR_{12\ March\ 2019} = \frac{251.40297}{233.33058}$$

$$= 1.07745$$

Therefore, settlement price on $1mn notional = 1.0745 * (100.375 + 0.096685…)% * $1mn

= $1,082,532.17

The typical indexation lag for Canadian-style linkers is the same as the one illustrated above. However, some countries have slightly different inflation lags. For example, in Japan, the three-month lag is to the 10th day of the month, rather than the first, and in South Africa, the lag is four months. Other variations also can apply. In Sweden, for instance, day count conventions for inflation accrual are based on a linear rate that assumes 30 days in each month, which means discontinuous accretion at month-end for months that are not this length. The Swedish market trades almost entirely on a real yield basis, but with quoted prices including inflation uplift as Canadian conventions were adopted only after the market began.

Some other trading formats

The simplicity of the Canadian model has made it very popular; the developed linker markets have generally adopted that framework. Other trading formats used in some markets also provide a real yield measure but the price indexation methods can be very different. The individual country sections later in this publication provide thorough explanations of these. Here, we outline the main characteristics of some.

Old-style UK linkers

Issuance in UK linkers is now exclusively in Canadian-style bonds. Old-style linkers trade in clean price cash (nominal) terms (ie, not unadjusted for inflation). The traded price rises and falls to reflect inflation that has occurred. Because they trade in nominal terms, it is necessary to know the inflated value of the next coupon so that the true accrued coupon can be calculated. As a result, indexation is done with an eight-month lag. The derivation of the real yield measure also entails an inflation assumption to project the future value of the bond's cash flows.

Australia

Australian linkers are similar to old-style UK index-linked bonds in that the inflated value of the next coupon amount is always known. Indexation is done with a six-month lag. Notably, Australia's CPI is published quarterly. The calculation of cash flows (coupons and principal repayment) differs significantly from other markets and is based on a mathematical formula.

Latin-American linkers

Given the experience of very high inflation in many Latin American countries, the indexation lags tend to be shorter than in the developed markets. Typically, this means that once an index value is published, it is "instantaneously" integrated into the indexation calculations.

In Brazil, bonds linked to the IPCA consumer price have an indexation lag that implies that their actual value in the early part of each month cannot be computed using the published index values. During this period, the bonds are priced off a consensus expectation for the next IPCA number, calculated from the official ANBIMA's (Brazilian Association of Financial and Capital Market Companies) inflation forecast. The market then switches to the actual value of the IPCA once it is released.

In Mexico, the UDI inflation index is released twice a month such that there is a very short *de facto* lag in the indexation mechanism. In each period, the UDI index changes by the daily geometric equivalent of the corresponding bi-weekly inflation rate. That said, the daily interpolation of the Reference Index means that the mechanics are very similar to the standard Canadian model.

In Argentina, linkers are based on the CER Index, which is calculated via a formula using the geometric mean of the changes in the Argentine CPI, with the latter tracked with a one-month lag. Prices are quoted in nominal terms, but once this is adjusted for past inflation, a real yield can then be computed in much the same way as for a Canadian-style linker.

Israel

In Israel, indexation has a one- to a one-and-a-half-month lag. There is no official daily indexed reference, so the principal and coupon can have step moves according to the release of the latest CPI report. Given that the quoting convention is to use the inflation-adjusted prices, the latest CPI report is used to compute the index ratio from the time of issue. The inflation-uplifted price can then be deflated and an implied real yield derived.

The breakeven concept

Inflation-linked bonds provide a real yield. To gauge the total yield that is earned, ie, in nominal terms, one needs to add inflation to that real yield. For instance, if a 10y linker carried a real yield of 2.5% when it was bought and annualised inflation over that 10y holding period was constant at 2.2%, then the nominal-equivalent yield that would have been earned is roughly 2.5% plus 2.2%, ie, 4.7% (assuming reinvestment of coupons at the same initial real yield). Put differently, if a 10y nominal bond is currently quoted with a nominal yield of 4.7% and a 10y linker (same issuer, credit quality, etc., as the nominal bond) currently trades with a real yield of 2.5%, this means that annualised inflation over the 10y holding period needs to be about 2.2% in order for the total realised nominal-equivalent yield on the two bonds to be equal at 4.7% (excluding frictions due to coupon reinvestments, different coupons dates, compounding, etc.). If the market functions on a no-arbitrage opportunity principle and factors such as nominal/linker market liquidity differences, credit and inflation risk premia, etc. are ignored, this suggests that it is effectively pricing inflation to be about 2.2% annualised over the coming 10 years. Indeed, if expected inflation is not 2.2%, for instance lower at 2%, this effectively means that the total return to maturity on the nominal bond is expected to be higher than for the linker.

Theoretically, this would drive demand for the nominal bond and selling pressures in the linker until the nominal/real yield spread adjusts to 2%.

The Fisher equation, as we shall see in more detail later, provides the theoretical connection between real and nominal yields. In Fisher's framework, a nominal yield can be broken down into three components: inflationary expectations, a required real yield that investors demand over and above those inflationary expectations, and a risk premium element such that:

(1 + nominal yield) = (1 + real yield)*(1 + expected inflation)*(1 + liquidity-adjusted inflation risk premium)

The inflation risk premium reflects the assumption that investors require additional compensation for accepting the undesirable inflation risk inherent in holding nominal bonds. On the other hand, there is usually a liquidity discount on linkers versus nominals. In practice, what is most relevant for investors is the level of future inflation that would equate the returns on a linker and the nominal bond to which it is being compared. This level of inflation is commonly referred to as "breakeven inflation" or "breakeven" and is such that:

(1 + nominal yield) = (1 + real yield)*(1 + breakeven)

If the nominal and real yields are low, the previous equation above can be approximated in an additive form and we have:

Breakeven = nominal yield - real yield

Following the above, the breakeven priced by the market is a combination of expected inflation and the liquidity-adjusted risk premium. However, the latter is somewhat of an elusive concept and the breakeven is essentially interpreted as the market's pricing or expectation of future inflation. There is no exact rule for choosing the nominal comparator of a linker. Of course, it typically needs to be from the same issuer and of a maturity which is as close as possible to that of the linker. However, sometimes, a different nominal bond with a less close maturity may be preferred because it is more liquid and its valuation less subject to distortions. A liquid nominal comparator is important, because linkers also trade on a breakeven basis; ie, market participants would trade a linker against its nominal comparator to express a view on the evolution of the breakeven. Usually, there is market consensus on what the assumed nominal comparator for a linker is when talking about its breakeven.

Embedded deflation floors in linkers

The inclusion of a deflation/par floor on the principal at maturity is a common feature for Canadian-style linkers, although Canadian linkers themselves do not have such floors embedded in them. The idea of the floor is simple: the principal reimbursed at maturity cannot be below par, even if the index ratio applicable at maturity is less than one. Effectively, this means that if there is a deflation floor, we have:

Principal repayment at maturity = $Max\{Par, Par * IR_{maturity\ date}\}$

What needs to be stressed here is that, except for Australia, the floor applies only to the principal repayment at maturity, not to coupons. If during the life of the bond the index ratio is below 1 for a coupon payment date, the coupon will be paid off a sub-par principal.

It is also important to note that what is floored is the inflation accretion from the base date to maturity, not the accretion from the current settlement date to maturity. Consider a linker that had an initial 15y maturity when it was issued and now has a remaining maturity of 10 years. We assume that the current index ratio (IR) on that bond is 1.12; ie, 12% of inflation has already accrued on its principal. We consider that in the coming 10 years, there is deflation such that the index ratio at maturity would be 1.05. In that case, the principal repaid would be

1.05*100 =105. There has been deflation, but it has not been severe enough to completely reverse the initial increase in the index ratio and push it below 1. On the other hand, if the index ratio at maturity is 0.98, the floor will kick in; the principal repaid will be 100.

When many breakevens turned negative in 2008 and the developed world experienced deflation in 2009, market participants started to look more closely at the embedded deflation floors in linkers. Prior to that, deflation was seen as a very remote possibility and the value attached to these floors was negligible. When the market started to price the threat of deflation, especially for US TIPS, it became crucial to understand how floors affect the valuation of different bonds.

We assume an environment in which the market expects deflation overall in the coming five years. We consider two linkers with the same residual maturity of five years. The first has just been issued so that its index ratio is currently 1; ie, no inflation has yet accrued on its principal. The second is a seasoned bond which was issued 10 years ago, and its index ratio is currently 1.20. We assume that the market believes that deflation over the coming five years will be 2% annualised. This means that the factor representing the fall in the price index over the five-year period is (1-2%)^5 = 0.904. Therefore, given that its index ratio is currently 1, the market is pricing the index ratio of the first bond to be 1 * 0.904 = 0.904 at its maturity. However, the principal on that bond is floored at par such that the market cannot price/integrate that deflation fully in that bond. The deflation can, of course, be priced on the coupon payments, but this effect is marginal. On the other hand, again taking the market's deflation expectations, the index ratio at maturity on the seasoned bond would be expected to be 1.20 * 0.904 = 1.085. This is above 1, so the market can fully price expected deflation in that bond.

We have implicitly shown that the amount of inflation that has already accrued on a bond determines the extent to which the deflation floor is out of or in the money. To illustrate this, we compare two bonds as of 11 March 2019, the TII January 2023 and the TII April 2023.

FIGURE 1

Seasoned bonds can usually "absorb" more deflation than recent issues before par floor is hit

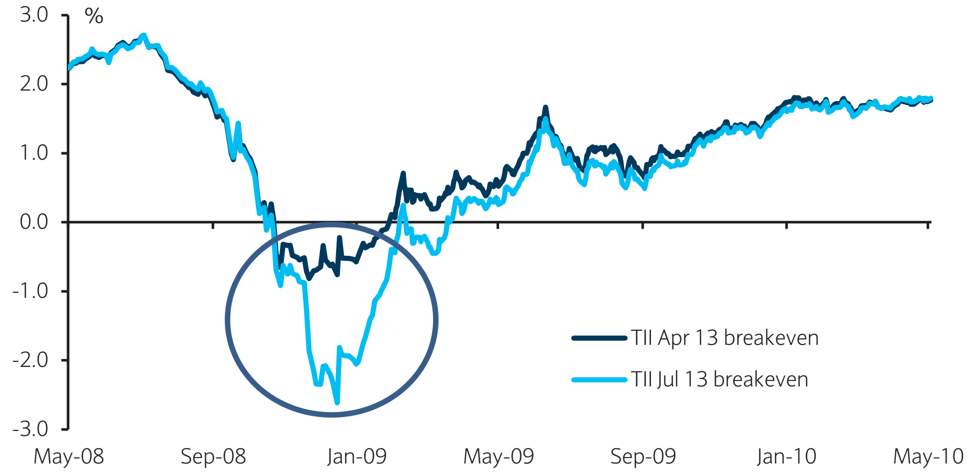
Trade date	11 March 2019	
Settlement date	12 March 2019	
	TII 0.125% Jan 2023	**TII 0.625% Apr 2023**
Maturity date	15 January 2023	15 April 2023
Issuance date	31 January 2013	30 April 2018
Remaining time to maturity	3.84… years	4.09… years
Base CPI value	230.82203	248.39153
DRI for 12 March 2019	251.40297	251.40297
IR for 12 March 2019	1.08916	1.01212
Annualized inflation needed for the IR to equal 1 at maturity	**[(1÷1.08916)^(1÷3.84…)]-1 = -2.196%**	**[(1÷1.01212)^(1÷4.09…)]-1 = -0.294%**

Source: Barclays Research

Figure 1 shows that given that the TII April 2023 has recently been issued, only very little inflation has accreted on it. Therefore, even if the annualized deflation to maturity is low at 0.294%, its index ratio at maturity will hit 1. Implicitly, this means that the strike of its deflation floor, expressed in annualized terms, is -0.294%. The TII Jan 2023, on the other hand, is a seasoned bond. It can withstand annualized deflation of about 2.196% for its index ratio to hit 1 at its maturity. The strike of its deflation floor is therefore about -2.196%.

FIGURE 2

Relative floor valuations can trigger a sharp divergence in breakevens



Source: Barclays Research

Deflation floor strikes in different, albeit close-maturity, TIPS had a strong influence on relative breakevens towards the end of 2008/start of 2009, when the market was at its peak in pricing deflation. This is quite explicit in Figure 2. The TII Jul 2013 was more seasoned than the TII Apr 2013 and therefore had accreted much more inflation. At that time, the deflation strike of the TII Apr 2013 was about -0.9%, so the lowest breakeven that the market priced on it was about -0.8%. The deflation strike on the TII Jul 2013 was significantly lower and the market pushed its breakeven to as low as -2.6% in December 2008. Therefore, when the market is keen to price deflation, there can be a significant disconnect between the breakevens of even close maturity bonds. Once breakevens started rising in 2009, those of the TII Apr 2013 and TII Jul 2013 converged again, reflecting the fact that at higher breakeven levels, the valuations of the embedded floors become negligible and therefore do not affect relative breakeven valuations significantly.

INFLATION PRODUCTS

Real yield and breakeven carry

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The concept of carry is essential to the analysis of inflation-linked bonds. Inflation accretion can vary greatly from month to month because of such factors as seasonality and energy price volatility. In periods of extreme seasonality or discrete shocks to inflation, the carry on linkers can be significant and therefore needs to be factored in when evaluating the richness/cheapness of valuations or interpreting market moves.

Carry is a much more important factor for linkers than for nominal bonds, although the general concept is similar in both cases: it is the required change in yield over a specified holding period such that the total income received (intermediate coupon payments + the difference between the purchase and selling invoice price of the bond) is equal to the repo cost of financing that position. Carry is basically the required change in yield such that the non-arbitrage principle holds. For a linker, a real yield carry is calculated. As we will show, this is inherently volatile from one month to another because of seasonality in price indices; for some periods, the magnitude of that carry can be significant. We explain the mechanics of carry calculations in the Canadian model.

The income or return from buying and holding a linker over a period has three components: any coupon payments received (assumed to be reinvested) and/or coupon accrual, the inflation accretion on the principal and the change in the quoted "real" price. As we discuss in "Seasonality: Estimation and adjustment" in this publication, consumer price indices exhibit patterns during specific periods that tend to be reproduced from one year to another. For example, in the euro area, monthly euro HICPx inflation is typically very negative in January because of the sales period. Given the lag in the indexation of bonds linked to the euro HICPx, January's very negative monthly inflation would accrete on such a linker's principal from 1 March to 1 April (in terms of settlement date). Therefore, if one buys the linker at the start of a period and holds it until the end of that period, the inflation accretion component will tend to be very negative. This means that for the total income from holding the bond to equal the repo cost, the quoted "real" price (ie, the price before inflation indexation is applied) must rise a lot or, put differently, the real yield on the linker will need to fall. Therefore, the real yield carry of holding a euro HICPx linker over that period would be negative. On the other hand, monthly euro HICPx inflation tends to be very positive in March and April. The combined inflation from those two months would accrete on a linker from 1 May to 1 July; therefore, the real yield carry over that period will tend to be very positive.

We illustrate the exact carry calculations via an example. Consider an OATi, linked to the French CPI ex-tobacco (FRCPIx), bought on 4 March 2019, with the purchase financed via repo. We calculate the carry to 28 March 2019.

The DRI and IR calculations below are truncated to six decimal places and rounded to five decimal places, as per the calculation rules for French linkers.

Bond: OATi 1 March 2028

Real coupon rate: 0.1%, paid annually

Trade date: 4 March 2019

Settlement date: 6 March 2019

Notional: €100

Quoted price $P^{CU}_{4\ March\ 2019}$ = 105.511, corresponding to a real yield of -0.498%

Previous coupon date: 1 March 2019

Next coupon date: 1 March 2020

Number of days between last coupon date and settlement date: 5

Number of days between last and next coupon date: 366

Real accrued coupon (on €100 notional) = $AC_{6\ March\ 2019}$

$$= \frac{5}{366} \times 0.1\% \times €100$$

= 0.00136612…

DRI_{Base} = 100.04 (which is the DRI for 1 March 2016, the base date of the bond)

FRCPIx December 2018 = 103.16

FRCPIx January 2019 = 102.67

$$DRI_{6\ March\ 2019} = 103.16 + \frac{(6-1)}{31} \times (102.67 - 103.16)$$

= 103.08097

$$IR_{6\ March\ 2019} = \frac{103.08097}{100.04}$$

= 1.03040

Settlement price paid = 1.03040 * (€105.511 + €0.00136612…)

= 108.7199…

We now look at calculations for 28 March 2019, the trading date to which carry is calculated. This is commonly known as the forward trade date.

Corresponding settlement date: 1 April 2019 (called the forward settlement date)

Holding period = 26 days (calculated as difference between the settlement dates)

Assumed repo rate for financing the purchase of the bond: -0.45%

There are no intermediate coupon payments over the holding period in this case. Therefore, the income from the position will consist only of the difference between the settlement price to be received when the bond is sold and that paid at the beginning to purchase it. To calculate the carry, we need to find the settlement price received that makes the total income equal to the repo cost. This is called the forward settlement price. So we have:

Forward settlement price – Settlement price paid = Repo Cost

Forward settlement price = Settlement price paid + Repo Cost

$$\text{Repo Cost} = \frac{Holding\ period\ in\ days}{360} \times repo\ \ rate \times Settlement\ \ price\ \ paid$$

$$= -0.45\% \times \frac{26}{360} \times €108.7199\ ... = \ -€0.0353\ ...$$

Forward settlement price = €(108.7199…-0.0353…)

= €108.6846…

This forward settlement price has been derived using a non-arbitrage principle, ie, derived in such a way that the return received is equal to the financing cost. We now need to find the real yield that corresponds to a settlement price of €108.6846… on the 1 April 2019 forward settlement date. Being a settlement price, it should include everything, ie, the accrued coupon on the forward date, and, importantly, inflation-adjusted by the index ratio corresponding to the forward date. We have seen in "Linker cash flows and yields" that for a real yield to be extracted from a linker's price, that price needs to be expressed without the adjustment for past inflation accretion. We therefore need to divide €108.6846… by the index ratio that corresponds to the forward settlement date.

FRCPIx January 2019 = 102.67

FRCPIx February 2019 = 102.73

$$DRI_{1\ April\ 2019} = 102.67 + \frac{(1-1)}{30} \times (102.73 - 102.67)$$

$$= 102.67$$

$$IR_{1\ April\ 2019} = \frac{102.67}{100.04}$$

$$= 1.02629$$

Forward settlement price unadjusted for past inflation = $\frac{€108.6846...}{1.02629}$

= €105.900484…

€105.900484… corresponds simply to $\left(P^F \div \frac{I_0}{I_{base}}\right)$ in the general price formula that we saw in "Linker cash flows and yields" and that enables a real yield to be calculated:

$$P^F \div \frac{I_0}{I_{base}} = \sum_{t=1}^{m} \frac{100 * IC\%}{(1+RY)^t} + \frac{100}{(1+RY)^m}$$

The above calculations can easily be laid out in a spreadsheet. In the last step, the real yield RY can be derived as a solution of the equation, via an iteration calculation. It is called a "forward real yield"; here, we find that it is equal to -0.543%.

Note also that €105.900484… is a "dirty" price, as it contains the accrued real coupon. We calculate the "clean" inflation-unadjusted price, which corresponds to a "screen" clean price.

For the 1 April 2019 settlement date, we have:

Previous coupon date: 1 March 2019

Next coupon date: 1 March 2020

Number of days between last coupon date and settlement date: 31

Number of days between last and next coupon date: 366

Accrued real coupon at forward date = $AC_{1\ April\ 2019}$

$$= \frac{31}{366} \times 0.1\% \times €100$$

= €0.0084699…

Therefore, forward "clean" inflation-unadjusted price

$$= P^{CU}_{1\ April\ 2019\ fwd}$$

= €(105.900484…-0.0084699…)

= €105.892….

€105.892… therefore corresponds to a "screen" quoted price on the 28 March 2019 forward trade date (1 April 2019 settlement date) such that the income from holding the position equals the repo cost. Although the forward real yield can be calculated at the earlier step above, it is, however, useful to calculate $P^{CU}_{1\ April\ 2019\ fwd}$ as, in practice, in some systems, it is that input, rather than the "dirty" price that is required to get the corresponding real yield. For example, using €105.892 as the input in the "yield" function in Excel or the "YA" (Yield Analysis) page on Bloomberg, we get -0.543% as the corresponding real yield. We can now calculate:

Carry = Forward real yield – real yield when bond was purchased

= -0.543% - (-0.498%)

= -0.045% or -4.5bp

The carry is negative in our example, which is not surprising given that it corresponds to a holding period when the index ratio has decreased. March is the month with typically the most negative inflation accrual in euro HICPx and FRCPIx linkers. The inflation accrual during that month is so negative that it offsets the real coupon accrued and the negative repo cost on the OATi28.

A -4.5bp carry means that if the real yield falls by that amount, the holder will get just the right amount of total income from the bond to cover the repo cost (a negative cost in this case). If the real yield falls by less, then a profit would be made; if it falls by less than 4.5bp or rises, a loss is incurred. For example, if on the 28 March 2019 trading day, the selling price of the bond is such that the real yield is -0.518%, ie, 2bp lower than at the beginning, the real yield would appear to have rallied by 2bp. Actually, after adjusting for the carry (2bp minus 4.5bp), we can see that a 2.5bp loss has been made. Therefore, the real yield will have sold off even if it appears to have rallied.

In the example above, we have considered a forward settlement date for which the index ratio is already known. However, let us assume that the forward settlement date considered was 14 June 2019. The daily reference index for that date is calculated as an interpolation between the FRCIPx of March and April 2019. However, the index for both March and April 2019 would not yet have been available on the calculation date (4 March 2019). Indeed, the carry for linkers is known with certainty over a horizon that is as far as the last available data allow. For instance, on 4 March 2019, the last FRCIPx print known was for January 2019, which implies that carry was then known with certainty only up to the 1 April 2019 settlement date. When the February 2019 data were released on 15 March 2019, the horizon of exact carry calculations was then extended, and calculations for any settlement date in April and 1 May could be computed. To circumvent the constraint imposed by data release dates, it is very common to estimate carry for horizons beyond the point of exact calculations using inflation forecasts, ie, projections of future values of the price index. These can be based, for instance, on one's own projections, economists' forecasts or pricings from the front end of the inflation swaps curve (resets market). The calculation principles do not change, though.

Note also that our example does not contain any intermediate coupon payment over the holding period considered. If this is the case, one needs to calculate the forward linker settlement price to that intermediate date when the coupon is paid using the same non-arbitrage principle used above. Clearly, that forward price and the value of the coupon payment may need to be estimated using projected index values if the date is too far in the future. The assumption, then, is that the intermediate coupon payment is reinvested in the bond once it is received, with the price paid being the forward price calculated. What this implies is that at the end of the holding period considered, the notional held in the bond will be higher than at the beginning. If the holding period is so long that there is more than one coupon payment, the same assumption applies; ie, each coupon flow is reinvested in the bond with the successive forward bond prices calculated such that the non-arbitrage principle is respected. Exhibit 1 formalises carry calculations in a general case when an intermediate coupon is paid out during the holding period.

Exhibit 1: Computation steps for carry calculations

We assume that the bond is purchased and financed in the repo market at a trade settlement date T_0 and held until the settlement date T_2. We assume that an intermediate coupon is paid on the settlement date T_1. We calculate the carry from date T_0 to the forward date T_2.

The following notations are used:

P_t^{cu} is the clean quoted price, unadjusted for past inflation accrual, at settlement date t

AC_t is the accrued real coupon at settlement date t

P_t^{du} is the dirty price, unadjusted for past inflation accrual, at settlement date t

C is the real coupon, ie, unadjusted for past inflation accrual, for each payment date

IR_t is the Index ratio at settlement date t, and can be a known or expected ratio

Repo is the repo rate used to finance the position and is assumed to be constant

t can be the spot or a forward date

In T_0, the cash settlement price paid $= \left(P_{T_0}^{cu} + AC_{T_0}\right) * IR_{T_0}$

$$= P_{T_0}^{du} * IR_{T_0}$$

Using the non-arbitrage principle for forward calculations, the total proceeds, ie, resale value plus any reinvested coupon, from the bond at date T_2 should be equal to the cash settlement price in T_0 uplifted with the repo cost. Given the coupon to be paid in T_1, the forward bond price in T_1 has to be computed first; it is assumed that the coupon received will be reinvested in the bond at the calculated forward bond price for T_1. $P_{T_1}^{du}$ at settlement date T_1 should satisfy the same non-arbitrage constraint and is deduced from the equation:

$$\left(C + P_{T_1}^{du}\right) * IR_{T_1} = \left(P_{T_0}^{du} * IR_{T_0}\right) * \left[1 + \left(\frac{T_1 - T_0}{360} * repo\right)\right]$$

The monetary coupon payment in T_1 is equal to $C * IR_{T_1}$. This is assumed to be reinvested in the bond. The additional inflation-unadjusted notional bought is therefore $\frac{C * IR_{T_1}}{P_{T_1}^{du} * IR_{T_1}}$, ie, $\frac{C}{P_{T_1}^{du}}$.

Total inflation-unadjusted notional held in T_2 is therefore $1 + \frac{C}{P_{T_1}^{du}}$. $P_{T_2}^{du}$ at settlement date T_2 is then deduced from the equation:

$$\left(1 + \frac{C}{P_{T_1}^{du}}\right) * P_{T_2}^{du} * IR_{T_2} = \left(P_{T_0}^{du} * IR_{T_0}\right) * \left[1 + \left(\frac{T_2 - T_0}{360} * repo\right)\right]$$

The forward real yield can then be derived from $P_{T_2}^{du}$ using the generic present value formulation for the inflation-unadjusted price of a linker in the Canadian model

We also have: $P_{T_2}^{cu} = P_{T_2}^{du} - AC_{T_2}$

In practice, the forward real yield for T_2 can then be obtained through the "Yield" function in Excel or the "YA" (Yield Analysis) page on Bloomberg, with both using $P_{T_2}^{CU}$ as an input.

The real yield carry is the difference between the forward real yield calculated and the real yield on the bond at the start of the holding period.

The magnitude of carry will naturally tend to be higher the shorter the linker. When the difference between the linker's price at the beginning and its calculated forward price is transformed into the required change in real yield, the magnitude of that change is implicitly determined by the bond's duration. For instance, for the OATi 25 July 2021, which has a maturity 6.6 years shorter than the bond considered in the example above, the real yield carry calculated using the same method is -19.5bp, significantly higher in magnitude that the -4.5bp in the case of the OATi 1 March 2028.

In fact, intuitively, the basis point real yield carry on a linker over a given month can be approximated via the formula below:

[M/M inflation accretion + (real yield– repo rate)/12]/modified duration of bond

The inflation accretion may therefore be the same on the two bonds, but the shorter one's real yield carry has a notably higher sensitivity to that accretion because of its shorter duration.

Given that linkers also trade on a breakeven basis, ie, against nominals, it is also common to calculate the carry on the breakeven. This is defined simply as the real yield carry on the linker minus the nominal yield carry on the nominal bond. We assume that we are looking at a DV01-neutral pure breakeven position, ie, where trade notionals are set such that the real yield DV01 on the linker is equal to the nominal yield DV01 of the nominal bond. Consider again our example above. On 4 March 2019 (6 March 2019 settlement date), the nominal yield on the OAT October 2027 (which is the nominal comparator of the linker) was 0.363%. The breakeven on the linker was therefore 0.861%. Using the same repo rate as before, we calculate the carry on the OAT October 2027 at +0.75bp to the 1 April 2019 settlement date. The carry on the breakeven is therefore -4.5bp minus 0.75bp = -5.25bp. This means that for a long breakeven position (where one buys the linker versus the nominal comparator) to generate a profit, the breakeven over the holding period must rise by more than 5.25bp.

The mechanics of the carry calculations for a linker depend on its trading format and can therefore be very different from the Canadian model. Old-style UK linkers are a notable example. One important consideration there is that each time an RPI inflation print is released, the actual release replaces one month of the 3% inflation assumption. Therefore, there is a mechanical adjustment to the real yield of an old-style linker on every release date. As explained in the section dedicated to the UK inflation-linked market, this implies clear differences in terms of carry calculations versus the Canadian model.

Why is carry important for linkers?

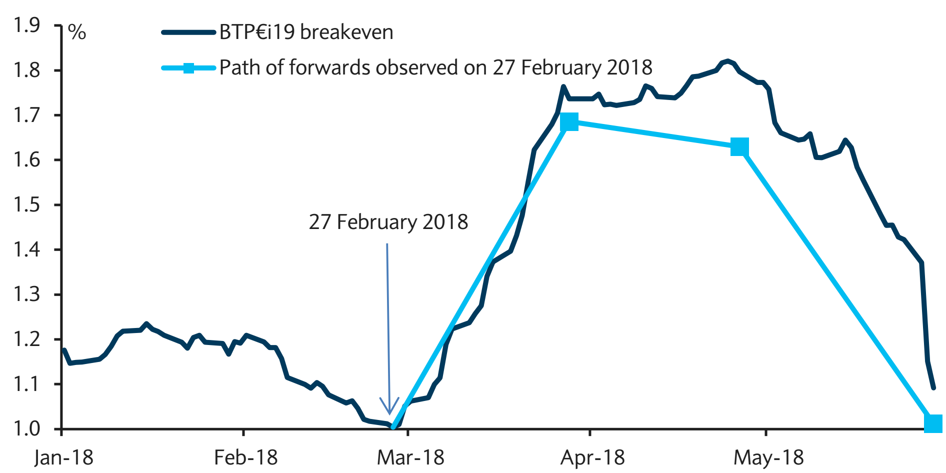
When looking at the evolution of a linker's real yield or breakeven history, it is important to bear in mind that the spot level may be distorted by seasonality and provide a biased assessment of richness/cheapness. For example, if a bond's breakeven is low by historical standards, it would appear cheap. However, if carry is so negative over the coming month that the breakeven needs to rise significantly over that period for a long position to yield a profit, that low breakeven may not appear so attractive after all. Plotting the forward real yield and breakeven points over a horizon during which carry is expected to be extreme therefore provides a more accurate picture of where valuations stand. This is particularly important for short-dated linkers, where the absolute value of carry tends to be high.

Moreover, when carry is extreme in linkers, there tends to be a convergence toward forwards. For example, as noted above, carry is very negative on euro HICPx linkers between the start of March and the start of April. All else equal, as the index ratio falls day by day over that period, there is a tendency for the market to adjust the inflation-unadjusted price on a linker correspondingly higher such that the inflation-adjusted settlement price is not biased mechanically higher. Therefore, over that period, the real yield on a linker will tend to fall significantly (or the breakeven tend to rise), but what can then appear to be a strong rally may just represent a mechanical adjustment to the very negative carry.

Figure 1 illustrates this tendency for a mechanical adjustment. We look at the evolution of the BTP€i19 breakeven from the start of January 2018 to 30 May 2018 (corresponding to the 1 June 2018 settlement date). We compute the path of monthly forward points observed on 27 February 2018, ie, the forwards to late March, late April and late May (we compute the forward path using realised monthly January, February and March 2018 euro HICPx values, although the February and March prints were unknown on 27 February 2018). M/m euro HICPx was very negative in January (-0.91%), moderately positive in

FIGURE 1

Extreme carry tends to induce mechanical adjustments in spot levels



Note: The forward path is computed using realised monthly January to March 2018 euro HICPx values, although the February and March prints were unknown on 27 February 2018. Source: Barclays Research

February (0.20%) and very positive in March (0.97%), hence the path of monthly forwards in Figure 1. The spot breakeven has largely tracked this path. In other words, what appeared to be a significant bullish momentum in March and a very bearish move in May merely reflected adjustments to carry swings.

Plotting the forward real yield or breakeven points helps, but does not necessarily solve, the problem of optically biased valuations. For example, an investor trading a euro HICPx linker at the start of March may look at the forward real yield/breakeven to the start of April to correct for the very negative inflation accrual over the coming month. However, a forward date to the start of April would then correspond to the start of a three-month period when carry is typically very positive. Therefore, that forward would not itself be unbiased. For a forward real yield or breakeven to be unbiased from any element of seasonality, it needs to be calculated to a forward date when its residual maturity is a multiple of whole years (by definition, inflation over a whole year has no seasonality). For example, consider a bond with a residual maturity of two-and-a-half years. We assume that the half-year period up to the date when it will be a two-year bond is one of very negative seasonality. The bond's real yield or breakeven is expressed in annualised terms, and given the half-year of negative seasonality, the real yield or breakeven measures appear cheaper than they really are if that negative seasonality is accounted for. Of course, if there is another date during the year (other than when its maturity is in whole years) when the residual seasonal bias on a linker is nil or negligible, it is also appropriate to calculate its forward real yield or breakeven to that date.

In practice, the picture is complicated by the fact that linkers mature at different times of the year. For example, US TIPS mature in mid-January, mid-February, mid-April or mid-July. In euro HICPx linkers, French ones mature on 25 July or 1 March, while the German issues have 15 April maturities. This means that to compare French with German euro HICPx bonds, choosing a 25 July forward date corrects the seasonality on some of the French ones but not the 1 March maturing issues and not on the German ones. A 15 April forward date does not solve the problem, either. In short, when comparing linkers that mature in different periods, it may not be possible to find a forward date such that the adjustment for carry removes valuation biases. In that case, it may be better simply to adjust the different linkers for their own respective embedded seasonals. The methodology is explained in "Seasonality: Estimation and adjustment" later in this publication.

INFLATION PRODUCTS

Seasonality: Estimation and adjustment

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Seasonality is an important factor for several areas of inflation-linked markets because such bonds and swaps are typically linked to non-seasonally adjusted inflation indices. This influences the level of breakevens across the year and micro valuations on the curve. It is also very important for valuing non-annual inflation swap points – a seasonal model is needed to build the infrastructure for inflation swaps.

Inflation indices are subject to seasonality; that is, they usually have persistent deviations from trend at specific times of the year. Seasonal adjustment attempts to isolate such patterns from a time series by de-trending it, filtering out any seasonality. This process typically employs an algorithm or model to search for seasonal patterns, including statistical diagnostics. There are two ways to construct a seasonal vector: additive and multiplicative. Additive seasonality is used when the index is stationary and the amplitude of seasonal adjustments constant. Most price indices, however, have a marked long-run upward trend, meaning that multiplicative adjustment should be used; that is, calculating factors that seasonally adjust the index by multiplying it. Seasonality is most commonly quoted either in vector form (the degree to which the underlying index has to be adjusted to create a seasonally adjusted series) or as an average month-on-month factor. This can be confusing, but a direct transformation between these two formats is mathematically straightforward. The vector format is most useful in assessing relative seasonal value between different maturities, whereas the m/m factors highlight the seasonal trends that will be reflected in bond carry.

To the extent that seasonal trends are predictable, an efficient market ought to price these in. However, observing seasonality is not always straightforward. Even in countries where statistics agencies publish full seasonality estimates, there is uncertainty as to how this seasonality will evolve. Typically, bond and swap markets price in significantly less seasonality for future years than statisticians estimate based on current data. However, there is an argument that certainty over the seasonal vector declines over time, so any forecast seasonal factor should contain a decay component. A counter-argument is that there is no reason to dampen an unbiased estimation, while, from a practical perspective, evidence from many countries shows that the magnitude of seasonality has tended to increase in recent years. We believe it is appropriate to assume a static seasonal vector and to adjust this as more information becomes available.

Several methods of seasonal adjustment are common: ratio versus moving average (or sum); regression using dummy variables; the US Census Bureau's X-13-ARIMA-SEATS (previously X-12ARIMA); and the Bank of Spain's TRAMO/SEATS procedure which the US Census Bureau has now incorporated into its software. The Census Bureau 'X' adjustment is the most widely used by statistics agencies, having existed in some form since the late 1960s, while TRAMO/SEATS is widely used in Europe. The main historical difference is that TRAMO/SEATS estimates and fits an ARIMA model to the data to derive an estimate of seasonality, whereas the core seasonal adjustment method underlying 'X' uses a series of non-parametric moving average filters, with fitting an ARIMA model being optional. Moving average filters are more useful than ARIMA when constructing a seasonal vector – it includes individual components that do not exhibit highly statistically significant seasonality, but still show discernible patterns for which the vector needs to account.

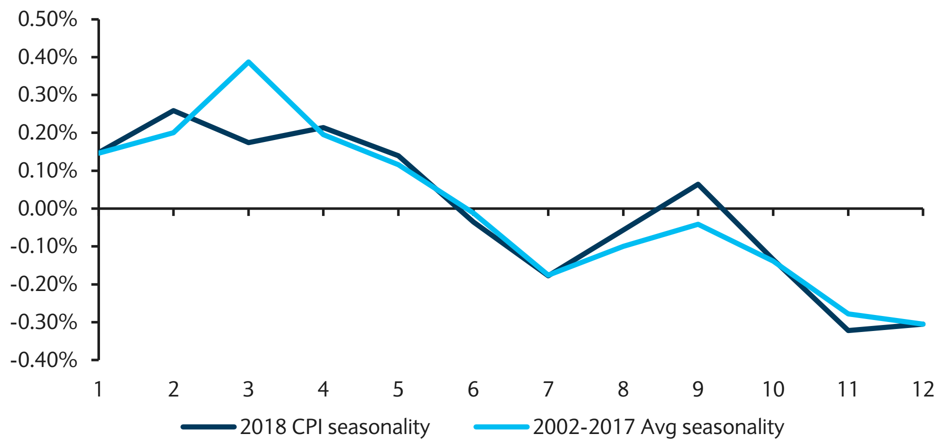
Generally, we prefer to use seasonality estimates from statistics agencies if they are published in sufficient detail. Where these do not exist, we suggest using an X-13 estimation at as low a level of aggregation as feasible. Estimation on an aggregate series on average tends to produce a slightly higher seasonality than considering sub-components, whether or not the sub-component approach estimates all variables or only those with significant seasonal components. Problems can arise in adjusting an inflation index constructed from an unchained series using a set of weights, then chained at the index level. Successive unchaining and chaining of series is not only laborious, but can bias the end result (because of the Cauchy-Schwarz inequality). This can, however, be circumvented by estimating a seasonal vector for each component of the index, then aggregating each one by the index weights to give an overall seasonal vector for the index.

United States

Consumer inflation, as measured by the Consumer Price Index, follows a regular seasonal pattern. One way to visualise the typical seasonal pattern is shown in Figure 1, which plots the average difference between the Not Seasonally Adjusted (NSA) and Seasonally Adjusted (SA) monthly percentage change in the CPI. Although seasonals vary over time, prices have tended to rise more quickly in the early part of each year, with seasonality negative from July onward. The NSA CPI tends to rise most notably between February and May, but decline significantly in November and December.

FIGURE 1

CPI seasonals, 2002-18 (difference between m/m NSA and SA% chg)



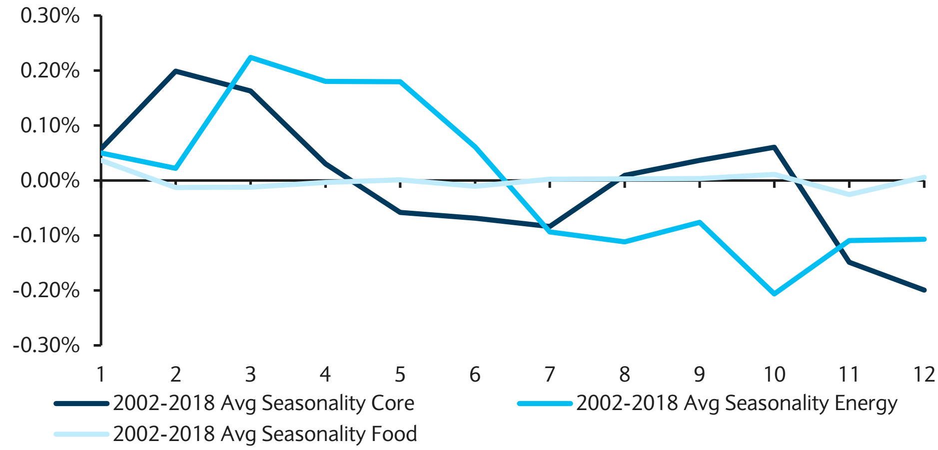
Source: BLS, Bloomberg, Barclays Research

The Bureau of Labor Statistics (BLS) estimates the seasonal factors by applying the X-13-ARIMA seasonal adjustment model, which attempts to adjust for monthly distortions, at an individual component level. Where appropriate, an intervention analysis is used, which adjusts for sharp and permanent shifts in the underlying trend. These have the potential to distort the results of the seasonal adjustment and are accounted for via regression-ARIMA models. Seasonal factors are estimated and published at the start of each year, coinciding with the January data release and causing a change in the historical seasonally adjusted series. The adjustment is applied to subcomponents of the index and then aggregated, which tends to produce a slightly more conservative estimate of seasonal factors than top-down estimation, even before the dampening effect of the intervention analysis is considered.

Figure 2 breaks down the estimated seasonal contributions of the main CPI components. These are calculated as the implied difference between the NSA and SA percentage changes for these components, weighted by their relative importance in the headline CPI. Seasonal fluctuations in the headline index are driven mainly by movements in core and energy prices during the year; food prices, in contrast, are relatively stable. Energy prices tend to rise most in March-June, as the anticipation and onset of the summer driving season puts upward pressure on retail gasoline prices. In contrast, energy prices tend to fall off in the second half of the year. The seasonal pattern of home heating oil is generally the reverse of gasoline but has a much smaller weight, so gasoline is the dominant factor. However, although the seasonality of energy is larger than for other components, it is also less stable.

FIGURE 2

Contributions of components to headline CPI seasonal pattern, average 2002-18 (difference between m/m NSA and SA % change of CPI components)



Source: BLS, Haver Analytics, Bloomberg, Barclays Research

As Figure 2 shows, NSA core inflation tends to rise significantly in February and March, fall off in May-July, rise in October, and fall sharply in November and December. Figure 3 shows the most important factors behind this: shelter and apparel costs. Seasonality in shelter is mainly driven by out-of-town lodging, which tends to soften in September-December as demand falls off after the summer travel season. December marks the low point of the year for out-of-town lodging costs, presumably because travellers tend to stay with family rather than in hotels during the holiday season. Shelter costs begin to rise early in the year as travel patterns start to normalise. As for apparel, these prices fall off in November-January as holiday discounting dominates, then rise notably in February and March. They fall off again in June-July as summer merchandise is cleared ahead of the back to-school season, when they pick up again.

Seasonality and TIPS

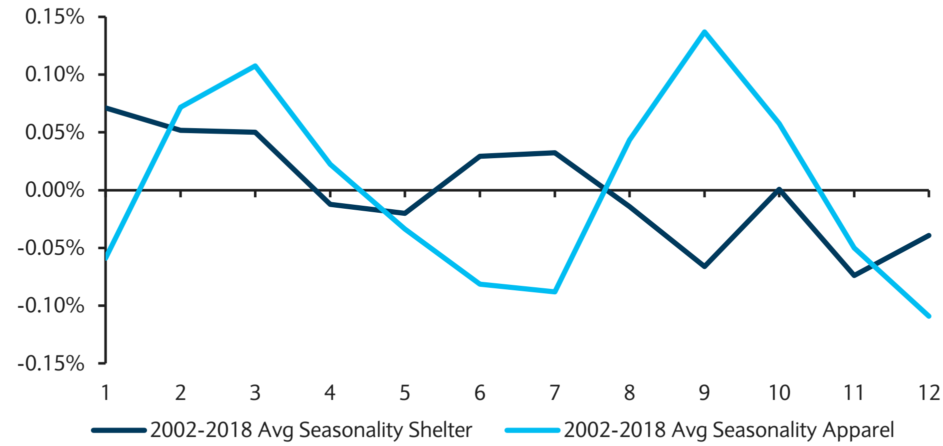
TIPS accrue inflation off the NSA CPI, so the seasonal patterns in inflation can affect valuations. Generally, inflation tends to be higher in the first half of the year. Initially, as the TIPS market was starting out, the market took some time to adjust to this (Figure 4).

This trend also shows up in differences between issues that mature in different months because seasonal factors do not tend to change much from year to year. For example, because July maturity TIPS pick up one extra good spring carry period, they should, all else equal, trade rich to TIPS with January and April maturities.

In February 2019, the BLS released 2018 seasonal vector. The largest differences, in terms of the effect for TIPS, in 2018 relative to 2015-17 appear in the March through May seasonal factors (Figure 6).

FIGURE 3

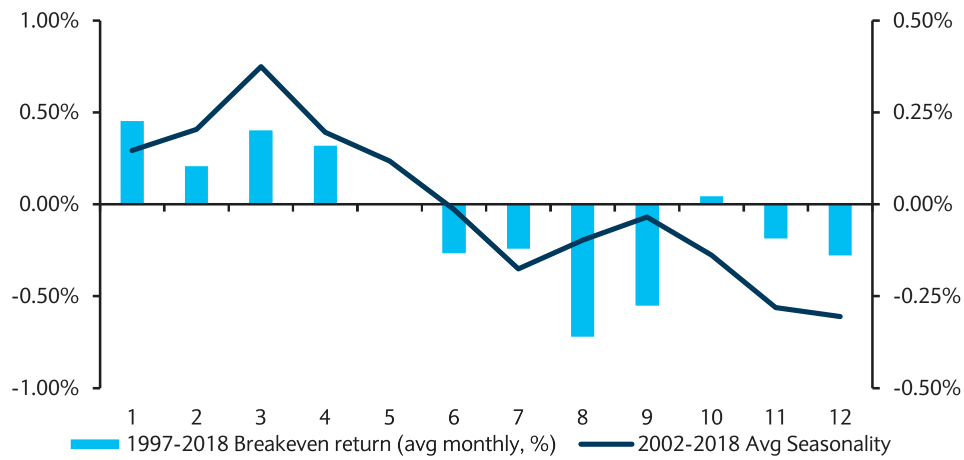
Contributions of core components to headline CPI seasonal pattern, average 2002-18 (difference between m/m NSA and SA % change of CPI components)



Source: BLS, Haver Analytics, Bloomberg, Barclays Research

FIGURE 4

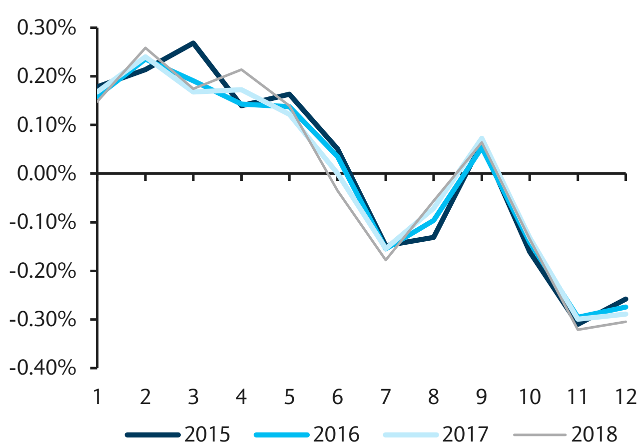
Average monthly breakeven returns are higher in the first half of the year – efficient markets



Data: From Feb 1997 to Dec 2018. Source: Barclays Research

FIGURE 5

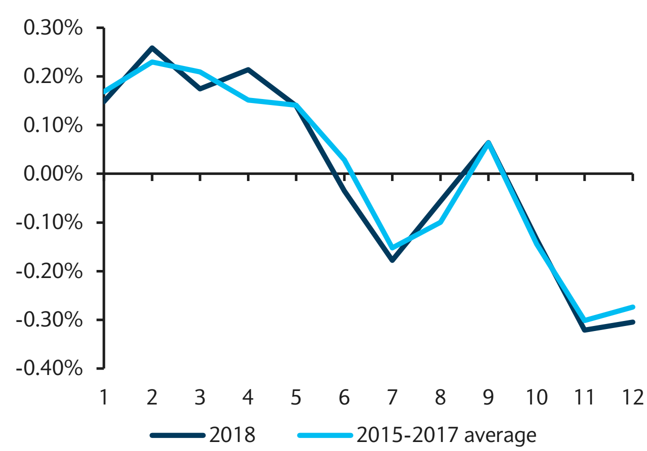
Annual seasonal patterns (m/m NSA – m/m SA)



Source: BLS, Barclays Research

FIGURE 6

Recent seasonal patterns



Source: BLS, Barclays Research

As stated previously, July maturity issues tended to be considerably and consistently cheap relative to other TIPS with other maturity months because, we believe, the market did not price seasonality correctly ("Christmas in Julys," *Market Strategy Americas*, November 19, 2009). However, July issues have become less cheap over the years. To see this, in Figure 7, we compare the cheapness in July issues using the latest 2018 seasonal vector to the average of the seasonal factors from 2002-2017. Using the latest vector, July issues are just slightly cheap to January issues while, using the historical averages, July issues look particularly cheap. So, either the market has repriced seasonals or the vector itself has caught up to the actual seasonal pattern; or both. This can be seen in the decline over time of seasonals at the beginning of the year, for example in Figure 1. However, some volatility in our measure of what the market is pricing in for seasonality is due to issue-specific relative value (rather than seasonality), so it is not a precise metric. Over time, we expect seasonality to be increasingly priced in more fairly.

FIGURE 7

Cheapness of July issues versus January issues after adjusting for seasonality

Issue	Seasonal mispricing, using 2018 seasonal vector, 12 Feb 2019	Seasonal mispricing, using avg of 2002-17 seasonal vectors, 12 Feb 2019
Jul20s	1.7	11.1
Jul21s	1.1	6.6
Jul22s	0.3	4.3
Jul23s	0.5	3.5
Jul24s	0.5	3.0
Jul25s	0.8	2.9

Source: Barclays Research

Method of calculating seasonally adjusted value

This example calculates the TIIJul20 seasonal fair value based on 2018 seasonality assumptions and the trend BEI rate over Jan20-Jan21.

To judge bonds versus the seasonality of any given year, we start by looking at bonds that are a year apart in maturity (Apr19-Apr20, Jan21-Jan22, etc). For example, using Jan20-Jan21, we can estimate what the Jul20 breakeven should be, assuming 2018 seasonality. Over a one-year cumulative period, the seasonality between Jan20 and Jan21 should be zero. Using current market-implied breakeven rates for Jan20 and Jan21 and reference CPI for a 13 February 2019 settle date (251.6930), we first estimate what the market-expected maturity NSA CPI is for each of the bonds. Jan20 and Jan21 BEIs are 1.53% and 1.68%, respectively. The final maturity CPI date that matters for Jan20 is mid-October-November 2019 and for Jan21 is mid-October-November 2020. For simplicity, we have assumed annual compounding; the exact calculations should be done with semi-annual compounding.

Reference CPI for 13 February 2019 settle date: 251.6930

$\text{Jan20MaturityCPI} = 251.6930 * (1+1.53\%)^{T1} = 255.2279$

$\text{Jan21MaturityCPI} = 251.6930 * (1+1.68\%)^{T2} = 259.8707$

T1~ Time to Maturity from settle to the maturity of Jan20, 0.92y

T2~ Time to Maturity from settle to the maturity of Jan21, 1.92y

From the Jan20 and Jan21 maturity CPI NSAs, we get a 1y CPI rate between Jan20 and Jan21 of about 1.82% (259.8707/255.2279 – 1).

Deriving the 2018 seasonality vector

With this 1y trend rate of 1.82% (between Jan20 and Jan21) and our 2018 seasonality assumption, we can determine CPI prints for each month from the middle of October-November 2019 to October-November 2020. First, we determine what the seasonality vector is for 2018. For this, we need 2018 CPI NSA and 2018 CPI SA prints. We take m/m changes in each series in 2018 and then take the difference between NSA m/m and SA m/m. Once we know the m/m seasonality (Figure 1), we can form a seasonality multiplier vector (Figure 8).

FIGURE 8

2018 CPI seasonality vector

Dec-17	100
Jan-18	100.15
Feb-18	100.41
Mar-18	100.59
Apr-18	100.81
May-18	100.95
Jun-18	100.92
Jul-18	100.74
Aug-18	100.69
Sep-18	100.76
Oct-18	100.62
Nov-18	100.30
Dec-18	100.00

Source: Barclays Research

With the trend rate of 1.82% between Jan20 and Jan21 and the cumulative seasonal accretion of 0.42% between the January (mid-October-November multiplier) and July issues (mid-April-May multiplier), we can determine what the maturity CPI NSA should be for Jul20 (assuming a 2018 seasonality vector). Knowing the Jul20 maturity CPI NSA, we can calculate the breakeven (or inflation) rate from the settle date's reference CPI and compare this 2018 seasonality derived breakeven with where the market Jul20 breakeven is priced. Specifically, we start with the Jan20 maturity CPI NSA of 255.2279 and grow it exponentially by 1.82% * T3 plus the cumulative seasonality of 0.42%. T3 is the time to maturity from Jan20 to Jul20, roughly 0.5y.

Jul20MaturityNSACPI = Jan20MaturityNSACPI * exp (T3*1.82% + 0.42%) = 258.6253

13 February 2019 settle reference CPI = 251.6930

Using the Jul20Maturity NSA CPI divided by spot reference CPI, we get an annualized breakeven rate of 1.93% (Jul20 annualizing time-to-maturity factor is 1.42y). Currently, the market-traded Jul20 breakeven rate is 1.92%, ~1bp cheaper than the 2018 seasonality derived breakeven rate of 1.93%.

Euro area

Eurostat does not publish an official seasonally adjusted HICP series, but the ECB does publish them for headline HICP and HICPx, using the latter to adjust bond breakevens in its macro analysis. These indicate that there is now more seasonality in the euro area than in the US. They use an X model similar to that of the US, but conducted at a higher level of aggregation (only five sub-sectors) and excluding energy, as the ECB argues that there is no evidence of seasonality in this series while estimation is volatile. Relative to the BLS estimation at the lowest possible level of aggregation and with more intervention, the ECB methodology may produce a slightly higher estimate. However, the exclusion of energy components is somewhat controversial and tends to reduce aggregate seasonality. An X analysis of the energy series suggests that any seasonality is highly unstable and, unlike in the US, there are few months in which the sign of the month-on-month seasonal has stayed the same over the long term. On the other hand, there has been, for example, a strong tendency for petrol prices to rise in the three months to June for the past 10 years, increasing by an average of 5%, but offset by a similar fall in the three months to January.

Seasonality in euro area HICPx increased in the early 2000s, mainly on measurement changes and the deregulation of retail prices. Eurostat has encouraged a standardisation of processes across Europe, leading to more seasonality in the aggregate series as the timing of distortions is more consistently measured. This has lessened the tendency of the aggregate index to be smoothed out. The clearest example is that until 2001, Italy and Spain did not include apparel sales prices in their data, but there has been a tendency toward increasing volatility of retail prices in other countries, as well. EC Regulation No 330/2009 on the treatment of seasonal products came into force on HICP indices for Member States with the January 2011 index. 'Seasonal products' are defined by Eurostat as "goods and services that are available for purchase in some period of the year, but are not available for purchase, or purchased in small or negligible volumes, for certain periods in a typical annual cyclical pattern". The regulation allows for the application of two calculation methods: strict annual weights and class-confined seasonal weights. The end result of the changes is that seasonality can be imputed into price indices even if the underlying trend in prices is stable when the goods are not available. Overall, this increases the amplitude of seasonality in indices, which in practical terms exacerbates positive and negative periods of seasonal carry.

We are fairly comfortable using the ECB data for HICPx seasonality for considering valuations within the euro inflation market, but given the exclusion of energy components we caution against comparison with seasonals in other countries that include this sub-sector. Figure 9 shows monthly seasonality estimates for Euro HICPx and French CPIx, respectively, for the past three full years of data. The trends have become more similar in recent years. The differences stem mainly from varying sales periods and a greater upward bias for euro (particularly German) prices for Christmas and Easter that are subsequently unwound.

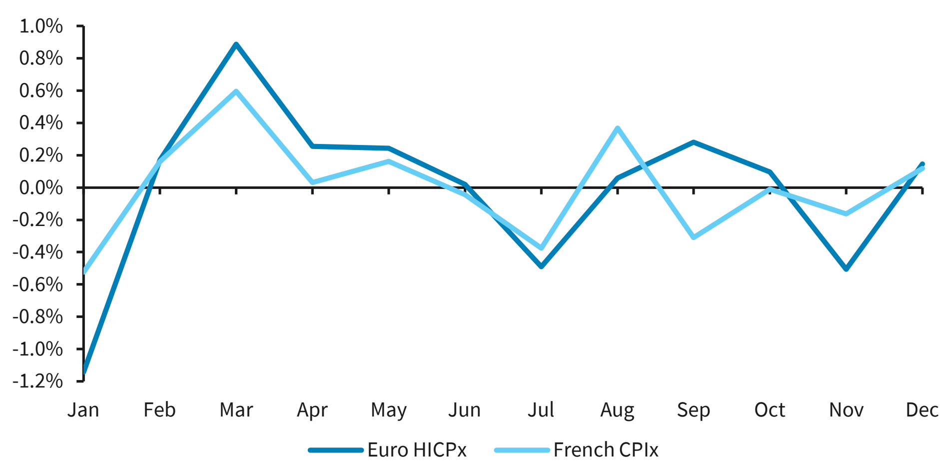
Example of seasonal adjustment for euro linkers

The first step toward seasonally adjusting a specific bond is to calculate a cumulative vector. Typically, we estimate m/m vectors to provide a clear illustration of seasonality patterns, but given the cumulative nature of inflation accrual on linkers, each m/m seasonal preceding a given month needs to be multiplied together. In mathematical terms:

$$Cumulative\ \ Seasonal(m) = \prod_{1}^{12}[1 + MoM\ \ seasonal(m)\ ]$$

FIGURE 9

Normalised 2018 m/m seasonality estimates for Euro HICPx and French CPIx



Source: Eurostat, ECB (Euro HICPx vector), Insee (French CPIx), Barclays Research

FIGURE 10

Euro HICPx m/m and cumulative vectors

	M/M seasonal vector (%)	Cumulative vector
Jan	-1.142	-1.142
Feb	0.169	-0.975
Mar	0.888	-0.096
Apr	0.254	0.158
May	0.242	0.401
Jun	0.020	0.421
Jul	-0.491	-0.073
Aug	0.059	-0.014
Sep	0.280	0.266
Oct	0.096	0.363
Nov	-0.506	-0.145
Dec	0.145	0.000

Source: ECB, Barclays Research

Taking as an example a settlement date of 27 March 2019:

Settlement: 27 March 2019
3m lag seasonal: 0.000 (December)
2m lag seasonal: -1.142 (January)
Interpolation factor: (D-1)/Dm = (27-1)/31 = 0.839
Interpolated spot seasonal: (1 – 0.839)* 0.000 + 0.839*-1.142 = -0.958

FIGURE 11

Seasonal adjustment of euro linkers

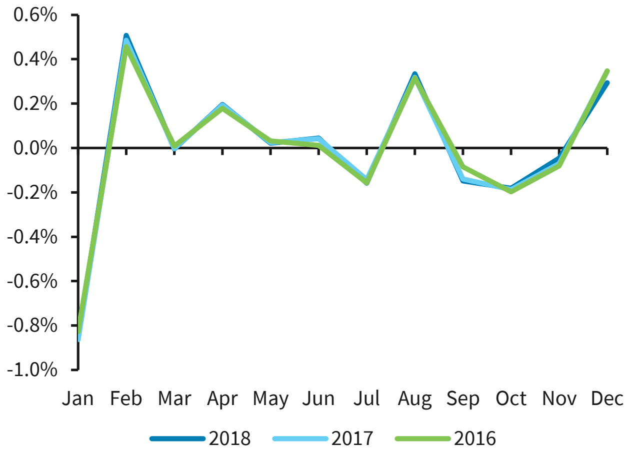
Settlement: 27 March 2019				
	DBR€i23	OAT€i24	BTP€i24	SPGB€i24
Maturity	15/4/2023	25/7/2024	15/9/2024	30/11/2024
3m lag seasonal	0.00 (Dec)	0.00 (Dec)	0.00 (Dec)	0.00 (Dec)
2m lag seasonal	-1.142 (Jan)	-1.142 (Jan)	-1.142 (Jan)	-1.142 (Jan)
Interpolated Spot Seasonal	-0.96	-0.96	-0.96	-0.96
Interpolated Maturity Seasonal	-1.06	0.346	0.191	0.257
Relative seasonal (maturity – spot)	-0.106	1.30	1.15	1.22
Modified Duration	4.1	5.4	5.1	5.5
Seasonal (bp): Relative Seasonal/Modified Duration	-2.6	24.3	22.4	22.1

Source: Barclays Research

The outright seasonal of the specific bonds is not variant intra-year, but clearly the spot seasonality at any point in time varies, as does inflation accrual. For European inflation markets, seasonality in the bond markets gives rise to significant optical distortions and explains why German breakevens can sometimes appear cheap to other issues, when in fact once accounting for seasonality they are not. Typically, given the magnitude of seasonal differentials in Europe, markets tend to factor in these distortions accurately, as otherwise there would be a clear potential arbitrage. In previous editions of this publication, we have shown charts of the evolution of seasonality for the various issuer markets; however, issuers have started to diversify the range of months in which linkers mature and so this would be less useful now than previously. We include daily seasonally adjusted breakeven estimates in the *Inflation-linked Daily* to assist investors with understanding the influence of seasonality on breakeven valuations.

FIGURE 12

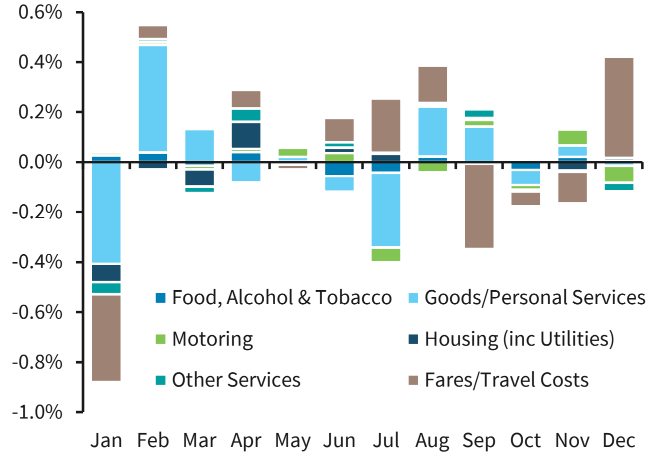
Barclays estimated UK RPI m/m seasonality



Source: National Statistics, Barclays Research

FIGURE 13

Key contributions to 2018 RPI seasonality vector



Source: ONS, Barclays Research

United Kingdom

For the UK, seasonal adjustment of the overall RPI Index derives statistically significant seasonality, but the Office for National Statistics (ONS) does not produce a seasonally adjusted RPI series. To gauge the stability and drivers of seasonality, we created a seasonal vector by using X-12 to adjust the key components of the RPI, then aggregating these vectors using the official index weights. We avoided deploying an ARIMA model as part of the X-12 process, as for some components there is no evidence of an underlying ARIMA process, which would mean an inconsistent estimate.

Figure 12 shows the estimated seasonality for the past three years and indicates that the seasonal vector is reasonably stable, although an estimation without stripping out mortgage interest payments would be notably less so. The relatively long sample period of 1987-2013 allows for a more accurate estimation of the underlying trend and seasonal factors than in the euro area. Even so, seasonality appears to be also more stable than in the US and most large euro countries. Figure 13 shows the contribution of the various key components of RPI to the month-on-month seasonality. As the figure shows, there is a strong upward effect on housing in April because of council tax, as well as duty changes on alcohol, tobacco and motoring in the UK Budget, although these have been fairly modest in the past few years. Goods show a strong downward January effect from seasonal sales; this is also observed in July. The ONS produces a seasonally adjusted series for RPIY, which excludes indirect taxation, as well as mortgage interest payments, but as a significant element of UK seasonality is driven by tax factors, we prefer to use our own series.

The ONS has implemented changes for treatment of seasonal products similar to those mandated by Eurostat for HICP. This has resulted in an increase in seasonal distortions, particularly in volatile series such as clothing and footwear. Dispersion in the subgroups of such indices has also consequently increased, causing the formula effect between RPI and CPI to be more pronounced. An additional consideration in estimating seasonality in UK inflation has been alterations to VAT. The Labour government cut VAT to 15% effective January 2009 for a year in an effort to shore up consumption, restoring the previous 17.5% rate at the start of 2010. The coalition government subsequently increased this to 20.0% effective January 2011 to bolster the public finances as part of the ongoing fiscal consolidation package. This is likely to have biased seasonals, particularly in January; as such, calculations of seasonality may underestimate the recent strong January effect. In practice, controlling for the effects of VAT would add complexity to the estimation of seasonality, and the practical benefits of this would likely be small. There is no guarantee that seasonality will be statistically stable over time, and any estimate is inherently backward-looking. Therefore, we see little benefit in adding a VAT dummy to our estimates. It is also worth noting that the main Budget has been moved by Theresa May's government to November/December from March, so any duty increases are likely to take effect then rather than in April as they have done historically. Additionally, the introduction of a household energy price cap by the regulator OFGEM effective January 2019 means that energy prices will most likely rise and fall in April and October now.

Estimating seasonal effects on UK linkers

Caution needs to be applied when considering the effect of seasonality on UK linkers. The indexation models of old- and new-style linkers are not directly comparable; therefore, considering seasonal differences between the two differing lines is not meaningful. Seasonal analysis is useful for new-style UK linkers, which follow the standard Canadian model with both March and November maturities issued. March issues suffer seasonally disadvantaged accrual relative to November lines and, as such, tend to trade cheap on curves. Calculation of the seasonal bias is calculated similarly to the examples for the euro issues presented above, with the practical seasonality experienced illustrated below.

Japan

As is the case with consumer prices elsewhere, Japanese core CPI (CPI excluding fresh food) exhibits fairly regular seasonal patterns that reflect corporate sales practices, as well as consumer habits and preferences. Historically, seasonality has been "most negative" in the first quarter of the year; ie, Japanese consumer prices in Q1 tend to be lower than prices in other months, regardless of whether the year as a whole exhibits positive, flat or negative inflation rates. The main reason for this is that in January-March, prices of Japanese goods (especially clothing) tend to fall sharply due to the effect of New Year and year-end inventory clearance sales. Prices of services also tend to decline overall in Q1, as fees for entertainment facilities, for which usage declines in winter, decrease.

In contrast, seasonality tends to improve from the second quarter of the year and becomes "most positive" (or strongest) during August-December. This reflects price hikes in clothing from April, as well as the fact that during the summer vacation season of July-August, leisure-related service prices, such as for travel services, tend to increase significantly. On the other hand, prices of goods tend to decline on the effect of sales following summer bonus payments and clearing sales on summer clothing. Clothing prices subsequently rebound as winter lines come in, and prices of goods such as food and rice tend to rise as preparations for the New Year holidays get under way, a development that pushes consumer prices significantly above the year's average in the last quarter of the year.

Normalised Seasonality Estimates

FIGURE 14

Estimated m/m normalised seasonals – 2018

Developed Markets												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
US CPI	0.151%	0.261%	0.177%	0.217%	0.143%	-0.033%	-0.175%	-0.054%	0.067%	-0.132%	-0.319%	-0.302%
Euro HICPx	-1.142%	0.169%	0.888%	0.254%	0.242%	0.020%	-0.491%	0.059%	0.280%	0.096%	-0.506%	0.145%
France CPIx	-0.524%	0.160%	0.595%	0.030%	0.162%	-0.044%	-0.376%	0.368%	-0.311%	-0.011%	-0.163%	0.118%
UK RPI	-0.853%	0.507%	-0.004%	0.196%	0.022%	0.045%	-0.158%	0.334%	-0.148%	-0.181%	-0.046%	0.293%
Japan CPI ex-fresh food	-0.497%	0.100%	0.099%	0.298%	0.099%	-0.099%	-0.198%	0.099%	0.000%	0.198%	0.000%	-0.098%
Canada CPI	0.155%	0.455%	0.225%	0.224%	-0.002%	-0.002%	0.072%	-0.225%	-0.299%	-0.001%	-0.300%	-0.300%
Sweden CPI	-0.918%	0.487%	0.127%	0.178%	0.058%	-0.045%	0.098%	-0.233%	0.225%	-0.095%	-0.116%	0.242%
Denmark CPI	-0.203%	0.705%	0.045%	0.190%	0.016%	-0.136%	0.355%	-0.348%	-0.100%	0.082%	-0.316%	-0.286%
Australia CPI			-0.18%			-0.18%			0.27%			0.09%
New Zealand CPI			0.10%			0.00%			0.20%			-0.29%
Emerging Markets												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Brazil	0.214%	0.159%	-0.101%	0.041%	0.144%	-0.216%	-0.046%	-0.226%	-0.087%	-0.019%	0.032%	0.105%
Chile	-0.204%	0.068%	0.024%	0.092%	0.121%	0.012%	-0.097%	-0.012%	0.011%	-0.041%	0.091%	-0.065%
Colombia	0.548%	0.566%	0.074%	0.180%	-0.052%	-0.140%	-0.361%	-0.202%	-0.229%	-0.248%	-0.173%	0.044%
Israel	-0.363%	-0.092%	0.050%	0.387%	0.249%	0.169%	0.132%	-0.162%	-0.089%	0.189%	-0.377%	-0.089%
South Korea	0.465%	0.389%	-0.242%	-0.048%	-0.013%	-0.234%	-0.069%	0.304%	0.109%	-0.133%	-0.595%	0.072%
Mexico	0.276%	0.025%	0.058%	-0.591%	-0.597%	-0.207%	-0.048%	0.025%	0.011%	0.252%	0.458%	0.346%
South Africa	0.132%	0.663%	0.229%	0.276%	-0.299%	-0.061%	0.371%	-0.575%	-0.140%	-0.069%	-0.259%	-0.261%
Thailand	-0.107%	0.025%	-0.190%	0.303%	0.346%	-0.076%	-0.275%	0.003%	0.243%	0.057%	-0.079%	-0.248%
Turkey	0.983%	-0.417%	-0.166%	0.410%	-0.226%	-0.524%	-0.317%	-0.284%	-0.179%	0.904%	-0.127%	-0.044%

Source: National Statistics Agencies where available, Barclays Research estimates from Jan 2000 – Dec 2018 otherwise. Note: Australia and New Zealand CPIs are quarterly series; the presentation of these estimates reflects this.

INFLATION PRODUCTS

Fitting an (adjusted) real yield curve

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A fitted real yield curve can be used to assess micro relative value. We describe a cubic spline methodology used to fit the TIPS real yield curve and then add seasonality and option adjustments to produce an adjusted real yield curve for further fitting. Both measures highlight interesting tactical and structural micro relative value opportunities across the curve.

Introduction and motivation

In our *Inflation-Linked Daily* TIPScores framework, we employ three metrics across TIPS issues to assess micro relative value. We find that the sum of these scores provides a good starting point to further evaluate *tactical* dislocations on the TIPS curve. One of these is a 3m z-score on the issue's spread to our real fitted curve. We recently rebuilt the infrastructure behind our real curve and describe its methodology below. To complement this curve, in an effort to incorporate a measure of *structural* relative value on the curve, we introduce a new spread measure, also described in this piece, based on a seasonality- and option-adjusted fitted real curve measure. We have also incorporated this measure on Barclays Live Chart as the "Spread to Adjusted Real Yield Curve" field.

Building a cubic spline curve

A common exercise in fixed income analysis involves determining the term structure of interest rates (ie, the spot or zero curve) for a particular market, given observable pricing data on traded coupon bonds. Using this resulting zero curve, we are then able to discount the individual cash flows of a particular bond, compare its market yield with a yield derived from this new discounted market price, and assess micro relative value.

There are two main curve-fitting methodologies widely used to determine the term structure of interest rates, as reported by a BIS survey on central bank yield curve methodologies.[1] These include spline-based methods for the discount function, as first proposed by McCulloch,[2] and a parsimonious (parametric) model of forward rates using exponential polynomials developed by Nelson and Siegel and extended by Svensson.[3] Historically, we have preferred the former method as it fits a curve to the data using a set of polynomial segments, ensuring overall curve smoothness and continuity, instead of relying on a single functional form to describe all spot rates. Also, the parametric models suffer from insufficient localization, meaning small changes in front-end yields can cause large jumps in the long end; these models also limit the possible shapes of the resulting fitted curve, as they produce smooth curves that filter out any "kinks," an undesirable trait.

A spline is a piecewise polynomial function, made up of individual polynomial segments that are joined together at what are known as "knot points." It is a common practice to use cubic splines for extracting discount curves from prices of coupon bonds. A cubic spline is a spline constructed of piecewise third-degree polynomials defined by $\boldsymbol{s_i(t) = a_i(t-t_i)^3 + b_i(t-t_i)^2 + c_i(t-t_i) + d_i}$ for $\boldsymbol{t_i \epsilon [t_i, t_{i+1}]}$, where $\boldsymbol{t_i}$ are knot points, $\boldsymbol{n}$ is the number of knots, and $\boldsymbol{i} = 1,2,\ldots,\boldsymbol{n}-1$. At each knot point, the polynomials are restricted so that the level and first two derivatives of each cubic polynomial are identical; in

[1] Bank for International Settlements (2005). "Zero-coupon Yield Curves: Technical Documentation." *BIS Papers 25*, Monetary and Economic Department.
[2] McCulloch, JH (1971). "Measuring the Term Structure of Interest Rates." *The Journal of Business*, **44**(1), 19-31. McCulloch, JH(1975). "The Tax-Adjusted Yield Curve." *The Journal of Finance*, **30**(3), 811-830.
[3] Nelson C, Siegel A (1987). "Parsimonious Modeling of Yield Curves." *The Journal of Business*, **60**(4), 473-489. Svensson LE (1994). "Estimating and Interpreting Forward Interest Rates: Sweden 1992 – 1994." *Technical Reports 4871*, National Bureau of Economic Research, Inc.

other words, at each knot point, the slope and the curvature of the curve on either side must match. Fitting in the discount function space versus zero rate space or forward rate space ensures that we have no local/global convergence issues and that we are therefore confident in our fitted curve, and the estimation is fast with easy statistical computations.

McCulloch defined the discount factors as:

$$\delta(m_{ij},\beta) = 1 + \sum_{l=1}^{n} \beta^l g^l(m_{ij})$$

where m_{ij} represents the time to the *i*-th cash flow for the *j*-th bond, $g^l(m_{ij})(l = 1,\dots,n)$ defines the set of piecewise cubic functions, or "basis functions", and the unknown coefficient vector β can be estimated with ordinary least squares (OLS).

McCulloch defines an *n*-parameter spline with *n* – 1 knot points q_l. McCulloch's approach to knot selection ensured there are approximately an equal number of bonds between adjacent knots and set the number of basis functions, *n*, to the nearest integer to the square root of the number of bonds. We found that for the TIPS universe, this square root approach often led to entire sectors being rich or cheap and, thus, micro relative value became ineffective, if not impossible. After historical analysis of knot selection, we found that nine basis functions (eight knot points) provided the smoothest curve and best highlighted rich/cheap issues. Specifically, there are two external knots at 0y and the longest maturity bond, and six uniformly distributed interior knots (approximately equal number of bonds between each knot).

For $l < n$ the basis function is defined by:

$$g^l(m_{ij}) = \begin{cases} 0, & m_{ij} < q_{l-1} \\ \dfrac{(m_{ij} - q_{l-1})^3}{6(q_l - q_{l-1})}, & q_{l-1} \le m_{ij} < q_l \\ \dfrac{(q_l - q_{l-1})^2}{6} + \dfrac{(q_l - q_{l-1})(m_{ij} - q_l)}{2} + \dfrac{(m_{ij} - q_l)^2}{2} - \dfrac{(m_{ij} - q_l)^3}{6(q_{l+1} - q_l)}, & q_l \le m_{ij} < q_{l+1} \\ (q_{l+1} - q_{l-1})\left[\dfrac{2q_{l+1} - q_l - q_{l-1}}{6} + \dfrac{m_{ij} - q_{l+1}}{2}\right], & q_{l+1} \le m_{ij} \end{cases}$$

For $l = 1$, we set $q_{l-1} = q_l = 0$, and when $l = n$, the basis function becomes $g^l(m_{ij}) = m_{ij}$.

The discounted cash flows can then be compared with the actual prices of the individual bonds, and the unknown coefficient vector β can be approximated using simple OLS, by minimizing square pricing errors between observed and approximated values. With the final discount function determined, it is a trivial procedure to convert discount factors to spot, par, and forward rates. Finally, although TIPS are quoted on a semi-annual yield basis, all computations are done using continuous compounding, as is the usual convention in the literature for such curve fitting exercises, and proves computationally easier.

Unadjusted real yield curve

To produce our TIPS real yield curve, we use the entire universe of TIPS, real yields and clean prices for a given trade date. We have developed our curve fitting routines in the R statistical programming language, using the **termstrc** package and its required dependencies.[4]

First, we make no adjustments for seasonality or floor values; we simply take the raw coupon bond prices and real cash flows as input and build the fitted real yield curve as described above (Figure 1). Note that Barclays Live Chart employs an exponential spline

[4] Ferstl R, Josef H (2010). "Zero-Coupon Yield Curve Estimation with the Package termstrc." *Journal of Statistical Software*, 36.1: 1 - 34.

methodology as described by Vasicek and Fong,[5] but does not fit the data using a derived discount function; it is simply akin to "drawing a line through the points." The two curves in Figure 1, therefore, do not match exactly.

With the fitted curve built, we can then discount the cash flows of each individual bond to derive a new market price. Using this new market price, we then compute a single YTM for comparison to the market-traded YTM. We subtract the two to arrive at a spread to fitted real yield curve (Figure 2); positive values indicate actual yield above fitted yield, ie, the issue appears cheap to our fit. (Note that the curves in Figure 1 are par curves, but it is the originally derived discount factors that we use to produce the new market prices; again, converting from discount factors to spot and par rates is trivial.)

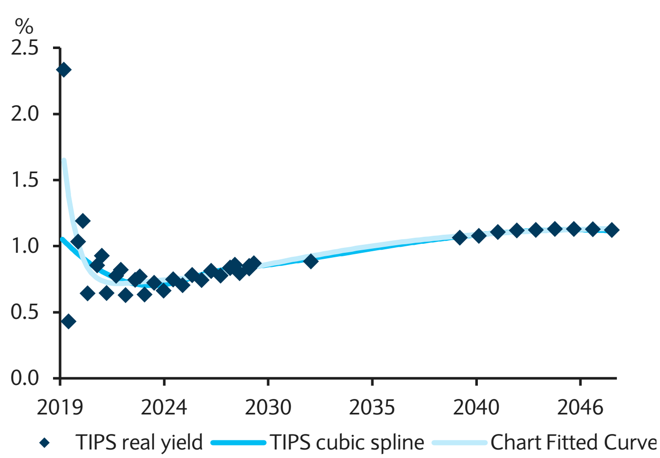
Our *Inflation-Linked Daily* incorporates three relative value metrics across issues, one of which is a 3m z-score versus a TIPS real yield spline. This calculation uses the aforementioned exponential spline methodology. By valuing rich/cheapness using a 3m z-score, we remove any persistent effects from seasonality and/or par floor values. Otherwise, July maturity issues would nearly always appear rich and April maturity issues cheap. We are currently populating the "Spread to Fitted Real Yield Curve" and "Spread to Fitted Real Yield Curve 3M Z Score" series fields in Barclays Live Chart with daily calculations of computed spreads using the more robust cubic spline methodology.

Adjusting the curve for seasonality and the par floor

We also introduce a new fitted spread metric that lends itself to persistent relative value analysis, as it accounts for TIPS-specific technical factors. In particular, to account for the seasonality and floor value effects that are inherent in all TIPS issues, we make adjustments before entering new prices into the curve fitting methodology just described. To adjust for seasonality across issues, we first adjust all real cash flows on a particular date using an index ratio derived from a CPI curve created from zero coupon inflation swaps for the same date. These new nominal cash flows are then discounted at the bond's quoted real yield to arrive at a new nominal price. We then take the same CPI curve and adjust by the latest BLS (2018) seasonality vector (Figure 3). Discounting these new nominal cash flows at the bond's real yield produces a seasonally-adjusted nominal price. Subtracting the two nominal prices from each other and adding this seasonal residual to the bond's real clean price, we get a new seasonally adjusted clean price. We then convert this price to a seasonally adjusted YTM.

FIGURE 1

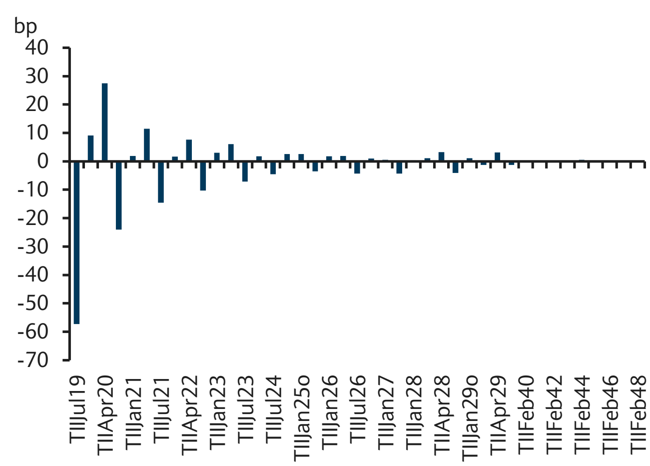
Fitted real yield curve, as of February 11, 2019



Source: Barclays Research

FIGURE 2

Spread to fitted real yield curve, as of February 11, 2019



Source: Barclays Research

[5] Vasicek OA, Fong HG (1982). "Term Structure Modeling Using Exponential Splines." *The Journal of Finance*, **37**(2), 339-348.

FIGURE 3

2018 CPI seasonality vector

Jan-18	99.591
Feb-18	99.848
Mar-18	100.022
Apr-18	100.236
May-18	100.376
Jun-18	100.340
Jul-18	100.163
Aug-18	100.106
Sep-18	100.170
Oct-18	100.036
Nov-18	99.714
Dec-18	99.410

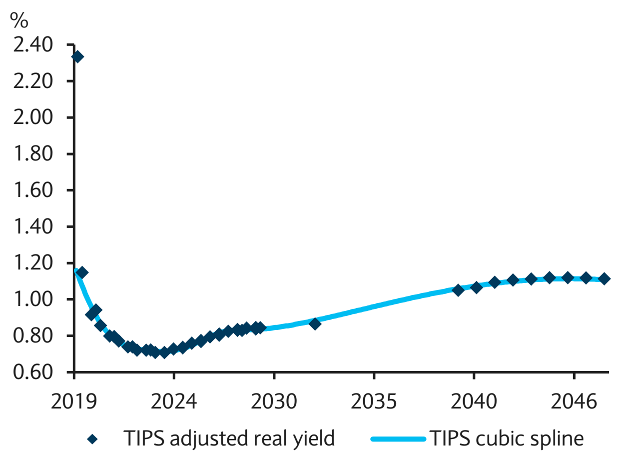
Source: BLS, Barclays Research

From this seasonally adjusted YTM, we add back the par floor value (in yield terms) of each issue to adjust for the exceptional richness of particular issues. In particular, we use a Black log-normal model on the forward index ratio to price floors (see the “Par floors in linkers” chapter of this guide for further details). These option values can be found in Barclays Live Chart. With this final seasonally and floor adjusted real yield in hand, we convert back to a final clean price for each bond. Figure 6 shows all the values of our computation for each step. We run these bonds, with their real cash flows and new prices, through the same curve fitting cubic spline methodology as above to create a new fitted yield curve (Figure 4). As before, we compare the fitted yields with our new computed seasonal and option adjusted real yield to produce a fitted spread for each issue (Figure 5), in order to assess relative value. Again, higher spreads indicate cheaper issues.

We have also back-tested this new spread measure by computing 3m z-scores for comparison to the unadjusted real yield spread 3m z-scores already produced in our daily packet; we found the two show very similar histories. However, unlike the spreads from the unadjusted real curve where July/April issues were perennially “rich/cheap” to the curve,

FIGURE 4

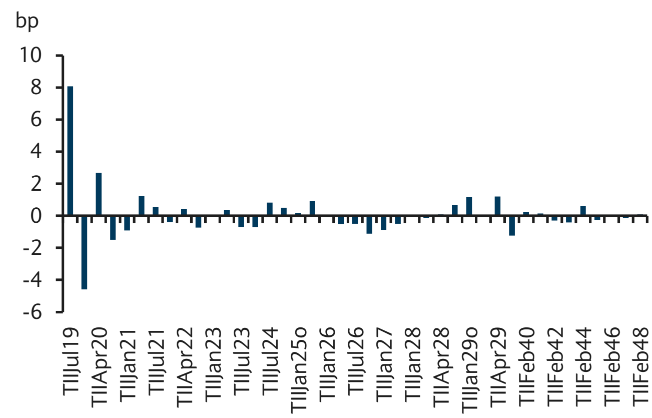
Adjusted fitted real yield curve, as of February 11, 2019



Source: Barclays Research

FIGURE 5

Spread to adjusted fitted real yield curve, as of February 11, 2019



Source: Barclays Research

this new measure now provides a useful absolute level of rich/cheap as we have adjusted for seasonality and optionality. We have also incorporated this measure on Barclays Live Chart as the "Spread to Adjusted Real Yield Curve" field.

FIGURE 6

TIPS real yield curve with adjustments, as of February 11, 2019

Name	Real Yield (%)	Real Price	CPI Projected Nominal Price	CPI Projected Nominal Price w/ Seasonal Vector	Seasonally Adjusted Real Price	Seasonally Adjusted Real Yield (%)	Floor Premium (bp)	Seasonal/ Option Adjusted Yield (%)	Seasonally/ Option Adjusted Price
TII 0.125% Apr19	2.334	99.625	99.670	99.670	99.625	2.334	0.000	2.334	99.625
TII 1.875% Jul19	0.430	100.609	101.569	101.873	100.305	1.148	0.000	1.148	100.305
TII 1.375% Jan20	1.034	100.313	101.725	101.617	100.421	0.916	0.019	0.916	100.421
TII 0.125% Apr20	1.190	98.766	100.158	99.868	99.056	0.938	0.360	0.942	99.051
TII 1.250% Jul20	0.642	100.859	102.280	102.583	100.556	0.856	0.044	0.856	100.555
TII 1.125% Jan21	0.854	100.516	101.931	101.825	100.622	0.798	0.037	0.799	100.621
TII 0.125% Apr21	0.927	98.281	99.666	99.378	98.569	0.791	0.447	0.796	98.560
TII 0.625% Jul21	0.645	99.953	101.361	101.662	99.652	0.770	0.111	0.771	99.650
TII 0.125% Jan22	0.775	98.125	99.507	99.400	98.233	0.737	0.156	0.739	98.228
TII 0.125% Apr22	0.820	97.828	99.207	98.921	98.114	0.728	1.122	0.739	98.079
TII 0.125% Jul22	0.629	98.297	99.682	99.980	97.999	0.718	0.302	0.721	97.989
TII 0.125% Jan23	0.745	97.609	98.986	98.879	97.717	0.716	0.433	0.721	97.700
TII 0.625% Apr23	0.770	99.406	100.805	100.520	99.692	0.700	2.177	0.722	99.603
TII 0.375% Jul23	0.633	98.875	100.269	100.565	98.578	0.702	0.607	0.708	98.552
TII 0.625% Jan24	0.722	99.531	100.934	100.829	99.636	0.700	0.740	0.708	99.600
TII 0.125% Jul24	0.663	97.141	98.510	98.803	96.848	0.719	0.848	0.727	96.804
TII 0.250% Jan25	0.747	97.125	98.494	98.389	97.230	0.729	0.758	0.736	97.187
TII 2.375% Jan25	0.748	109.406	110.945	110.853	109.499	0.733	0.059	0.734	109.495
TII 0.375% Jul25	0.704	97.938	99.318	99.611	97.645	0.751	0.786	0.759	97.596
TII 0.625% Jan26	0.781	98.953	100.348	100.246	99.055	0.765	0.852	0.774	98.998
TII 2.000% Jan26	0.780	108.203	109.726	109.634	108.295	0.767	0.117	0.768	108.287
TII 0.125% Jul26	0.743	95.547	96.893	97.182	95.258	0.784	1.013	0.794	95.187
TII 2.375% Jan27	0.812	111.969	113.545	113.458	112.056	0.801	0.166	0.803	112.042
TII 0.375% Jan27	0.812	96.656	98.018	97.917	96.758	0.798	1.162	0.810	96.670
TII 0.375% Jul27	0.776	96.734	98.097	98.385	96.446	0.812	1.219	0.825	96.349
TII 0.500% Jan28	0.833	97.141	98.509	98.410	97.239	0.822	1.276	0.834	97.131
TII 1.750% Jan28	0.838	107.828	109.345	109.257	107.916	0.828	0.213	0.830	107.897
TII 3.625% Apr28	0.859	124.344	126.087	125.792	124.638	0.829	0.031	0.829	124.635
TII 0.750% Jul28	0.795	99.594	100.996	101.286	99.304	0.827	1.521	0.842	99.167
TII 2.500% Jan29	0.850	115.672	117.299	117.220	115.751	0.842	0.308	0.845	115.719
TII 0.875% Jan29	0.831	100.422	101.836	101.742	100.516	0.821	1.645	0.837	100.360
TII 3.875% Apr29	0.870	129.188	130.999	130.702	129.484	0.844	0.048	0.844	129.479
TII 3.375% Apr32	0.884	130.906	132.743	132.451	131.199	0.864	0.111	0.865	131.183
TII 2.125% Feb40	1.063	119.938	121.624	121.258	120.304	1.046	0.405	1.050	120.219
TII 2.125% Feb41	1.077	120.484	122.179	121.814	120.850	1.060	0.450	1.065	120.752
TII 0.750% Feb42	1.106	92.781	94.088	93.737	93.132	1.088	0.568	1.094	93.021
TII 0.625% Feb43	1.118	89.641	90.903	90.558	89.985	1.101	0.556	1.106	89.875
TII 1.375% Feb44	1.122	105.500	106.985	106.642	105.843	1.107	0.519	1.112	105.726
TII 0.750% Feb45	1.129	91.469	92.756	92.419	91.806	1.114	0.547	1.119	91.688
TII 1.000% Feb46	1.129	97.000	98.365	98.029	97.337	1.114	0.499	1.119	97.222
TII 0.875% Feb47	1.127	93.953	95.276	94.944	94.285	1.113	0.513	1.118	94.166
TII 1.000% Feb48	1.121	97.000	98.366	98.039	97.327	1.108	0.531	1.113	97.197

Source: Barclays Research

INFLATION PRODUCTS

Building a market-implied BE and CPI swaps curve

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We review a market-implied breakeven curve framework with the addition of seasonal paths, floors, and proceeds ASWs adjustments. With it, we can value inflation-linked cash flows on a mark-to-market basis and provide a reference for forward inflation expectations.

We discuss how to build a market-implied CPI NSA or inflation curve to value cash flows or back out a constant-maturity forward, such as a 5y5y forward breakeven rate. As of February 12, 2019, our basic framework yielded a forward 5y5y breakeven value of 1.84%, very close to the bootstrapped bonds measure of 1.87%. The framework adds seasonality between TIPS issues and adjusts for deflation floor premiums. One can take a similar approach to building a zero-coupon CPI swap curve by adjusting the aforementioned BE-based curve with the relative proceeds ASWs at the common nodes. Such a curve can be used to mark to market a payer/receiver CPI swap position daily.

Constructing an inflation curve

As of February 2019, there were 42 TIPS bonds outstanding in the market; combining each one with its nominal comparators (nominal yield-real yield) gives a measure of inflation expectations to the lagged (two to three months) maturity of the bond. We then subtract deflation floor premiums to adjust for the exceptional richness of these issues. We use the inflation derivatives market-based floor valuations (available on Barclays Live Chart). Figure 1 shows outright and adjusted breakeven levels for each issue and projected CPI NSA levels (based on adjusted BEIs) to maturity (years) as of the settle date of February 13, 2019 (Ref CPI NSA: 251.6930). It also shows projected CPI NSA prints based on the floor and proceeds-ASWs-adjusted BE curve (essentially replicating a CPI swaps curve). A trader can synthetically replicate a CPI swaps position by being long BEs using TIPS versus nominal proceeds ASWs, in which case, he is paying the funding differential between TIPS and nominals on top of the BE position (see equations below for these positions). Theoretically, to replicate a CPI swaps position, one should use z-spread ASWs, as they would properly account for the duration difference between TIPS and nominals. In practice, z-spread ASWs are not traded, so proceeds ASWs are used in the calculation of a market-implied CPI swaps curve.

Floor-Adjusted BE = Long TIPS + Short Comparator Nominal + Short TIPS Floor

Replicated CPI Swaps = Floor-Adjusted BE + TIPS Proceeds ASWs – Nominal Proceeds ASWs

Future CPI NSA = Spot Reference CPI NSA * (1 + Adjusted_BEI/2)^(2*Maturity)

We have quite a few pairs of bonds that are one year apart, but we do not have exact market-implied monthly CPI NSA prints between two end points. We can use the forward rate between the two bonds to project these. Although we know that inflation does not grow at a constant forward rate, there are clear seasonal patterns. Inflation prints in the first half of the year tend to be better than in the second (Figure 2). In the next section, we use the 2018 seasonality pattern as a guide to project a CPI NSA path between two bonds' lagged maturity dates.

FIGURE 1

Market-implied CPI NSA levels adjusted for deflation floors and relative ASWs, as of February 12, 2019

Bond Issue	Mid-maturity CPI prints	BE (%)	Floor Value (bp)	Floor Adjusted BE (%)	TIPS-Nominal Rel ASW (bp)	Floor and Rel ASW adjusted BE (%)	Floor adjusted BE forward NSA CPI	Floor and Rel ASW adjusted BE forward NSA CPI
TIIApr19	Jan-19 - Feb-19	0.32	0.00	0.32	10.98	0.43	251.83	251.88
TIIJul19	Apr-19 - May-19	2.14	0.00	2.14	23.39	2.37	253.93	254.18
TIIJan20	Oct-19 - Nov-19	1.53	0.02	1.53	13.49	1.66	255.24	255.56
TIIApr20	Jan-20 - Feb-20	1.38	0.36	1.37	17.24	1.54	255.75	256.26
TIIJul20	Apr-20 - May-20	1.92	0.04	1.92	13.68	2.05	258.60	259.09
TIIJan21	Oct-20 - Nov-20	1.68	0.04	1.68	15.47	1.83	259.90	260.67
TIIApr21	Jan-21 - Feb-21	1.59	0.44	1.59	15.81	1.74	260.47	261.36
TIIJul21	Apr-21 - May-21	1.87	0.11	1.87	14.75	2.02	263.29	264.23
TIIJan22	Oct-21 - Nov-21	1.72	0.15	1.72	16.07	1.88	264.64	265.87
TIIApr22	Jan-22 - Feb-22	1.68	1.11	1.67	16.76	1.83	265.28	266.69
TIIJul22	Apr-22 - May-22	1.87	0.30	1.87	15.37	2.02	268.21	269.61
TIIJan23	Oct-22 - Nov-22	1.76	0.43	1.76	17.15	1.93	269.61	271.41
TIIApr23	Jan-23 - Feb-23	1.74	2.14	1.71	18.12	1.89	270.25	272.29
TIIJul23	Apr-23 - May-23	1.87	0.60	1.87	17.18	2.04	273.24	275.30
TIIJan24	Oct-23 - Nov-23	1.79	0.73	1.78	18.82	1.97	274.70	277.24
TIIJul24	Apr-24 - May-24	1.88	0.84	1.87	18.30	2.06	278.48	281.23
TIIJan25	Oct-24 - Nov-24	1.82	0.75	1.81	19.03	2.00	280.09	283.24
TIIJan25o	Oct-24 - Nov-24	1.81	0.06	1.81	17.92	1.99	280.11	283.07
TIIJul25	Apr-25 - May-25	1.87	0.78	1.87	19.70	2.06	283.59	287.16
TIIJan26	Oct-25 - Nov-25	1.81	0.84	1.80	21.31	2.02	285.01	289.21
TIIJan26o	Oct-25 - Nov-25	1.81	0.12	1.81	19.79	2.01	285.13	289.03
TIIJul26	Apr-26 - May-26	1.87	1.00	1.86	22.25	2.08	288.70	293.46
TIIJan27o	Oct-26 - Nov-26	1.81	0.16	1.81	21.39	2.02	290.33	295.25
TIIJan27	Oct-26 - Nov-26	1.81	1.15	1.80	23.89	2.04	290.09	295.58
TIIJul27	Apr-27 - May-27	1.87	1.20	1.85	24.03	2.09	294.00	299.95
TIIJan28	Oct-27 - Nov-27	1.82	1.26	1.81	24.93	2.06	295.61	302.20
TIIJan28o	Oct-27 - Nov-27	1.82	0.21	1.82	23.14	2.05	295.79	301.91
TIIApr28	Jan-28 - Feb-28	1.80	0.03	1.80	21.09	2.02	296.79	302.54
TIIJul28	Apr-28 - May-28	1.87	1.50	1.86	24.87	2.11	299.66	306.70
TIIJan29o	Oct-28 - Nov-28	1.82	0.30	1.82	25.43	2.07	301.31	308.94
TIIJan29	Oct-28 - Nov-28	1.84	1.63	1.82	26.63	2.09	301.44	309.44
TIIApr29	Jan-29 - Feb-29	1.80	0.05	1.80	23.96	2.04	302.11	309.49
TIIApr32	Jan-32 - Feb-32	1.84	0.11	1.84	22.73	2.06	320.28	329.92
TIIFeb40	Nov-39 - Dec-39	1.83	0.40	1.83	30.01	2.13	368.74	392.51
TIIFeb41	Nov-40 - Dec-40	1.85	0.45	1.84	28.56	2.13	376.93	401.15
TIIFeb42	Nov-41 - Dec-41	1.86	0.56	1.85	31.27	2.16	384.63	413.05
TIIFeb43	Nov-42 - Dec-42	1.86	0.55	1.86	31.43	2.17	392.55	423.02
TIIFeb44	Nov-43 - Dec-43	1.86	0.51	1.86	30.36	2.16	399.81	431.03
TIIFeb45	Nov-44 - Dec-44	1.87	0.54	1.87	31.78	2.18	408.05	442.87
TIIFeb46	Nov-45 - Dec-45	1.88	0.49	1.87	31.15	2.18	416.27	452.44
TIIFeb47	Nov-46 - Dec-46	1.87	0.51	1.86	32.36	2.19	423.15	462.91
TIIFeb48	Nov-47 - Dec-47	1.89	0.52	1.89	30.22	2.19	433.93	473.30

Source: Barclays Research

Generating market-implied CPI prints using assumed m/m seasonality

Inflation prints in the first half of the year tend to be better than in the second

We used the difference between 2018 m/m percentage change CPI NSA and CPI SA series as a pattern for future seasonal changes. These assumptions can be changed; 2018 seasonals are used merely as an example. The sum of the seasonal factors over the year is zero, so there is no net effect on a y/y basis. We used the functional form in Figure 3 (with the assumption of constant seasonality over the month) to bring forth seasonality in a CPI NSA path.

Example

Using Jul20 and Jul21, we get an implied forward breakeven rate of 1.80% between lagged maturities of April-May 2020 and April-May 2021. The projected maturity CPI NSA for Jul20 is 258.5973; for Jul21, it is 263.2929. Using the functional form shown in Figure 3, we calculate the CPI NSA path for May-June 2020. April-May to May-June seasonality is +0.66% (annualized).

CPI (May-June 2020) = CPI (April-May 2020) * exp (((1/12)* (1.80% + 0.66%))

= 258.5973 * exp ((1/12)* (1.80% + 0.66%)) = 259.1279

For the June-July 2020 CPI NSA print, we use the cumulative annualized seasonality from April-May to June-July to project forward.

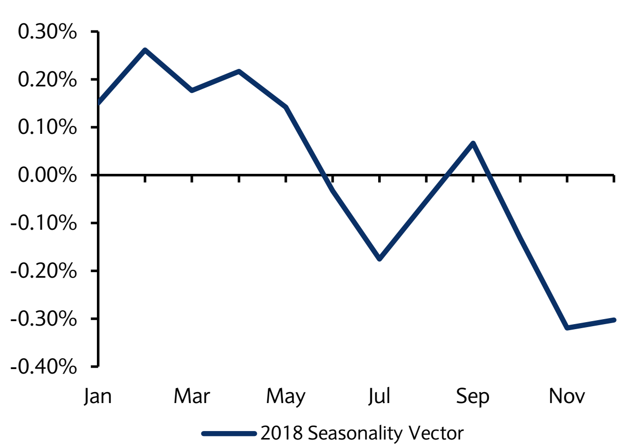
In practice, the Jul20-Jul21 and Apr20-Apr21 issues imply an overlapping, but possibly different, CPI NSA path. Another caveat is that all of the TIPS issues mature at the middle of any given month, so when creating true seasonals, one should take the average of two monthly seasonals. For the July maturity, one can take the average of the March-April (NSA-SA) and April-May (NSA-SA) m/m seasonality prints.

Resulting curve

Using these market and 2018 seasonality-implied CPI NSA expectations paths, we created an annualized (floor adjusted) market-implied breakeven curve and a CPI swap curve (Figure 4). We compare these curves with the market-traded CPI swaps curve. The m/m breakeven curve shows a clear seasonal pattern. Also, as one would expect, the market-implied breakeven curve trades below the market-implied CPI swap curve. This differential exists because the CPI swap curve has embedded funding costs (TIPS ASWs minus nominal ASWs). The market-implied CPI swaps curve lines up with the traded CPI swaps curve. At the longer end, the traded CPI swap curve is cheaper than the implied CPI swap curve, likely because of the convexity adjustment at the longer end. Also, given the scarcity of issues at the longer end, it is difficult to estimate starting forward breakeven rates.

FIGURE 2

M/m CPI NSA – m/m CPI SA, 2018 CPI seasonality



Source: BLS, Barclays Research

FIGURE 3

Functional seasonality form

CPI(0,Ti) = CPI(0,Ti-1)* exp ((Ti-Ti-1)*(fi + si))

i = 2….360, time frame between any two CPI NSA projections

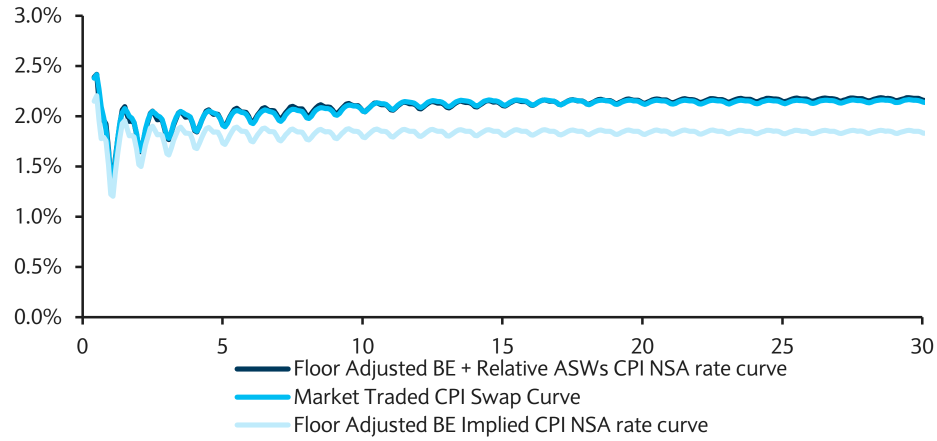
f = Annualized Forward Rate between two CPI NSA paths,

s = Cumulative annualized seasonality between two time frames.

Source: Barclays Research

FIGURE 4

Market-implied breakeven and CPI swap curves versus the traded CPI swap curve as of February 12, 2019



Source: Barclays Research

INFLATION PRODUCTS

Real yield and breakeven fair value models

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10y TIPS breakeven (monthly) model

We use 10y BE fair-value models as a starting point to assess level/value in breakevens. Specifically, we use factors such as growth, market-anticipated Fed reaction function and gasoline moves to assess 10y BE levels relative to history. We then try to develop a forward-looking 10y BE view based on our growth and inflation forecasts in the context of the current FOMC reaction function. We also think it is important to have a view on the volatility of model residuals (although they are mean-reverting) based on other factors to determine whether it is worth taking a market position. This latter revision is a function of learning from the 2008 financial crisis, when model residuals became volatile and indicated 10y BE drivers other than economic fundamental factors.

Prior to the 2008 financial crisis, we had relied on a relatively parsimonious three-factor model for 10y TIPS breakeven fair value (fed funds slope, global ISM and gasoline prices; Figure 1). However, as bank balance sheets and the liquidity constraints of TIPS versus nominals came to the fore in 2008, this model proved relatively unstable because it failed to capture the relative liquidity factor between TIPS and nominals during a crisis.

FIGURE 1

10y US BE model factors (w/o liquidity factor), Jan98 – June08

	Coefficient	t-stat	R^2
Fed Funds Slope	0.31	8.39	0.82
Global Industrial Confidence (1m lag)	0.19	4.70	
Gasoline (log)	0.87	16.97	
Constant	1.51	46.80	
Period	Jan 1998 - June 2008		

Source: Bloomberg, Barclays Research

This model is fine as a stand-alone starting point for fair-value assessment, but during a banking crisis, cash needs and risk tolerance become acute as banks try to shore up their balance sheets with very liquid assets (e.g., cash, cash-equivalents, bills) to meet demand from their liabilities and counterparties. In such events, fundamental valuations can diverge sharply from traded valuations as market participants seek the safety of the most liquid assets as risk aversion rises. While TIPS have the same credit quality as nominal Treasuries, they are less liquid, so suffer on a relative basis during flights to liquidity.

Even as central banks step in to provide liquidity, investors' behaviour can remain risk averse for some time, as they closely assess each bank's ability to honour daily settlements, given higher anticipated asset price volatility. Thus, risk aversion is slow to dissipate. In recognition of this factor, in 2009 we introduced a liquidity measure in our breakeven model in the form of on/off-the-run Tsy spread, which would capture acute cash needs. We have since switched to using the L-OIS spread to better capture liquidity constraints, as the Fed's QE has eliminated the use of Tsy on/off-the-run spread as an explanatory liquidity variable.

Figure 3 shows that the L-OIS-added 10y BE model (Liquidity Model) explained 70bp of additional divergence versus the 10y BE market value during the 2008 crisis. The t-stat on this variable is also significant (Figure 2). The one caveat is that in this liquidity-based model, we used a longer period to back out the coefficients with respect to each time series. Specifically, the period we used in the liquidity-based 10y BE Model is January 1998-May 2010, while the fundamental breakeven model used January 1998-June 2008. We used a longer period for the liquidity-based model to assess the coefficient on the liquidity factor. On average, the liquidity factor shows that a 10bp rise in L-OIS leads to compression of about 5bp in 10y breakevens. The effect here makes sense, as higher risk-aversion should mean lower liquidity in TIPS relative to nominals, i.e., artificial compression of breakevens relative to fair value.

FIGURE 2

10y US BE model factors (with liquidity factor), Jan98 – May10

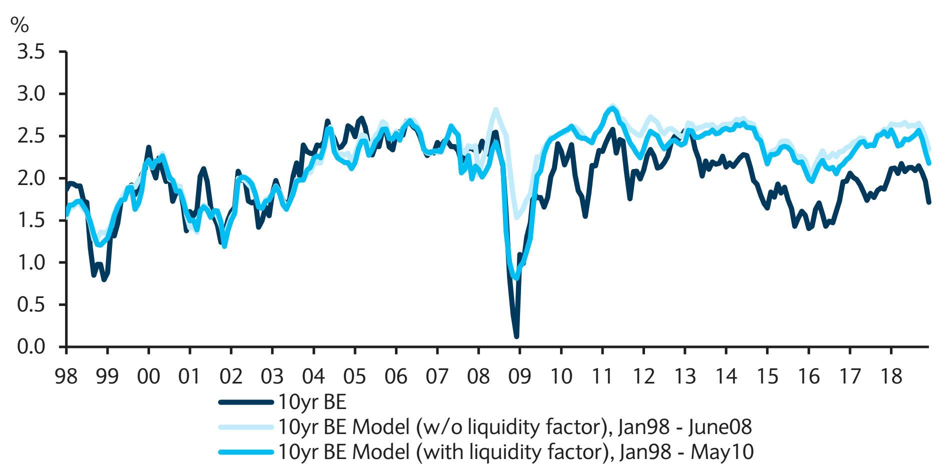
	Coefficient	t-stat	R^2
L-OIS	-0.47	-7.54	0.80
Fed Funds Slope	0.33	7.63	
Global Industrial Confidence (1m lag)	0.27	8.59	
Gasoline (log)	0.79	14.17	
Constant	1.61	42.92	
Period	Jan 1998 - May 2010		

Source: Bloomberg, Barclays Research

More recently, however, the model has failed to capture recent declines in 10y breakevens. Specifically, starting at the end of 2014, the Liquidity Model has diverged notably from actual breakeven levels (Figure 3). To quantify and analyze this likely regime change, we show two additional time frames for the Liquidity Model, in Figures 4 and 5. The first runs from January 1998 to December 2014, and the latter from January 2015 to December 2018. We first note that, while the pre-2015 model shows a constant of 1.66, the post-2015 model has a constant of 0.83. As rates and inflation have been particularly low the past four years, this lower starting level makes sense, and is also largely associated with decreased Fed credibility over the latter time period. As the Fed has proved unsuccessful in stoking inflation from below, breakeven rates have been stuck at low levels. Second, on a similar note, while the fed funds slope coefficient is largely unchanged, its significance drops in the more recent time period (t-stat = 1.77). With rates so low and the Fed unable to raise inflation, the fed funds slope has been less important for explaining breakevens. Last, over the past few years, liquidity events have been less common, funding markets have been healthy (and improving), and balance sheet constraints are loosening. As such, the L-OIS coefficient remains little changed from the previous time period, but the t-stat (1.05) is now insignificant. This illustrates that the liquidity factor “does not matter, until it does.” With no

FIGURE 3

Unlike during the 2008 financial crisis, the L-OIS vol measure does not capture recent liquidity-based declines in 10y breakevens



Source: Bloomberg, Barclays Research

liquidity events during the period, the usefulness of this variable has diminished. A model of the entire 1998-2018 period would fail to capture this regime change, so we find it most useful to break the data into these two different time periods. With the market unconvinced in the Fed's ability to raise inflation despite tight labour markets and raising wages, bullish moves in breakevens have been contained, resulting in a new lower constant and less significance of the fed funds slope (i.e., policy stance). Finally, the global ISM and gasoline variables continue to play significant roles in the model, as expected.

FIGURE 4

10y US BE model factors (with liquidity factor), Jan98 – Dec14

	Coefficient	t-stat	R^2
L-OIS	-0.37	-5.82	0.70
Fed Funds Slope	0.33	7.01	
Global Industrial Confidence (1m lag)	0.27	8.43	
Gasoline (Log)	0.57	13.24	
Constant	1.66	42.65	
Period	Jan 1998 - Dec 2014		

Source: Bloomberg, Barclays Research

FIGURE 5

10y US BE model factors (with liquidity factor), Jan15 – Dec18

	Coefficient	t-stat	R^2
L-OIS	0.15	1.05	0.76
Fed Funds Slope	0.36	1.77	
Global Industrial Confidence (1m lag)	0.28	3.83	
Gasoline (Log)	0.89	4.74	
Constant	0.83	5.01	
Period	Jan 2015 - Dec 2018		

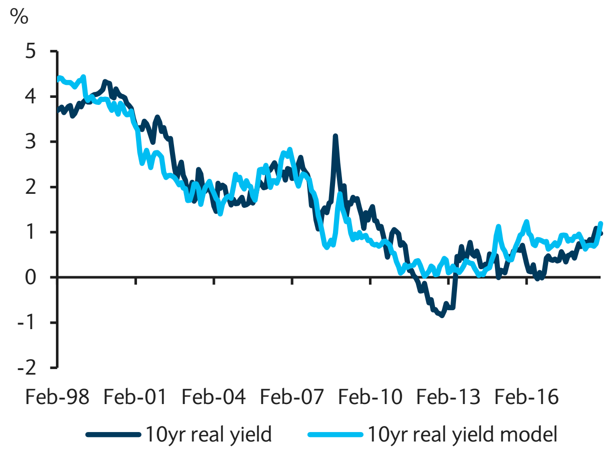
Source: Bloomberg, Barclays Research

10y TIPS real yield (monthly) model

We retain our broad model specification from the previous edition of this guide, but have re-estimated the model coefficients to the end of 2018. The fed funds rate logically remains the most significant driver of the level of real yields, with the slope of the fed funds futures curve accounting for expectations of future rate moves. Similar to our 10y breakeven model, the slope has become less important given the low level of rates and weakening Fed credibility. We continue to find a strong negative correlation between real yields and gasoline futures, which is consistent with the high pass-through from energy prices into CPI and the consequent influence on carry. There historically has been a positive correlation between the level of real yields and the dollar, but in the more recent environment of weak global growth, the safe haven status of Treasuries and reserve status of the dollar has resulted in yield rallies coinciding with dollar appreciation (and the now negative coefficient). The business loan growth factor has become a less significant structural driver of real yields as rates remain lower than justified by the strong domestic economy of the past few years. We retain a one-year lag for this variable in the model.

FIGURE 6

10y TIPS real yield model



Source: Bloomberg, Barclays Research

FIGURE 7

10y US real yield model coefficients and summary statistics

	Coefficient	t-stat	R^2
Change in nonfinancial business lending (1y lag)	0.00	0.51	0.86
Gasoline (log)	-2.32	-16.72	
Fed Funds Slope	0.12	1.32	
Fed Funds	0.32	16.77	
Trade Weighted Dollar	-0.03	-5.29	
Constant	5.65	9.07	
Period	Jan 1998 - Dec 2018		

Source: Bloomberg, Barclays Research

Daily TIPS regression models

With central bank policy around the globe remaining accommodative, the possibility of a rates regime shift has come to the forefront of investors' minds, as mentioned above for the case of the US. As such, we have augmented our existing monthly regression models with daily models, making a few variable adjustments in the process. Specifically, we introduce three new models, for the 10y breakeven, 10y real yield, and 10s30s breakeven curve, using daily data from the previous eight years. We find updating a few variables from our monthly models appropriate as the explanatory power of some previous variables has weakened for both technical and fundamental reasons, and daily data is simply not always reliable or available for some variables. These models are also presented in our *Inflation-Linked Daily*.

10y breakeven model

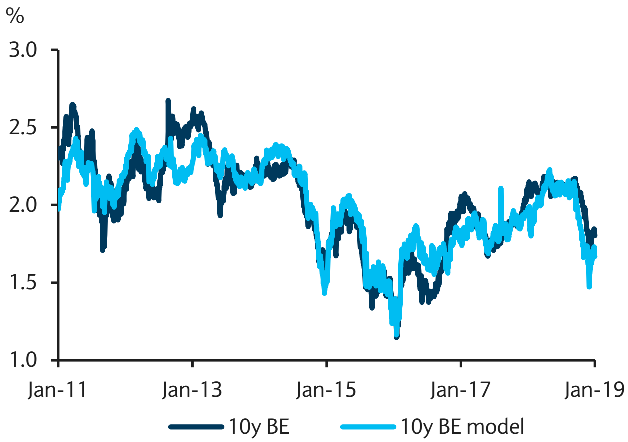
The monthly 10y breakeven model, above, is a four-factor model that uses the fed funds slope, Barclays' Global Manufacturing Confidence index, gasoline prices (log values), and Libor-OIS to explain the level of 10y breakevens. In developing our daily model, we made a few variable adjustments. First, we swapped the fed funds slope with the 3m10y Treasury yield slope because daily volumes in fed funds futures are quite low and we find closing prices often sporadically available (particularly in the front month contract). Also, and more important, as the Fed has been constrained by the zero lower bound on rates in the past decade, the fed funds slope, and the level of fed funds in general, has become a less powerful predictor of rates in several markets. The 3m10y slope, a notable predictor of recessions, proves more robust over time in helping to explain the level of inflation and breakevens, by extension.

Next, we have replaced Libor-OIS as a market stress indicator with the VIX. The former has been affected by a few technical episodes of late – notably, the money market mutual fund reform of late 2016 and debt ceiling debates over the past few years – that have caused the spread to widen during otherwise calm markets. We find the VIX index a purer form of market volatility.

Last, we have maintained the gasoline component of the monthly model, simply using daily prices instead. We have dropped the Global Manufacturing Confidence index because only monthly data is available. We have added the broad trade-weighted dollar, which we already have in our monthly 10y real rate model, as breakevens have historically been highly

FIGURE 8

10y breakeven model



Source: Bloomberg, Barclays Research

FIGURE 9

10y breakeven model coefficients and summary statistics

	Coefficient	t-stat	R^2
3m10y Slope (%)	-0.039	-6.01	0.80
Gasoline (log)	1.062	47.77	
VIX	-0.006	-9.90	
Trade Weighted Dollar	0.005	7.28	
Seasonal (dummy)	0.051	7.90	
Constant	0.758	6.94	
Period (daily)	1/24/11 – 1/24/19		

Source: Bloomberg, Barclays Research

(inversely) correlated with the dollar; as the dollar rallies, inflation expectations decline and breakevens sell off. Finally, we have added a new dummy variable that captures the historically high return of breakevens during positive carry months. Specifically, we donate a '1' value when we are in February to May, and '0' otherwise.

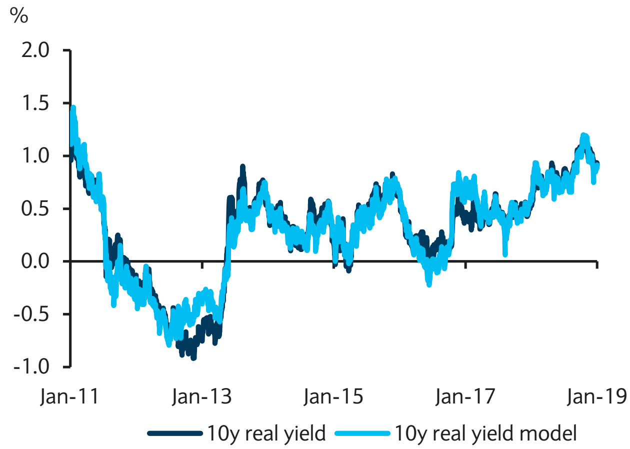
Taking the variable coefficients (Figure 9) in turn, we make a few observations. While historically, the 3m10y slope had a positive coefficient, suggesting that a steeper curve meant higher breakevens, the coefficient recently has turned negative. This likely reflects the fact that a steepening curve has been led by the front end as the market prices out the hiking cycle and prices in possible recession risk. In this respect, a steepening curve suggests weak growth and low inflation, leading to declining 10y breakevens, and hence the negative coefficient. Gasoline and the VIX coefficients follow intuitively, as higher gasoline and a lower VIX (less volatility in markets) should drive breakevens to rally. The positive coefficient on the dollar follows from a similar argument to the negative coefficient on the dollar in our monthly 10y real yield model above. Despite the historically negative coefficient in the breakeven model (as dollar appreciation meant lower breakevens), the demand for Treasuries and the Fed's policy of keeping rates very low have led the dollar and inflation expectations to break from the historical trend. Thus, as the dollar appreciates, breakevens have rallied as real yields have rallied on safe haven demand.

10y real yield model

Turning to our 10y real yield model, we again make a few adjustments to our monthly regression above. That model uses five factors: changes in nonfinancial business lending (1y lag), gasoline (log values), fed funds slope, fed funds itself, and the trade-weighted dollar. In our daily model, we first drop the business lending indicator, as it is not a daily series. We maintain gasoline prices and the trade-weighted dollar. For similar reasons to our new 10y breakeven model, we swap the fed funds slope for the 3m10y Treasury curve slope. Finally, we replace fed funds with the 10y nominal yield; again, in the same vein as the fed funds slope adjustment, namely, the reliability of daily data (including distortions over month- and quarter-ends) and the predictive power of the short rate being diminished by recent monetary policy, both domestically and abroad.

Figures 10 and 11 present the output of this new model. The coefficients again make sense. First, as the Treasury curve steepens, 10y real rates should sell off in turn. The negative correlation between real rates and gasoline is consistent with the high pass-through from

FIGURE 10
10y real yield model



Source: Bloomberg, Barclays Research

FIGURE 11
10y real yield model coefficients and summary statistics

	Coefficient	t-stat	R^2
3m10y Slope (%)	0.091	12.86	0.93
Gasoline (log)	-0.854	-36.10	
10y Treasury (%)	0.841	108.98	
Trade Weighted Dollar	0.002	2.41	
Constant	-1.407	-13.41	
Period (daily)	01/24/11-01/24/19		

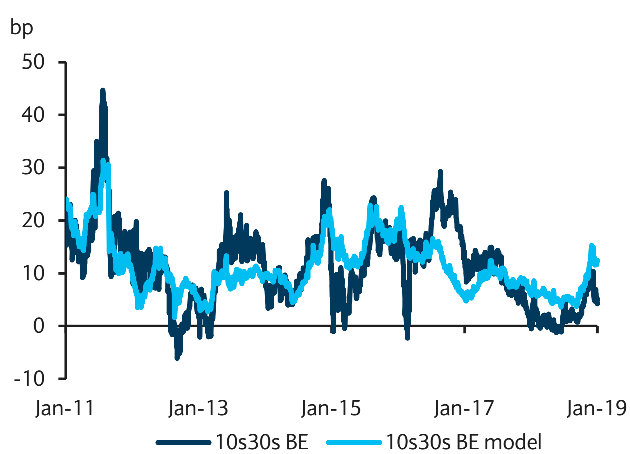
Source: Bloomberg, Barclays Research

gasoline to CPI and its resulting influence on real yield carry. Higher nominal Treasury yields naturally lead to higher real yields, though the high coefficient needs to be evaluated in light of the large negative constant in the model. Last, the coefficient on the trade weighted dollar is positive, a reversal from our monthly real yield model. However, the t-stat is quite low, so we conclude that given the newer time frame and recent Fed policy influence on both rates and the dollar, the dollar adds little predictive power to the level of real yields more recently. The high R2 (0.93) of the model confirms its predictive power.

10s30s breakeven curve model

Last, we present our daily model for the 10s30s breakeven curve. The model uses four factors to explain the curve: the 5y zero coupon inflation swap (ZCIS) rate, the 2s10s ZCIS curve, the VIX, and a dummy variable indicating the start of Operation Twist (i.e., set to '1' in mid-September 2011). The last variable accounts for the Fed's influence on the breakeven curve since the initiation of Operation Twist, which has greatly affected rate and curve levels.

FIGURE 12
10s30s breakeven curve model



Source: Bloomberg, Barclays Research

FIGURE 13
10s30s BE curve model coefficients and summary statistics

	Coefficient	t-stat	R^2
5y ZCIS (%)	-13.457	-31.21	0.49
2s10s ZCIS slope (bp)	0.046	10.21	
VIX	0.053	2.08	
Twist (dummy)	-14.808	-30.33	
Constant	49.276	37.54	
Period (daily)	01/24/11-01/24/19		

Source: Bloomberg, Barclays Research

Turning to the outputs (Figure 13), we look at the coefficients produced. On higher 5y inflation swap rates, we would expect the back end of the breakeven curve to flatten; the high negative coefficient confirms this observation. The 2s10s curve coefficient, though small, also makes sense, as a steeper short-end curve should lead to a steeper long-end curve. A higher VIX should indicate near-term risk aversion, potentially weaker growth and lower inflation in the belly (versus the back end), steepening the curve on higher market volatility. Last, the large negative coefficient on the Twist dummy variable confirms the idea that the Fed has greatly influenced the shape of the curve (flattening it substantially) over the past 6+ years. This is also noticeable in Figure 12, as the curve shifted down substantially starting at the end of 2011 and has stayed at a lower level since then.

We think these daily regression models complement our monthly models nicely and add to our arsenal of strategic and tactical valuation tools. Combining signals from our monthly and daily models, along with other relative value metrics, adds to our conviction on trade ideas and market calls in the US.

10y euro breakeven model

Modelling euro area breakevens is not straightforward, especially with a model spanning the euro area debt crisis, as each component of the multi-issuer market (French, German and Italian) has been influenced by specific factors. The tricky part is that some of those factors are relevant only during specific periods and are difficult to capture quantitatively. Obvious examples are the effect of the ECB's SMP or the run-up to the exclusion of BTP€is from the main Bloomberg Barclays indices. We use the 10y constant-maturity OAT€i breakeven data, the longest series on Barclays Live. We have adopted a top-down approach, initially considering a wide range of economic and financial market data as independent variables in the model. Our aim was to isolate three factors to capture what we believe are the main structural drivers of breakevens: perceptions of upcoming price pressures, market expectations about the economy, and general (not market-related) confidence regarding the broad macro backdrop. After several tests, we retained the following variables:

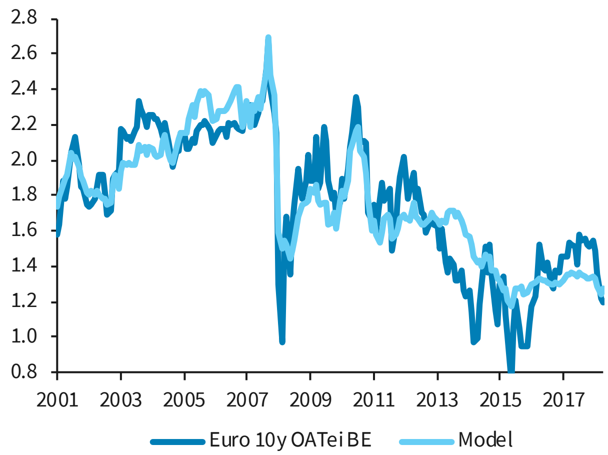
1. **TR/CoreCommodities CRB Commodity Index**: This captures price pressures from a wide range of commodities. Unlike for US breakevens, where gasoline prices stand out as the obvious driver of valuations from the commodities sphere, euro breakevens seem more sensitive to an overall commodity index. In addition, the TR/CC CRB Commodity Index does a better job than the Euro HICPx index in the model, indicating that the market reacts more to potential upcoming price pressures than to past data.

2. **The 1y1y Eonia swap rate:** This is generally linked to interest rate policy expectations in real time. Therefore, the 1y1y swap indirectly reacts to the broad market's varying assessment of improving/deteriorating macro or financial conditions, as those will affect monetary policy. Perhaps counter-intuitively, the coefficient for the euro 1y1y swap rate is positive, meaning that higher breakevens are consistent with tighter monetary policy. This reflects the fact that, at least theoretically, higher interest rates are associated with higher inflation. Also, factors that would push the 1y1y swap rates higher are typically hawkish and therefore either inflationary or, at least, "breakeven friendly."

3. **ZEW 6m ahead euro area macroeconomic expectations:** We see this as a key indicator of confidence in the euro area, with a positive correlation to euro breakevens. It is more useful within the model during the pre-crisis period. Its relevance fades slightly post-crisis. In previous models, we had used a global growth variable, but euro area breakevens have increasingly been much more focused on euro area macroeconomic prospects than the global environment.

FIGURE 14

10y euro (OAT€i) breakeven model



Source: Bloomberg, Haver Analytics, Barclays Research

FIGURE 15

10y euro BE model coefficients and summary statistics

	Coefficient	t-stat		Model Stats
3m Euribor – Eonia Spread	-0.21	-3.9	R^2	0.80
Core Commodity/CRB Index	0.0029	13.5		
ZEW 6m ahead expectations	0.00042	0.9		
1y1y forward Eonia	0.15	18.9		
Constant	0.81	14.3		

Model: October 2001 – December 2018

Source: Barclays Research

4. **Euribor-Eonia spread.** Overall, the three-factor model worked fine as a stand-alone fair value model before the 2007-08 crisis, but the market environment has changed significantly since then. Liquidity has become a key driver as market participants seek the safety of the most liquid assets as risk aversion rises; the sovereign debt crisis in Europe has extended these concerns. Therefore, we include the Euribor-OIS 3m spread to capture liquidity constraints better. The Euribor-OIS 3m spread incorporates market liquidity conditions in the model. It captures the severe liquidity constraints during the 2007-08 crisis and in 2011-12, when European banks came under pressure because of concerns about their solvency. The negative correlation with breakevens can be interpreted in two ways: 1) a higher Euribor-OIS 3m spread is associated with risk-off moves and, therefore, lower breakevens or 2) liquidity constraints mean that balance sheets need to be shored up, which is negative for linkers compared with nominals.

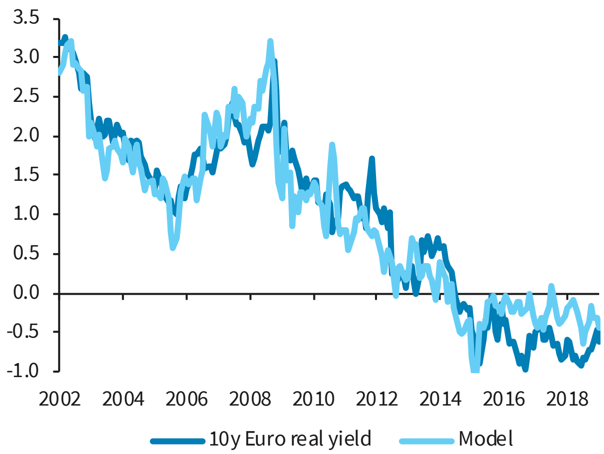
The European sovereign crisis has brought with it many changes in the structure of the market, which means that although fair value models can be useful for a broad assessment of valuations, they fail to capture the increased volatility. As we pointed out earlier, risk-on/risk-off episodes are now more relevant for breakevens. However, the magnitude of breakevens' reaction to those episodes is variable. As a result, the inclusion of variables that reflect the tone in risky markets is not a panacea. For instance, the Euribor-OIS 3m spread was able to capture concerns driven by speculation about the exit of Greece from the euro area and the effect on breakevens. On the other hand, the cheapening of the peripheral spread later on and President Draghi's "whatever it takes" speech in 2012 seem to have had an effect on breakevens that was not sufficiently captured by the Euribor-OIS 3m spread within the model.

10y euro real yield model

Euro real yields suffer even more from country-related distortions than breakevens, which makes constructing a viable fundamental fair value model somewhat challenging. The European sovereign debt crisis resulted in a significant widening of individual country yield spreads versus Germany since April 2010, with these spreads often volatile. Although France has been less affected than the periphery, French inflation-linked bonds suffered from the broad dislocations sweeping through markets in the last quarter of 2011, although they have subsequently tightened markedly relative to bunds. We use OAT€i linkers as the basis for our model because they have the longest and best-defined curve history of any of the European inflation issuers. Prior to the start of the European dislocation in April 2010, the element of sovereign risk was a relatively minor driver of valuations of French real yields.

FIGURE 16

10y euro (OAT€i) real yield model



Source: Bloomberg, Barclays Research

FIGURE 17

10y EUR real yield model coefficients and summary statistics

	Coefficient	t-stat		Model Stats
M3 3m change (1m lag)	-0.51	-12.8	R^2	0.87
ECB refi rate	0.92	34.0		
Brent crude (log)	-0.51	-7.9		
Constant	2.4	8.3		

Model: January 2002 – December 2018

Source: Barclays Research

More recently, while French yields have been more stable than peripheral Europe, France has nonetheless proved susceptible to contagion in periods of severe stress.

We retain the same specification for our euro real yield model as in the previous edition of this guide. Although there is potential for the dislocation in recent years in European government bond markets to change real yield dynamics permanently, there is little sign of a structural change in the key factors driving core real yields. We have found an inverse relationship between money supply and real yields in the past, consistent with economic theory that suggests that a larger money supply results in lower interest rates. We note a continued correlation between real yields and the ECB refi rate, although this relationship has been weakened by the movements in country spreads. Brent crude remains a driver of valuations, although, as noted in the Energy Hedging chapter of this publication, the sensitivity of euro area inflation to oil moves is not large. Broadly, euro real yields are far below where the model indicates fair value should be; this is largely a consequence of ECB policy, in our view, as well as the commencement in early 2015 of QE linker buying.

10y UK breakeven model

UK breakevens have tended to trade directionally with nominals in recent years and compressed following the expansion of BoE gilt purchases in October 2011. Breakevens fell markedly from May 2012 amid market fears surrounding the RPI formula effect review, but rebounded sharply in January 2013 when the National Statistician announced that the calculation of RPI would not be altered, contrary to market expectations. Monetary policy variables have tended to show a decent correlation with breakevens, as well as UK real yields, and we include the Bank Rate and money market slope variables from our real yield model in our breakeven model. We also include Global Manufacturing Confidence and the CRB Raw Industrials index as a proxy for broad inflationary concerns. The UK market is particularly sensitive to domestic supply and demand factors, more so than other comparable inflation markets. The marginal pricers of UK linker real yields and, by extension, breakevens are often domestic investors, and modelling supply/demand dynamics is in practice hard to achieve. This can be seen in the relatively low R^2 value for the UK breakeven model, and we are reluctant to place too much emphasis on its practical utility for investors.

FIGURE 18

10y UK breakeven model

Source: Bloomberg, Barclays Research

FIGURE 19

10y UK BE model coefficients and summary statistics

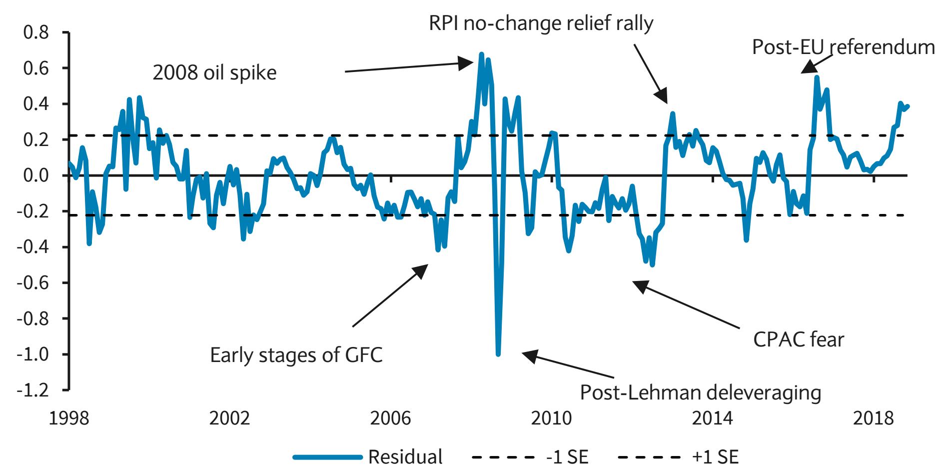
	Coefficient	t-stat		Model Stats
Global Manufacturing Confidence (1m lag)	0.21	6.9	R^2	0.58
CRB Raw Industrials	0.0025	9.9		
Short Sterling (4th vs 1st)	0.25	5.7		
BoE Bank Rate	0.097	7.9		
Constant	1.5	11.0		

Model: February 1998 – December 2018

Source: Barclays Research

FIGURE 20

UK 10y breakeven model residuals



Source: Barclays Research, Bloomberg

A key consideration when assessing fair value in UK breakevens is the outlook for the RPI/CPI basis, as discussed in the UK market overview in this publication. As a case in point, a 1pp RPI/CPI basis on a 10y breakeven of 3.0% implies that the market is pricing the MPC to hit its inflation target in the medium term; a basis assumption of 0.5pp would imply an overshoot. UK breakevens are, to an extent, sensitive to movements in Bank Rate via the mortgage interest payments component of RPI. Indeed, this component historically has been the key driver of volatility in the basis. When the RPI/CPI basis is close to flat, this can limit tactical interest in UK breakevens, as there is a tendency to extrapolate recent readings into the future. Given the relatively low sensitivity of RPI inflation to energy factors and RPI/CPI basis uncertainty, it comes as little surprise that the model is unstable. The global factors in our breakeven model do not capture UK-specific risks, as these are hard to proxy for in readily available economic variables. This was particularly noticeable after the EU referendum, when the market had tended to price an elevated probability of inflationary risks associated with the UK leaving the EU.

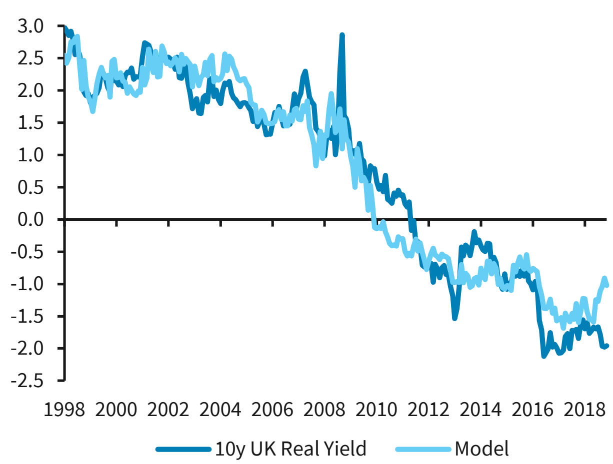
10y UK real yield model

The Bank of England official Bank Rate is the most significant driver of UK 10y real yield valuations, and the slope of the short sterling futures curve has also been historically significant. Bank Rate reached its effective lower bound in March 2009, but UK real yields have posted significant moves since then. A combination of BoE gilt purchases and euro-fuelled risk aversion caused UK real yields to rally to record lows in H1 2013 before starting to cheapen alongside most other core market real rates. The UK vote to leave the EU saw UK real yields rally sharply on the resultant risk aversion and expectations of a looser path of policy. This has resulted in 10y UK real yields trading far richer than the model estimate of fair value.

Traditionally, UK real yields have showed an inverse relationship with the FTSE 100, which might at first appear counterintuitive given that rates tend to rally when risk assets sell off. However, the inverse relationship can be rationalised by considering the interaction between pension schemes and linkers, with domestic pension funds historically one of the largest investor bases in the asset class. A rise in equity prices in theory improves pension solvency, and this can generate demand for linkers from pension fund de-risking. This has formed part of a structural shift in pension fund allocations away from equities into fixed income. Although pension solvency has suffered following the sharp rally in UK yields over the past five years, improvement in solvency ratios is likely to see de-risking demand from pension schemes return. We also find that our proprietary Global Manufacturing Confidence indicator adds explanatory power to the model as a broad proxy for economic strength and pipeline inflation pressure.

We estimate the UK real yield model during January 1998-December 2018. This avoids distortions from a structural break following the decision to grant the Bank of England independence in May 1997 and also coincides with the introduction of the minimum funding requirement (MFR) for pension funds. Model coefficients have remained fairly stable over the past few updates of this publication.

FIGURE 21
10y UK real yield model



Source: Bloomberg, Barclays Research

FIGURE 22
10y UK real yield model coefficients and summary statistics

	Coefficient	t-stat		Model Stats
BoE Bank rate	0.54	44.8	R^2	0.93
4th-1st SS Contract	0.78	12.5		
FTSE 100	-0.00054	-17.5		
Global Manufacturing Confidence (1m lag)	-0.15	-3.2		
Constant	2.2	11.0		

Model: January 1998- December 2015

Source: Barclays Research

INFLATION PRODUCTS

Valuing front-end linkers

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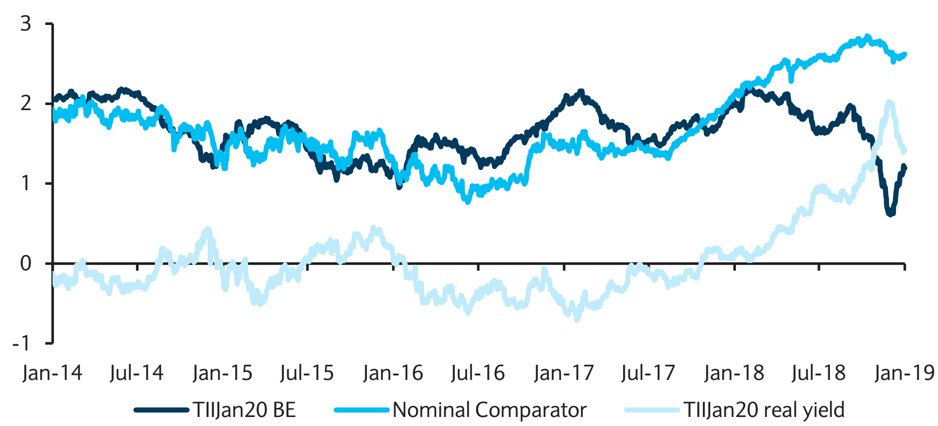
Front-end linkers tended to trade perennially cheap to inflation forecasts in the US, but not necessarily in the euro area or UK, where market dynamics differ. We discuss how we value the short end and look at drivers of the historical cheapness in the US and why more recent structural changes have changed that dynamic.

What's real and what's for sale?

Longer-maturity inflation-linked securities can be valued separately on a real rate and a breakeven basis. However, because short nominal rates are usually relatively stable, real rate movements make up most of the volatility in short maturity breakevens, and there is often little difference between the P&L of an outright position and the one expressed as a breakeven (Figure 1). At higher yield levels, the case can be made for separate valuations, but, particularly in the US, short-end real yields – which as of February 2019 remain low and very volatile – reflect the fact that short nominal rates are low and stable and that breakevens are positive and non-static. Therefore, we value short TIPS almost exclusively on a breakeven basis.

FIGURE 1

TIIJan20s breakevens driven mostly by real yield moves (%)



Source: Barclays Research

At first blush, valuing short breakevens is rather trivial. As the term implies, if the breakeven is higher (lower) than expected, it is fundamentally rich (cheap). However, there are several factors to keep in mind. First, breakevens, like yields, are quoted on an annualized basis. This means that with only a few months left to maturity, they can be much higher or lower than the underlying trend; for example, a strong print of 0.5% m/m could translate into an annualized inflation accretion rate of 6.17%; thus, a 1m breakeven would be 6.17%. Seasonality can also have a significant effect on deviations in breakevens from the general inflation trend (for more on this, see the seasonality primer in this guide). It is also important to line up dates correctly since TIPS mature mid-month, so the final reference CPI will be close (but not exactly equal) to the average of the NSA CPI prints from the second and third prior months. For example, an April maturity issue is dependent on both the January and February prints.

Forecasts must also be updated for moves in energy futures. While we use our economists' NSA CPI forecasts in valuing front-end breakevens, they typically only update their forecasts twice per month. If energy futures change significantly from when forecasts were set, they may be stale for the purpose of valuing the short end. In Figure 2, we adjust our economists' NSA CPI forecasts for moves in energy futures, both WTI and RBOB, since the forecasts were released on 11 January 2019. We thus value front-end breakevens on 24 January 2019 against these adjusted forecasts. The third column shows market breakevens. The fourth shows breakevens less annualized inflation to maturity for each security as implied by Barclays NSA CPI forecasts. A negative number means that breakevens are lower than Barclays' inflation forecasts, implying they are fundamentally cheap. The final two columns adjust Barclays' forecasts for moves in oil (WTI) and gasoline (RBOB) futures since the latest forecasts were updated. The table shows that, in this example, TIIJan20s were about 43bp cheap to Barclays' forecasts after adjusting for RBOB moves. We include a version of this table in our *Inflation-Linked Daily*.

FIGURE 2

Breakeven cheapness versus base Barclays CPI forecast and forecast adjusted for energy

Instrument	TIPS real yield	BE	BE versus Barclays CPI forecast BE (bp)	BE versus Barclays CPI forecast BE (bp), crude adjusted	BE versus Barclays CPI forecast BE (bp), gasoline adjusted
TIIApr19	3.66	-1.22	-42	-53	-39
TIIJul19	1.15	1.35	-37	-43	-33
TIIJan20	1.46	1.13	-45	-47	-43
TIIApr20	1.50	1.10	-59	-60	-58
TIIJul20	0.96	1.65	-65	-66	-64
TIIJan21	1.09	1.51	-55	-56	-54
1y CPI swap		1.19	-35	-37	-33

Source: Barclays Research, as of January 24, 2019

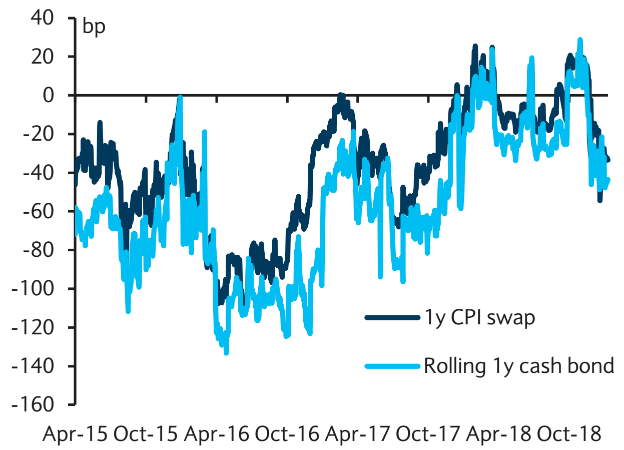
It is also important to account for carry when looking at spot breakeven moves. In a period in which a 1y breakeven has positive carry of, say, 100bp, breakevens could drop 80bp and a long position still would have outperformed the forwards. This is especially something to consider when looking at breakeven changes from Thursdays to Fridays of large (positive or negative) carry months. Continuing with the example of carry of 100bp in a month, or about 3bp/day, a long weekend would mean breakevens could drop 12bp from Thursday (Friday settle) to Friday (Tuesday settle) without a long BE position experiencing a P&L loss. It is therefore important to value short breakevens by lining them up against NSA CPI inflation forecasts to the specific maturity of the security because inflation over that specific period might be very different than the general inflation trend.

Cheap, but cheap enough?

We find that front-end breakevens typically trade cheap to inflation fundamentals. Historically, this translated to the front end being about 70bp cheap to energy-adjusted forecasts on average (Figure 3). Over the past two years, however, we have seen a structural shift in the market and do not expect the front end to return to such cheap levels. Much of the historical cheapness could be justified by the fact that there were few structural allocations to the front end and that tactical investors demanded a premium for taking on the lower liquidity/higher volatility investment (relative to nominals) when 1y+ TIPS funds managers sold them as they rolled out of the index. By comparison, in nominal space, there is a natural transfer at the 1y point from intermediate investors to money market funds, but most money market funds either cannot buy linkers until the final cash flow is known (which means demand is usually strong inside of 1m to maturity) or they do not want to take on the volatility of short TIPS. Most cash in the front end of the nominal market is there specifically to avoid volatility and gain liquidity, so, to be enticed into TIPS, those real money funds that can buy them demand compensation for these properties.

FIGURE 3

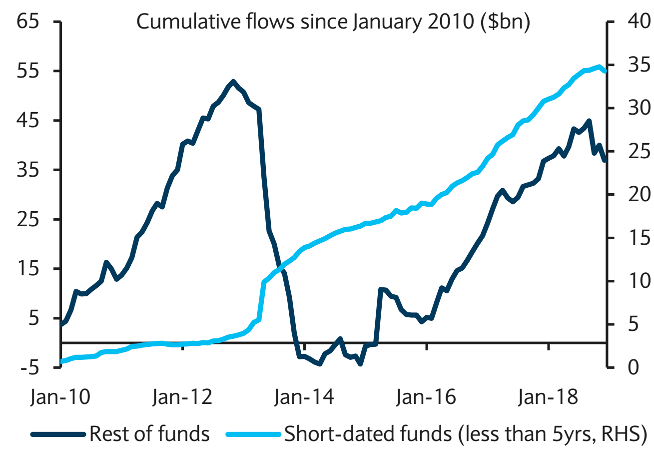
1y swap and cash RBOB-adjusted BEs



Source: Barclays Research

FIGURE 4

Short-dated TIPS mutual funds and ETFs becoming popular lately



Source: Bloomberg, Barclays Research

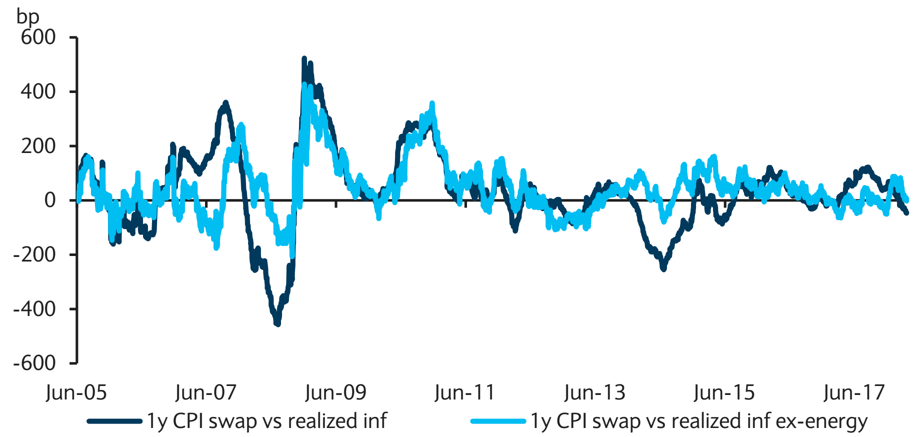
Over the past few years, though, structural demand has increased as the AUM of mutual funds and ETFs that track short-end TIPS indices (e.g., 0-5y) has grown significantly. These types of funds have been attracting inflows as investors look to increase their inflation exposure and decrease their duration risk (Figure 4). Additionally, more investors are hedging positions, both with energy futures and CPI fixing trades. Balance sheet allocations to this strategy by dealers and hedge funds also appear to have risen. Furthermore, if investors feel energy prices have settled into a range, they will demand less of a discount to compensate for the energy volatility exposure. So, if the old range (2015-2017) implied investors should sell when 1y breakevens were 30bp cheap to forecasts, and buy when they were over 100bp cheap, the new range appears to be 10bp rich to 30bp cheap. While this is less exciting and presents more risks, we believe opportunities will still arise.

So, how have they performed?

With front-end breakevens historically cheap to (energy-adjusted) CPI forecasts, it appears the market consistently undervalues the front end. So while we prefer to trade the ranges highlighted above, it would seem that a (rolling) long in the front end should have positive P&L versus realized inflation. To back-test this simple strategy, we compare the 1y CPI swap rate to the subsequently realized inflation over the same tenor of the swap, both outright and with an energy hedge. As seen in Figure 5, CPI swaps have generally underpriced the resulting inflation over each one-year period. As expected, the risk/reward of the trade is considerably improved when including the energy hedge, given the high volatility and pass-through from energy to breakevens. While longs still produced slightly positive P&L over the past two years, as the perennial cheapness of the front end has deteriorated, so, too, has the average P&L compared with earlier years.

FIGURE 5

1y CPI swap vs realized inflation



Source: BLS, Bloomberg, Barclays Research

Front-end EUR linkers: No clear cut cheapness

Similar to the US market, front end linkers in the euro area often trade at a discount to fundamentals implied, for instance, by economists' forecasts. One possible reason is the lack of a deep natural investor base once those linkers drop from 1y+ bond indices. Also, over the past few years, the fact that euro area inflation has generally surprised to the downside has likely driven the market to price in a discount versus central "point" scenarios. In other words, while economists publish modal forecasts, market valuations (from short-dated linker and inflation swaps) tend to price in risks to modal expectations, and those risks have largely been perceived as being to the downside lately. Despite this, the cheapness of EUR linkers is not always as clear-cut and compelling as in the US. With the existence of an active asset swap market for euro linkers, some issues are held to a large extent on that basis within hold-to-maturity positions. This means that even as those issues drop from 1y+ indices, the available float is not large enough to generate a sizeable discount to nominals. Some short-end investors do get involved in the euro linker market once the apparent discount to front-end nominals becomes large enough.

One thing to bear in mind is the non-negligible maturity mismatch that most euro linkers tend to have versus their nominal comparators. For example, most French linkers redeem on 25 July, but their nominal comparators typically mature on 25 April. For long-dated linkers, this mismatch can be overlooked, but for front-end issues, it can be sizeable in relative terms; a few extra months versus the nominal comparator cannot be ignored if the residual maturity of the linker is, say, below 1y. In that case, and unlike for TIPS, it is therefore not suitable simply to compare the potentially biased headline breakeven of the front-end euro linker against the remaining inflation accretion that is implied by, for example, economists' monthly forecast profiles.

To assess the cheapness of a front-end euro linker, we project its remaining cash flows in nominal terms. Using the projected cash flows and its current full market price, we can then calculate an implied nominal yield to maturity. This can then be compared with yields of similar maturity nominal bonds or bills to gauge the richness/cheapness of the linker versus the nominal market. We think it is desirable for short-end investors to have a nominal metric that is directly comparable with the yields of a range of short-end nominal bonds, rather than a single nominal comparator.

To project the linker's cash flows, we traditionally use our economists' forecasts. In addition, with sufficient liquidity in short-dated euro HICPx swaps (including the inflation resets market), projections can alternatively be made using those (effectively, the analysis then becomes analogous to a relative z-spread asset swap calculation). The resets/short-end market provides a transparent and tradable metric of euro HICPx projections, which means that tactical investors can eventually choose to trade front-end breakevens via either the cash or derivatives market. Some months on the resets curve may, however, be biased by inflation swap supply generated by asset swap activity; one has to bear that in mind when using the sub-1y euro HICPx curve as the basis for linker cash flow projections.

We provide a valuation analysis of short-dated €i linkers in our *Inflation-Linked Daily*. The analysis is only indicative because it takes as input our inflation trading desk's closing mid bond prices. However, for trading purposes, it is very important to use tradable offer/bid prices rather than mid prices when making such calculations because mid-to-offer or mid-to-bid spreads can be very wide on front-end instruments in yield terms, and some short-end linkers can sometimes trade at a notable bid-to-offer spread disadvantage versus nominals. In other words, what can appear very appealing versus nominals at mid prices may not be so attractive once realistic tradable prices are used.

Figure 6, from our *Inflation-Linked Daily*, shows the implied nominal yields on sub-2y €i linkers computed using 1) our economists' oil-adjusted euro HICPx projections and 2) projections from the euro HICPx swaps curve. The yields on neighbouring nominals (not only the nominal comparators) are also shown. The analysis shows that front-end €i linkers offer a discount versus nominals under both projection assumptions. Also, the discounts calculated using the inflation swaps curve are smaller than the ones based on our economists' euro HICPx projections, for the reason discussed above.

One needs to gauge if the discount calculated is enough to justify a long breakeven position or to substitute some short-dated linkers into an otherwise nominal-benchmarked portfolio. Let us assume that a portfolio manager relies on and trusts the inflation swaps curve (the same reasoning would apply to any other source of forecasts) as a reliable projector of inflation and finds a short-dated linker cheap enough versus nominals on that basis. It is important to note here that the pricing of front-end euro HICPx swaps at any point in time tends to take into account Brent futures at that point. As a result, the discount will change with oil prices move. To "lock-in" that perceived discount, the portfolio manager would therefore effectively need to hedge the oil exposure. Not only would the oil hedging cost need to be factored-in, but a position in oil futures may not be possible due to mandate constraints. Typically, we believe that the discount versus nominal needs to be at least 50bp to compensate for oil price exposure (for oil-unhedged positions) and forecast uncertainty.

FIGURE 6

Short-dated €i linker valuation versus nominals

	BTP€i 15 Sep 2019		SPGB€i 30 Nov 2019		DBR€i 15 Apr 2020		OAT€i 25 Jul 2020	
Real yield	-0.78%		-1.12%		-0.56%		-1.42%	
Breakeven	0.80%		0.75%		-0.11%		0.89%	
Nominal yield based on linker cash flow projections from:								
Inflation swaps curve	0.03%		-0.23%		-0.51%		-0.35%	
Barclays economists' oil-adjusted forecasts	0.53%		0.27%		-0.09%		0.11%	
Yields from neighbouring nominals	BOT 13 Sep 2019	0.02%	SPGB 31 Oct 2019*	-0.37%	DBR 04 Jan 2020*	-0.67%	OAT 25 Apr 2020*	-0.53%
	BTP 01 Sep 2019*	0.03%	SGLT 06 Dec 2019	-0.37%	BKO 13 Mar 2020	-0.60%	OAT 25 May 2020	-0.53%
							OAT 25 Oct 2020	-0.51%

* Usual nominal comparator for breakeven quotations. Data as of 24 January 2019.

Source: Bloomberg, Barclays Research

Front-end UK linkers: Some additional complexity

Dynamics specific to the UK linker market mean that front-end UK breakevens generally have not traded very cheap to inflation forecasts as they approach maturity. There has been less appetite in the past few years for holding sizeable short breakeven positions, owing to balance sheet constraints; a sizeable amount of bonds needs to be purchased to achieve reasonable DV01 breakeven exposure. When balance sheets were less constrained, this was not a significant impediment, but nowadays it tends to be. The methodology for valuing short-dated UK 3m linkers is similar to that already described for the US and euro markets; for old-style 8m lag issues, where conventions and, thus, valuations differ from Canadian model bonds; a different method must be used to assess fair value.

In the UK markets, the most widely tracked indices are the FTSE Actuaries all-linker and over-5y indices, the former including sub-1y maturity bonds. As such, index-related selling of bonds has historically been most prominent as their residual maturities approach 5y. This has resulted in bonds cheapening sharply as a result of the selling pressure; this typically unwinds if the cheapening results in the bond offering economically attractive breakeven value, on which hold-to-maturity investors can capitalise. Equally, if the bond in question offers cheap asset swap value relative to conventional gilts, this can also generate sizeable demand. In the past, when bonds dropped from over-5y indices, significant selling of the bond exiting those indices occurred. Asset swapping has provided an important demand cushion for absorbing the float of bonds created by these flows from passive indexers. Those with active benchmarks tend to sell or underweight bonds approaching a 5y residual maturity in advance to avoid selling the bond at a cheap valuation. In other markets, indexation to >1y indices is common, and as outlined above, this has tended to cause short breakevens to trade cheap close to maturity. As UK linker ownership has moved towards liability-focused hedging strategies, away from traditional indexation, the 5y index drop effect has become less pronounced.

As discussed in the UK country section, for old-style UK linkers, the real yield is derived via a model employing a 3% inflation assumption. This means the real yield must be adjusted after each RPI release to account for the deviation of the latest print from this underlying assumption. This causes notable distortions as the bond approaches maturity. To assess fundamental value, we prefer to calculate the money yield of the bond using our RPI forecasts and then compare this with either maturity-matched OIS or a similar short-dated gilt. The spread of the forecast-implied money yield to the comparison nominal rate then gives the cheapness of the old-style linker. The implied money yield to maturity can be calculated on Bloomberg using the YA (yield analysis) screen. Under 'economic factors', the current RPI print field should be set to the forecast RPI print, fixing the final value of the bond. Additionally, the 'assumed inflation rate' must be set to zero, rather than 3%, as we are specifying the full inflation accrual for the bond. This will then calculate the money yield implied by this RPI forecast, which is equivalent to the nominal yield to maturity that will be released should RPI inflation print in line with the forecast. For new-style linkers, the same techniques as used for US TIPS or euro linkers apply.

INFLATION PRODUCTS

Capturing "core" breakevens

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Why calculate "core" breakevens

Using headline BEs and food and energy futures curves, one can derive market-implied "core" breakevens. Market participants tend to have higher confidence in near-term core inflation (excluding food and energy) forecasts, as core trends tend to persist, while food and energy are much more volatile components of headline inflation. As such, deriving "core" breakevens allows investors to trade the front end of the breakeven curve with higher conviction. To address this need, we calculate 1y forward ex-energy and core breakevens using food and energy futures curves. We include ex-energy and "core" 1y forward breakevens out ten years in our *Inflation-Linked Daily*, with the latest curves shown in Figures 1 and 2 (as of 24 January 2019).

Modeling food and energy inflation

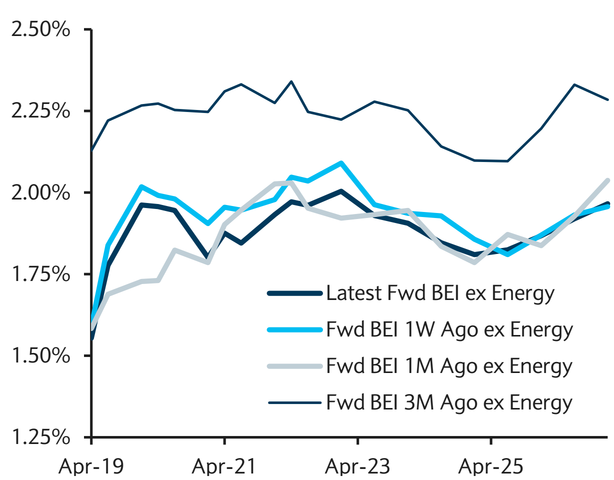
To derive ex-energy and core breakevens, given the historical difficulty in predicting moves in energy and food inflation, we simply strip out the futures' implied values for each. We address each in turn.

Food

To infer a market-based measure of future food inflation, which accounts for ~13.34% of headline inflation as of December 2018, we establish a relationship between food futures and food CPI. Specifically, we note a strong correlation between moves in the S&P Agriculture and Livestock Index (SPGCAL Index) at various lags (3m, 6m, 9m, 12m) and food CPI. With this correlation in mind, we use food futures that replicate the S&P index to predict 1y ahead food inflation.

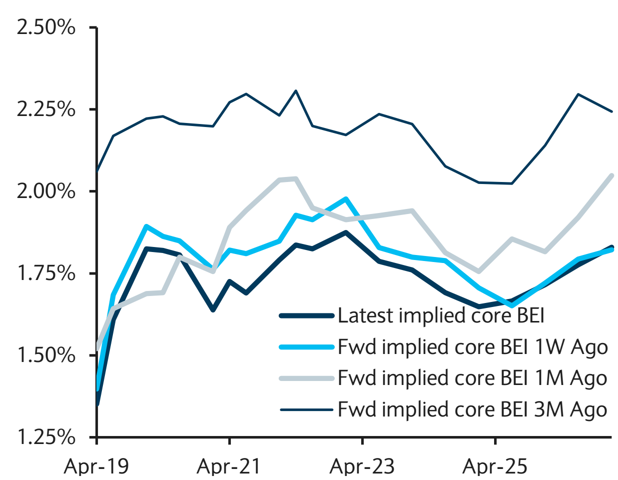
The SPGCAL Index consists mainly of the following food futures: corn (25% normalized index weight), wheat (21%), sugar (9%), cattle (28%), and soybeans (17%). We use 3m, 6m, 9m, and 12m futures for each of these, weighted accordingly, to derive future food inflation. As shown in Figure 3, 1y ahead food (annualized) inflation is currently estimated at 2.81% and has been increasing steadily since last fall.

FIGURE 1
1y forward ex-energy BEIs



Source: Bloomberg, Barclays Research

FIGURE 2
1y forward "core" BEIs



Source: Bloomberg, Barclays Research

Energy

To infer a market-based measure of future energy inflation, which accounted for ~3.947% of headline inflation as of December 2018, we establish a relationship between crude futures and energy commodities CPI. As highlighted in the *Hedging energy risk in breakeven positions* section of this Guide, there is a ~58% pass-through from crude moves to energy commodities inflation. While we could use gasoline futures (RBOB), which exhibits a tighter correlation to energy CPI, liquidity in these contracts is lower than that of crude (WTI), particularly for longer expirations. We can infer forward energy inflation between two dates by analyzing the implied moves in the energy futures curve over those dates. Because the crude curve is currently in backwardation beyond 2019, we would expect future deflation in energy (Figure 4).

Example

After explaining our food and energy inflation models, we provide an example to illustrate the calculations.

Take the Jan20/21 pair (as of 24 January 2019), which from the "Market implied 1y tenor cash Forward Breakevens" page of our *Inflation-Linked Daily* is priced at a forward breakeven of 1.87%. To arrive at the futures' implied energy move over the Jan20 to Jan21 period, we take the prices of the corresponding crude future contracts (mindful of the 2-3m lag for CPI prints to TIPS maturity). Specifically, the Jan20s have a maturity CPI between October and November 2019. The nearest maturity crude contract is the CLZ9 (last trade date of November 20, 2019). Similarly, the corresponding crude contract for the Jan21s is the CLZ0. Looking at current pricing, we have 54.33 and 54.06 $/bbl on the CLZ9 and CLZ0, respectively. Because the crude curve is currently in backwardation, we get implied energy deflation of -0.5% over this one-year period.

We have already determined our implied food inflation estimate (2.81%) above. We can then derive ex-energy and core breakevens, using these equations:

1yFwdBreakeven = (1 – WghtEnergy) * 1yFwdExEnergyBreakeven

+ WghtEnergy * EnergyPassThrough * 1yEnergyInf

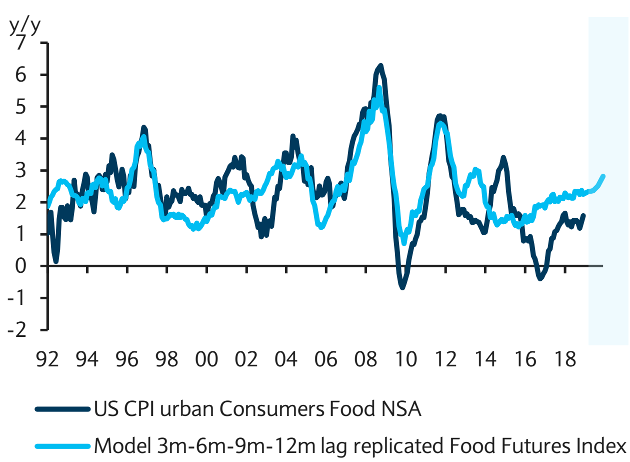
1yFwdBreakeven = (1 – WghtFood – WghtEnergy) * 1yFwdCoreBreakeven

+ WghtFood * 1yFoodInf

+ WghtEnergy * EnergyPassThrough * 1yEnergyInf

FIGURE 3

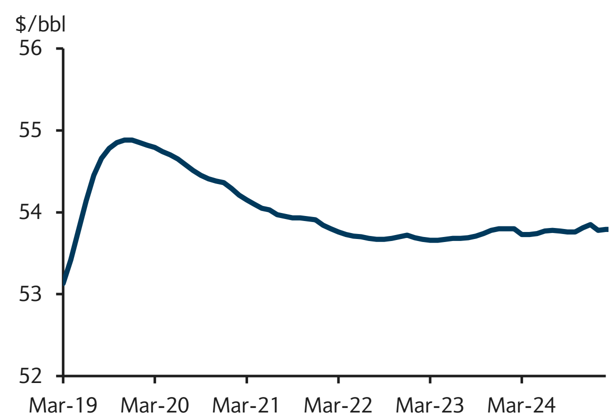
Predicting food CPI inflation using food futures



Source: Bloomberg, Barclays Research

FIGURE 4

Crude curve in backwardation beyond 2019



Source: Bloomberg, Barclays Research

Rearranging the previous equations, we arrive at:

1yFwdExEnergyBreakeven = (1yFwdBreakeven –
WghtEnergy * EnergyPassThrough * 1yEnergyInf) /
(1 – WghtEnergy)

1yFwdCoreBreakeven = (1yFwdBreakeven –
WghtEnergy * EnergyPassThrough * 1yEnergyInf –
WghtFood * 1yFoodInf) / (1 – WghtEnergy – WghtFood)

Using our Jan20/21 example, we solve for the ex-energy and core forward breakevens:

- Jan20/21 1y forward breakeven = 1.87%
- Weight of energy commodities CPI = 3.947%
- Energy pass-through = 58%
- Jan20/21 1y energy inflation = -0.5%
- Weight of food CPI = 13.34%
- 1y ahead food inflation = 2.81%

1yFwdExEnergyBreakeven = (1yFwdBreakeven –
WghtEnergy * EnergyPassThrough * 1yEnergyInf) /
(1 – WghtEnergy)

1yFwdExEnergyBreakeven = (1.87% – 3.947% * 58%* -0.5%) / (1 – 3.947%)
= 1.96%

1yFwdCoreBreakeven = (1yFwdBreakeven –
WghtEnergy * EnergyPassThrough * 1yEnergyInf –
WghtFood * 1yFoodInf) / (1 – WghtEnergy – WghtFood)
= (1.87% – 3.947% * 58%* -0.5% – 13.34% * 2.81%) /
(1 – 3.947% – 13.34%) = 1.82%

Thus, starting with a forward breakeven of 1.87% and stripping out the backwardation in the energy curve moves us up to 1.96% on an ex-energy basis. Adding in the ~2.8% move in 1y food inflation, we arrive at a "core" breakeven for Jan20 to Jan21 of 1.82%. Comparing this core value with our economists' Dec20 (furthest published) rate of 2.4% y/y on core shows the market pricing a bearish view on core CPI. That said, we often prefer to focus on ex-energy breakevens, as the pass-through from food futures to CPI comes with a long lag and we are unable to hedge these moves in the near term (compared with energy, which passes through to CPI and thus TIPS valuations quickly and is easily hedged). Even so, the ex-energy implied breakeven of 1.96% is still low compared with our economists' core CPI forecast.

INFLATION PRODUCTS

Hedging energy risk in breakeven positions

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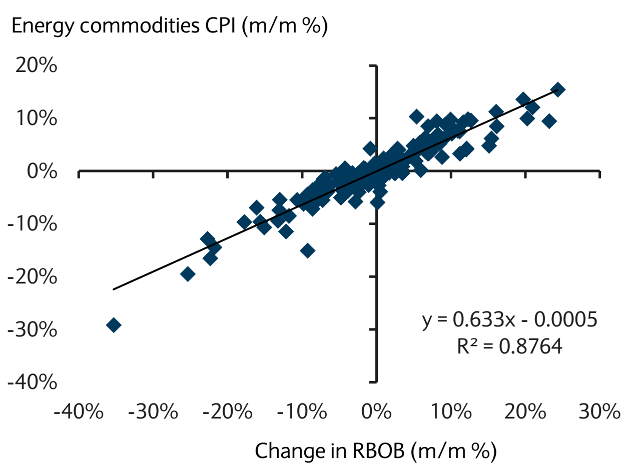
Why energy hedge?

Historically, front-end breakeven positions have been quite cheap to the expected near-term inflation forecasts. One reason is that TIPS shorter than 1y in maturity fall out of the TIPS index, which usually translates into large dealer inventory. In addition, these securities tend to be quite volatile because of their sensitivity to moves in energy and/or food commodity prices. This is because one CPI print matters much more for a 1y or 2y tenor TIPS than it does for, say, a longer-dated 10y, 20y or 30y TIPS. Moreover, core CPI tends to be persistent relative to headline CPI in the near term. Thus, food and energy commodities moves can lead to volatile front-end valuations. For investors who cannot hedge against moves in energy, higher volatility leads to a re-pricing of risk premium on the security. Using historical pass-throughs (from energy futures into energy commodities CPI or motor fuel CPI) and the energy commodities/motor-fuel weight in CPI, one can energy-hedge front-end TIPS trades to reduce volatility. From time to time, we think investors can capitalize on this higher risk premium on front-end US breakeven positions by energy hedging.

Approach to energy hedging in the US

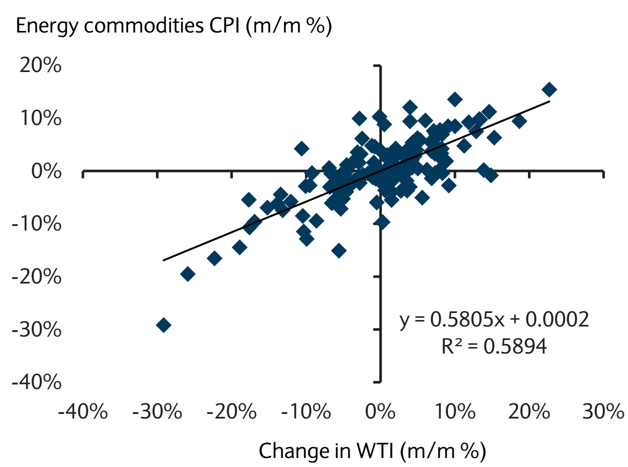
The intuition behind energy hedging is that for a held-to-maturity 1y breakeven position, the investor will be indifferent to the rate of energy commodities (motor fuel) inflation if the hedge works as expected. By selling matched-maturity gasoline or crude futures (or buying gasoline or crude puts) versus a front-end breakeven position, one can hedge against energy commodities/motor fuels CPI. Our analysis indicates that there is a ~63% pass-through of gasoline futures into changes in energy commodities CPI (Figure 1) with a fairly close fit. Figure 2 shows a ~58% pass-through of crude futures into changes in energy commodities CPI. One important aspect of hedging is to find a contract closest to (or slightly longer than) the matched energy futures (gasoline or crude) to the 2-3m lagged maturity of the TIPS security. The choice of crude or gasoline will depend largely on the liquidity of the available contracts; crude futures tend to be more liquid. Investors might also choose one over the other if they have a view on crack spreads. As of December 2018, energy commodities CPI made up about 3.947% of headline. Assuming Figure 1's regression

FIGURE 1
Energy commodities CPI changes (%) versus gasoline futures changes (%), pass-through is about 63%



Note: From November 2005 to December 2018. Source: Bloomberg, Barclays Research

FIGURE 2
Energy commodities CPI changes (%) versus crude futures changes (%), pass-through is about 58%



Note: From November 2005 to December 2018. Source: Bloomberg, Barclays Research holds, a 1% gasoline futures change passes through to energy commodities CPI at the rate of about 63%. Hence, for a 1y breakeven position, a 1% change in gasoline futures is worth about 2.5bp (1% gasoline futures change * 3.947% energy commodities CPI Weight * 63% pass-through).

Determining the number of crude/gasoline futures needed to hedge a front-end breakeven position

Using the aforementioned approach, we can derive how many gasoline/crude contracts one needs to hedge a held-to-maturity front-end breakeven position.

How many gasoline futures contracts to sell?

For example, as of February 4, 2019, to hedge a $100mn TIIJul19 breakeven position (underlying CPI is the mid-April and May 2019 CPI), the nearest maturity gasoline futures contract is XBM9:

1. **Determine the gasoline futures with which to hedge**. For our example, the nearest maturity gasoline futures contract is XBM9 (the last trade date is May 31, 2019). Our assumption is that gasoline futures are liquid. If they are not, we would use December contracts, which tend to be more liquid, or do this exercise with crude/Brent futures (see below).

2. **Translate 1% change in gasoline futures to 1y CPI change:** A 1% change in gasoline will move 1y CPI about 2.49bp (1% gasoline futures change * 3.947% motor-fuel CPI Weight * 63% pass-through).

3. **Translate 2.49bp CPI change to TIIJul19 BE move:** The reference CPI for the TIIJul19s, as of 4 February 2019 (settle: 5 February 2019), is 251.92300. A 2.49bp shock in CPI (assuming that it happens on the day) translates into shocked reference CPI of 251.98573 (= 251.92300*1.000249). TIIJul19 BE is 1.87% with time to maturity of 0.438y, so we can obtain “shocked” maturity CPI of 254.0389 (= 251.98573* (1 + 1.87/100)^0.438)) and “shocked” BE of 1.93% (= ((254.0389/251.92300)^(1/0.438)-1)*100). The energy shock in BE terms can be obtained as the difference between “shocked” BE and actual BE, and it is 5.79bp in this example (1.9279 % - 1.8700%). Note that we have assumed annual compounding here for ease of understanding, but the exact calculations should be done with semi-annual compounding.

4. **Translate the 5.9bp change into the dollar sensitivity amount on a $100mn TIIJul19 position.** This is about $30,316 (5.79bp * $100mn * 52.36/$10000 * 100), where 52.36 is the TIIJul19 DV01.

5. **Calculate the dollar sensitivity of 1 gasoline futures contract to a 1% change in the gasoline futures price.** A 1% change in 1 XBM9 contract (priced at $164.47 as of February 4, 2019 for 42,000 gallons) is worth about $690.77 (1% * 42000* $1.6447).

6. **Using the dollar sensitivities in steps 4 and 5, derive the number of gasoline contracts needed to hedge:** We simply divide $30,316, (for a 1% change in gasoline futures) by the sensitivity of 1 gasoline futures contract to 1% change in prices ($690.77): $30,316/$690.77, or about 44 XBM9 contracts to hedge a $100mn TIIJul19 BE position.

You can obtain the number of WTI futures contracts to sell following the same procedures described above but using the pass-through estimate for WTI futures (58%) and price for relevant WTI futures (CLM9, the price is $55.70 as of 4 February 2019). Our analysis shows you would need 50 contracts of CLM9 to hedge exposures of TIIJul19 BE to energy commodities CPI.

Ideally, for a held-to-maturity position, we prefer to hedge directly using ATM crude/gasoline futures puts because from a long-breakeven position perspective, we are concerned only with downside risks in inflation/energy. Typically, when front-end breakevens are cheap, we have found that the cost paid for a put on an energy futures contract is quite small versus the expected gain on a front-end breakeven position.

Reducing the hedge during the final 2-3 months of a held-to-maturity position

Example: How to roll off the energy hedge on TIIApr19s in January and February 2019?

As the termination period for TIIApr19s approaches, we discuss how one can roll off the energy hedge on this position linearly. The final prints that matter for the TIIApr19s terminal payoff are January 2019 and February 2019 CPI. Thus, on January 1, 2019, there are about 60 days left of energy price uncertainty. Using the approaches discussed above, we first determine the P&L should the gasoline futures (here, XBH9 is used to hedge TIIApr19s) instantaneously change by 1% for the entire 60-day period (from January 1 to February 28). Given the current price of $143.23 for XBH9, a 1% change in this gasoline future price equals roughly a $601.57 change in 1 XBH9 contract P&L.

Assuming this 1% shock persists for the coming 60 days, one can expect a pass-through of gasoline through motor fuel CPI of about 63% (see the historical relation in Figure 1). Energy commodities CPI makes up about 3.947% of headline CPI. Following the methodology explained above, you can obtain the dollar sensitivity amount on $100mn TIIApr19 BE position to a 1% change in gasoline futures. This is about $26,434, and the number of RBOB contracts you need to hedge the exposure of TIIApr19 BE to energy commodities CPI is about 44 contracts ($26,434/$601.57).

This applies for the entire 60-day period, but what if there are only 45 days left to the end of February? In this case, we should reweight the 1% holding period gasoline move (on the right side of the equation) by 1% * (45/60). More simply, since this is a multiplier term, we can reduce the 44 contracts position to 33 contracts (44 XBH9 contracts * 45/60). One subtlety in the above calculation is that gasoline futures tend to feed into retail gasoline prices with a 1w lag (or 8 business days). So an investor who is long TIIApr19s (security maturing April 2019) should start reducing energy hedges after the third week of December 2018, rather than 1 January 2019, and does not need to energy hedge a TIIApr19 BE position after the third week in February 2019.

Euro

Hedging energy price movements in the euro area inflation-linked market is a relatively new phenomenon compared with the US. One of the reasons historically is the relatively unclear pass-through of energy futures moves to the relevant components of HICP. This lack of a clear pass-through compared with the US is largely due to the influence of regulation (various tariffs, duties and taxes) on the final price paid by customers. A further complication is the lack of homogeneity across euro area countries, and somewhat sparse information in some cases about the pricing mechanisms, such that the impact of futures moves cannot be easily implemented within a multi-country bottom-up forecast framework for HICP.

However, while oil price moves prior to Q4 2014 could be disregarded because of low volatility and because high prices meant muted moves in percentage terms, it was not the case thereafter. The drop in global energy prices had a profound effect on price developments in the euro area, at a time when other components were also experiencing disinflation/deflation. The weight of energy within HICPx dropped sharply from 2013 to 2017, but edged higher in 2018 and 2019. Market participants are now more attentive than previously to the volatility in futures and the effect on m/m inflation prints. The increasing share of energy within the variability of HICPx also coincided with the period during which the euro HICPx resets/fixings market flourished (although we suspect there was causality from more volatile energy prices to the development of that market). This meant that the largest market participants, who would normally be involved in the resets markets, were increasingly conscious of the impact of energy prices moves on HICPx. In particular, in practice, many of those market participants (e.g., market-making desks) developed their own bottom-up forecasting models independently from forecasters such as economists. Therefore, the impact of energy futures became increasingly clear to those who were effectively trading inflation markets and, as a result, there was more of a natural incentive to hedge that impact.

Brent futures are typically used to hedge euro area inflation. The components of HICPx that are expected to exhibit a close link to futures are “Fuels and lubricants for personal transport equipment” and “Liquid fuels”. To assess the pass-though, the weekly petrol survey from the European Commission is useful, as it allows the analysis to be carried out with weekly data rather than monthly. The Euro-super 95 Pump Price, Auto Gas/Diesel Pump Price and Heating Gas Oil Consumer Price components of the weekly survey can then be mapped with the monthly “Fuels and lubricants for personal transport equipment” and “Liquid fuels” components to gauge the impact of futures moves on euro HICPx.

From our historical analysis, looking mainly at the dynamics since 2014, we currently estimate that a €1 move in the €-denominated Brent (at the current €/$ exchange rate, assumed 1.12) impacts HICPx by about 0.029%. This impact is on the index value, i.e., it shifts the curve of projected euro HICPx values by that proportion. The hedge in terms of contracts can then be derived. Earlier in this article, we explain the methodology to hedge a short-dated TIPS breakeven position. In the euro area, Brent could be used, for instance, to hedge short-dated euro HICPx swaps. The conversion to the number of Brent futures in this case is trivial. For example, the inflation DV01 of €100mn notional on a 1y euro HICPx swap is about €10k. Under our assumptions, a €1 move in €-denominate Brent will therefore generate a €29000 P&L change. With the value of €1 on Brent worth €1120/contract at the assumed €/$ exchange rate, we therefore estimate that around 26 Brent contracts (29000 divided by 1120) need to be traded to hedge €100mn notional on a 1y swap. Note that because we calculate the sensitivity of the HICPx index value to Brent moves, a similar number of contracts is often assumed to be required to hedge €100mn on a longer-dated swap, e.g., 10y. This nevertheless relies on the assumption that the inflation accrual factor on longer tenors is more or less offset by the nominal discount factor. Put differently, this approximation relies on the assumption that real rates are close to zero (i.e., real discount factors are close to 1). Of course, if they are not, then this approximation can be questioned, as the compounding effect from non-zero real rates can be non-negligible for long-dated inflation swaps. That said, for the latter, energy hedging with oil futures would be an approximate macro hedge anyway, so precise calculations accounting for real discount factors may not be warranted.

We point out that the sensitivity analysis has been carried out using moves in the front Brent contract. In practice, one would choose a longer-dated contract to avoid having to roll the oil hedge. Implicitly, this means that the hedge will also be sensitive to changes in the shape of the Brent curve. It may also be desirable to hedge the FX exposure on the hedge, given that Brent contracts are quoted in $.

UK

Two separate energy-related components, ‘petrol and oil’ and ‘fuel and light’ jointly comprise 7.3% of RPI. The former is easy to model based on readily available data, the latter has become highly complex following the introduction of the OFGEM retail price cap. Overall, the risks associated with energy need to be considered carefully as part of an inflation investment strategy but are not worth tactically hedging on a day-to-day basis.

Taking the easy part first: road fuels

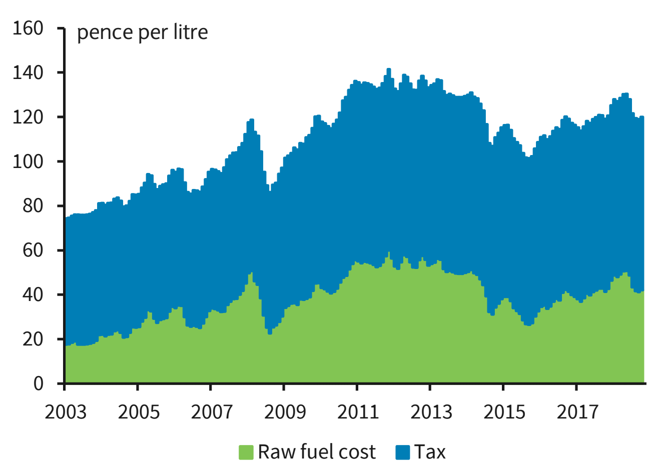
Petrol and diesel prices are relatively easy to model within RPI. The first step is to understand that the majority of the price UK motorists pay at the pump is tax; for petrol (gasoline), this is currently 65% of the retail price. A flat duty of 57.95 pence per litre is levied on road fuels on top of the raw cost of the fuel, and VAT (sales tax) of 20% is then added to the sum of these two figures to give the complete retail fuel price. The best source for this data is the UK Government Department for Business, Energy and Industrial Strategy.[1] This website has a spreadsheet containing historical and present fuel costs and taxes dating back to 2003. From this, it is trivial to derive an ex-tax price for road fuels. We find a simple linear regression model works well for modelling the ex-tax fuel price (Figure 4) against Brent oil in GBP terms. The pass-through is more significant one month after an oil price change, but further lags are not statistically significant. Petrol has a weight of 2.04% in RPI as of 2019 and diesel a weight of 1.33%. We advocate modelling projected m/m changes in ex-tax petrol and diesel prices using the specification in Figure 4. From these, a full petrol and diesel pump price can be derived by adding the flat duty of 57.95p to the ex-tax price, then adding 20% to the combined total. The aforementioned weights can be used to give the overall effect on RPI. We estimate that the effect of a 10% move in GBP-denominated Brent oil adds 0.1pp to RPI, split 40:60 between the immediate and next month in which the move occurs.

Rather more complicated: Household energy prices

Forecasting UK household energy price effect on RPI used to be a very straightforward exercise of paying attention to UK domestic news and price comparison websites for hints of price changes and then using OFGEM market share data to work out the pass-through to RPI. However, the regime changed in the UK effective January 2019 and household energy prices are now subject to a regulatory cap. We believe that RPI uses a standard dual fuel variable tariff for measuring this household cost; accordingly, the collected price will now effectively equal the OFGEM price cap. For reference, electricity has a 2019 RPI weight of 1.9% and gas a corresponding 1.5% weight.

The OFGEM cap is reviewed twice a year, split between summer and winter periods. Futures prices with a year ahead horizon are collected up to two months before the cap level is adjusted and weighted for demand to produce a figure for the 'wholesale cost' element of the energy price cap. Otherwise, the cap comprises 'network costs', 'policy costs', 'operating costs', 'payment uplift', 'EBIT', 'headroom' and 'VAT'. For the purposes of RPI forecasting, the most important component is wholesale costs, which comprises 40% of the April to

FIGURE 3
Breakdown of UK petrol pump prices



Source: Department for Business, Energy & Industrial Strategy, Barclays Research

FIGURE 4
Model for UK ex-tax fuel prices

	DL(ex-Tax petrol)		DL(ex-tax Diesel)	
	Coefficient	T-stat	Coefficient	T-stat
Constant	0.00	0.6	0.00	0.3
DL(GBP Brent)	0.29	10.1	0.26	12.0
DL(GBP Brent)_1	0.44	15.0	0.40	18.4
R-squared	0.78		0.84	
Durbin Watson	1.73		1.64	
Sample period	March 2009 - March 2019			

Source: Barclays Research

[1] https://www.gov.uk/government/statistical-data-sets/oil-and-petroleum-products-weekly-statistics

September 2019 cap and is likely to be the most volatile component of the energy cap. In terms of forthcoming caps, we think that the wholesale cap can be modelled as follows based on OFGEM documentation:

FIGURE 5

Relevant futures to watch for OFGEM price cap levels

	Cap period	Averaging Dates	Relevant Futures (inc)
Summer 2019	1 Apr 19 – 30 Sep 19	1 Aug 18 – 31 Jan 19	Apr19 : Mar20
Winter 2019	1 Oct 19 – 31 Mar 20	1 Feb 19 – 31 Jul 19	Oct19 : Sep20
Summer 2020	1 Apr 20 – 30 Sep 20	1 Aug 19 – 31 Jan 20	Apr20 : Mar21

Source: Barclays Research

This means that a clearer picture of the likely OFGEM cap adjustment will emerge closer to the cap adjustment announcement. However, this proposes a number of forecasting challenges and may increase the volatility of headline UK inflation forecasts. As an illustration, in formulating our updated RPI forecast after the February print, we have only six weeks of generic Bloomberg futures data to use and no sense of how closely this may match the 'commercially sensitive' data that OFGEM itself uses but redacts its published models. Nevertheless, there is a market expectation that inflation forecasts will incorporate some estimation of the likely changes in energy costs. Looking at time series data of the relevant gas futures for the winter 2019 cap, we are not convinced that replicating the full cap calculation will be useful.

A simpler approach is to note that the 6m moving average of the April 2019 gas futures was about 60 GBp/therm on 31 January. Currently, the October 2019 gas future is trading at about 43 GBp/therm, having fallen from 55 GBp/therm. If we assume that pricing settles at 45 GBp/therm (this is not a forecast), this implies a 25% drop in wholesale gas prices for the winter 2019 cap versus summer 2019. Assuming a full pass-through to the wholesale component and that gas and electricity prices move similarly, this would imply a 10% drop in the OFGEM price cap, equivalent to a reversal of the increase that will be applied to the initial cap in April (this was announced in February) come October. Over time, market understanding of the cap will likely increase and pricing will adapt; however, we think it important to emphasise the current heightened uncertainty for forecasting household energy prices and that a full replication of the OFGEM calculation is unlikely to be useful, given that the key inputs are not publicly available data. This is particularly the case for electricity market data, and also gas to some extent, given that the sophistication of the OFGEM energy price cap wholesale cost model takes into account micro-level variations in price and projected demand that will not be captured by generic futures prices.

INFLATION PRODUCTS

How to construct forwards

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Forward breakevens are an important market-based measure that the Fed and investors use as a gauge of and/or trading vehicle for inflation compensation. In addition to closely following the 5y5y forward breakeven – which the Fed has historically cited as its preferred forward measure because it is a medium-term structural measure constructed using the most liquid points on the curve – we find plotting forward 1y breakevens useful in evaluating the path of inflation that the market is pricing in and spotting relative value among various TIPS issues. Given the importance of forwards, we discuss our approach to approximating and tracking them using cash TIPS. Figure 1 shows the 5y5y fwd breakeven measure implied from cash breakevens versus the Fed's fitted curve-based 5y5y, and Figure 2 shows a curve of forward 1y breakevens as of February 8, 2019. Figure 1 confirms that our tradable measure tracks the spline-based theoretical measure of forward breakevens closely. Figure 2 shows that the Jan25-Jan26 forward breakeven looks cheap versus forwards created using pairs of surrounding issues. Below, we discuss how we calculate and trade a forward breakeven and then explain the nuances of why we believe this approach works in a practical sense.

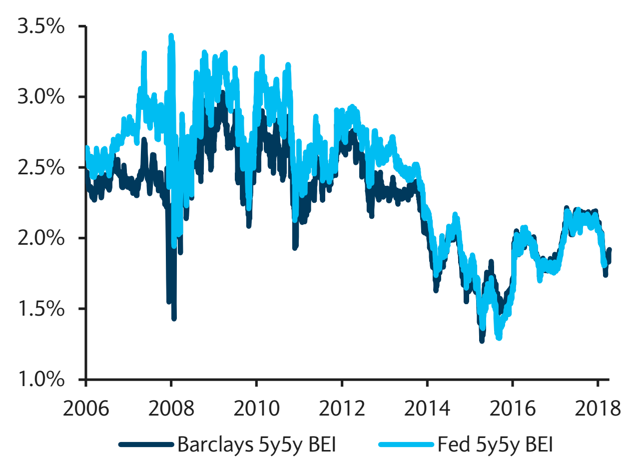
An example of Jan24-Jan25 forward breakevens

On February 8, 2018, the Jan24-Jan25 forward breakeven measure was trading at about 2.23%, rallying from 2% just two weeks prior (Figure 3). We constructed this measure by weighting breakevens using relative modified durations of each TIPS security.

$$\text{Jan24-Jan25 fwd breakeven} = \frac{(\mathit{Jan25ModDur} * \mathit{Jan25BEI} - \mathit{Jan24ModDur} * \mathit{Jan24BEI})}{(\mathit{Jan25ModDur} - \mathit{Jan24ModDur})}$$

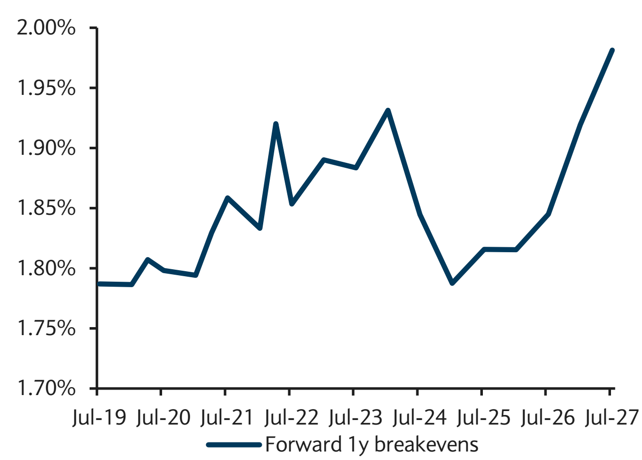
When we recommended this as a trade (*Inflation-Linked Daily*, 8 February 2018), we expected the rate to move back down to 2%. Figure 4 shows details of the trade at the time. We use a 112.6:114.3 notional ratio on the TIPS legs to achieve $10k DV01 on the trade, and then apply nominal DV01 weight ratios to get the nominal notional legs. The TIPS notionals have been weighted by relative index ratios and DV01 factors. While close, this trade is not cash neutral (as shown by the net residual cash amount). Figure 5 shows that over time (series up to July 13, 2018), the Jan24-Jan25 short fwd BE trade P&L (assuming

FIGURE 1
Our conceptual measure tracks the Fed's spline-based 5y5y fwd breakevens closely



Source: Federal Reserve, Barclays Research

FIGURE 2
Breakeven forwards that are one year apart

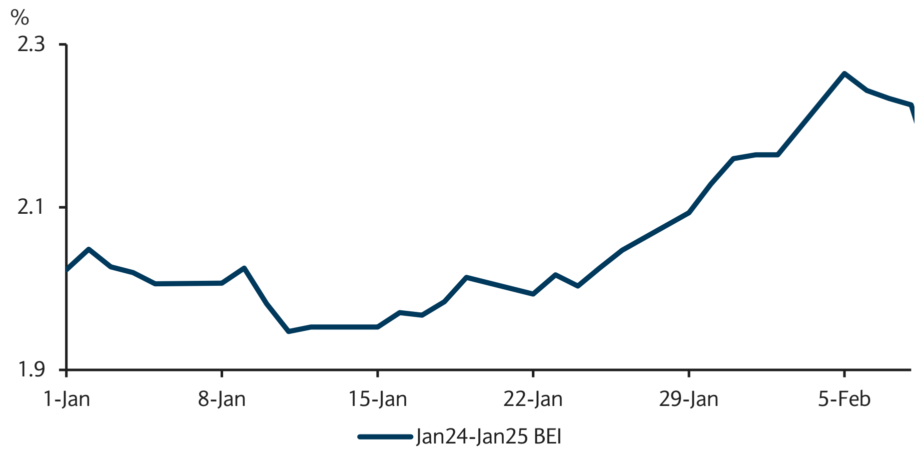


Source: Barclays Research

the initial setup outlined in Figure 4) has tracked very closely to the anticipated trade P&L based on the Jan24-Jan25 fwd BE time series. Below, we discuss why having an index ratio-neutral trade makes sense in approximating a forward breakeven. Essentially, we want to have zero P&L attributed to inflation accretion prior to the forward settle date. The only way this can happen is if both breakeven legs of the trade accrete inflation-related notional changes by the same amount. Both issues have off-the-run comparators, which should minimize any repo-based technical forward breakeven increase.

FIGURE 3

On Feb 8, 2018, the Jan24-Jan25 forward breakeven rate had rallied 20bp in two weeks



Source: Barclays Research

FIGURE 4

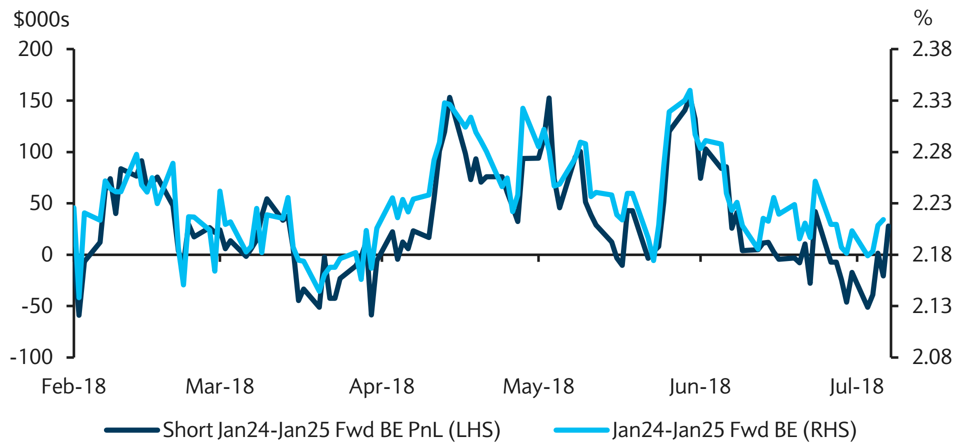
The Jan24-Jan25 (short) forward breakeven trade table, $10k DV01, as of February 8, 2018

Bond Type	Issue	Price (decimal)	Yield	DV01	Index ratio	Par weights (mn)	Cash value ($mn)	Modified duration
Long TIPS	TII 0.625 Jan24	100.14	0.60%	6.15	1.05699	112.6	119.3	5.81
Short nominal	T 2.75 Feb24	100.33	2.69%	5.53		125.3	127.4	5.44
		Breakeven	2.09%			Residual	8.1	
Short TIPS	TII 0.250 Jan25	97.23	0.66%	6.94	1.04126	114.3	115.8	6.85
Long nominal	T 2 Feb25	95.13	2.77%	6.16		128.7	123.7	6.41
		Breakeven	2.11%			Residual	(7.9)	
		Fwd BEI	2.23%			Net (Residual)	0.22	

Source: Barclays Research

FIGURE 5

Daily Jan24-Jan25 FWD BE measure tracks the cumulative P&L earned on a Jan24-Jan25 Fwd trade setup initiated on February 8, 2018



Source: Barclays Research

Creating a forward breakeven rate using TIPS and nominals

To fully appreciate forward breakeven (BEI) rates, one has to understand how spot breakeven trades are constructed. We define the breakeven rate as the difference between comparable TIPS (real yield) and nominal Treasury yields.

Spot breakeven rate = nominal yield – real yield

Essentially, this is the market's expectation of inflation over a given period, plus an inflation risk premium, less a liquidity premium differential. One can capture a breakeven rate movement by DV01 weighting the TIPS versus nominals, similar to capturing the relative spread movements of 2s10s. If one expects the breakeven rate to widen, one would expect nominal yields to move higher relative to real yields, so would go long TIPS and short a DV01-weighted amount of nominals. One can also do a TIPS beta-weighted trade, but here, we assume that the trade is DV01 weighted.

FIGURE 6

Standard breakeven position, as of February 11, 2019

Bond Type	Issue	Price (decimal)	Yield	DV01	Index ratio	Par weights (mn)	Cash value ($mn)
Short TIPS	TII 0.625 Jan24	99.53	0.72%	5.20	1.07882	100.0	107.4
Long Nominal	T 2.75 Feb24	101.24	2.49%	4.71		110.2	113.0
		Breakeven	1.76%			Residual	(5.6)

Source: Barclays Research

There will be some residual starting cash flows (because of the 'dirty' price mismatch), as well as coupon accrual differential, depending on the path of inflation and reinvestments. The return attribution to this residual compared with realized-expected breakeven returns will be small. A breakeven position can really be thought of as a synthetic par breakeven bond. The risk measure of such a bond would be:

Breakeven_DV01 = Breakeven_ModDur * Index_ratio

Figure 6 shows a breakeven position (short) for the TIIJan24s. The breakeven rate is 1.76%, and the residual is $5.6mn (borrow).

FIGURE 7

Long 5y5y cash breakeven trade, as of February 11, 2019, $100k DV01

Bond Type	Issue	Price (decimal)	Yield	DV01	Index ratio	Par weights (mn)	Cash value ($mn)	Modified duration, (BEI_DV01)
Short TIPS	TII 0.625 Jan24	99.53	0.72%	5.20	1.07882	196.6	211.3	4.84, (5.22)
Long Nominal	T 2.75 Jan24	101.24	2.49%	4.71		216.7	222.3	4.60
		Breakeven	1.76%			Residual	(11.0)	
Long TIPS	TII 0.875 Jan29	100.44	0.83%	9.50	0.99691	212.8	213.2	9.48, (9.45)
Short Nominal	T 2.625 Feb29	99.74	2.65%	8.73		231.6	231.0	8.75
		Breakeven	1.82%			Residual	17.8	
		Fwd BEI	1.88%			Net (Residual)	6.8	

Source: Barclays Research

Calculating the forward breakeven rate

A long forward breakeven rate position is essentially a position on a forward starting breakeven contract at the present time. The P&L of such a trade will be realized as the market's expectation of this forward's breakeven rate changes. Here, we go through the steps to create such a forward.

Forward breakeven contract = ForwardBEIRate + residuals (bp)

Residuals (bp) is the offsetting residual costs of two simultaneous breakeven positions (two are needed to construct a forward breakeven rate) described above. These residuals exist because we are approximating forwards using cash coupon bonds, whereas bootstrapping spot rates to create forwards is accurate only using zeros. An approximate *ForwardBEIRate* can be derived in the same way as forward nominal rates using zeros. Here, we assume zero breakeven rates (BEI) to be spot breakeven rates of equivalent maturity bonds. We further assume constant rates and continuous compounding to arrive at a *ForwardBEIRate*.

$$EXP\,(\text{ForwardBEIRate} * (T_2 - T_1)) = \frac{EXP(BEI_2 * T_2)}{EXP(BEI_1 * T_1)} = EXP\,(T_2 * BEI_2 - T_1 * BEI_1)$$

$$\text{ForwardBEIRate} = \frac{(T_2 * BEI_2 - T_1 * BEI_1)}{(T_2 - T_1)},\ T_2 > T_1$$

For zero-coupon bonds, the modified duration (D) is roughly equal to its time to maturity. So the time component in the above formula can be replaced with modified duration (breakeven modified duration). We use TIPS modified duration for approximation purposes.

$$\text{ForwardBEIRate} = \frac{(D_2 * BEI_2 - D_1 * BEI_1)}{(D_2 - D_1)},\ W_1 = \frac{(D_1)}{(D_2 - D_1)},\ W_2 = \frac{(D_2)}{(D_2 - D_1)}$$

$$\text{ForwardBEIRate} = W_2 * BEI_2 - W_1 * BEI_1,$$

For a 5y5y fwd breakeven rate (as of February 11, 2019), with respective modified durations for 5y and 10y of 4.84 and 9.48, the above weights (W_1 and W_2,) would have roughly a 2-to-1 ratio, meaning the *Breakeven_DV01* of the longer security has to be twice that of the shorter one. This forces the inflation-adjusted notionals of the two TIPS securities involved in forward breakevens to be the same. This is an important step for a forward position because equal TIPS notionals force the accrual inflation gains/losses prior to the forward start date to be zero. For a forward breakeven position, we want inflation exposure to be defined from the forward start date, not prior.

Inflation Sensitivity = Jan29Notional * Jan29_IdxRatio – Jan24Notional *Jan24_IdxRatio

= 212.8*0.99691 – 196.6*1.07882 = 0.0,

In other words, until the maturity of TIIJan24, the position will not incur any P&L due to net notional inflation accretion. In the example (Figure 7), we show how this translates to notionals on a 5y5y fwd breakeven trade, assuming $100k DV01. While the current OTR 5y is the TIIApr23, we use the TIIJan24s to better align the duration difference.

Next (Figure 8), we look at how this position performs in various breakeven curve shifts and changes in the forward rate. Given the index ratio-weighted positions ($196.6mn to $212.8mn) on each breakeven leg with modified durations of 4.84 and 9.48, if breakevens across the curve rise in parallel by 10bp (fwd breakeven will rise by 10bp), the long position in 10y will rise in value by $2mn, and the short position in 5y will lose $1mn, netting $1mn of positive P&L. If the 5y breakeven falls by 10bp while the 10y breakeven is unchanged, the forward breakeven will also rise by 10bp (breakeven curve steepens), and the 5y leg incurs positive P&L of $1mn. This P&L matches the net P&L of a 10bp parallel shift in forward breakeven position. We also show the declining forwards (-10bp) scenario through parallel curve shifts, as well as curve flattening. In both 10bp fwd breakeven narrowing scenarios, the trade loses $1mn. Therefore, we feel confident that the above-described weighting method approximates forward rate exposure ($100k DV01), even though we are using cash bonds, rather than zeros.

FIGURE 8

Index ratio-weighted breakeven position gives inflation exposure only

	$196.6mn short TII Jan24 position (BEI_DV01: 5.22)	P/L ($mn)	$212.8mn long TII Jan29 position (BEI_DV01: 9.45)	P/L ($mn)	Fwd BEI rate	Overall P/L ($mn)
At entry	1.76%		1.82%		1.88%	
+ 10bp parallel BEI shift	1.86%	(1.00)	1.92%	2.00	1.98%	1.00
5y BEI falls by 10bp, 10y unchanged	1.66%	1.00	1.82%	-	1.98%	1.00
- 10bp parallel BEI shift	1.66%	1.00	1.72%	(2.00)	1.78%	(1.00)
10y BEI falls by 5bp, 5y unchanged	1.76%	-	1.77%	(1.00)	1.78%	(1.00)

Source: Barclays Research

Creating a specified DV01 trade using the above approach

We would use the following approach to find relative notionals to create a specific DV01 forward breakeven rate trade. We used $100k DV01 above, and now solve for $50k DV01.

- Jan24 has DV01 of 51,948 per $100mn
- Jan29 has DV01 of 95,000 per $100mn
- Jan24 index ratio is 1.07882
- Jan29 index ratio is 0.99691
- Relative index ratio (Jan29/Jan24) is 0.92407
  - 50k DV01 trade = 95,000 x Jan29Notional – 0.92407 x Jan29Notional x 51,948
  - Jan29Notional = $106.40mn
  - Jan24Notional = 0.92407 x Jan29Notional = $98.32
  - Check that the relative index ratio weight is maintained = $98.32mn/$106.40mn = 0.92407; the inflation sensitivity of this trade will be zero until the first bond matures.
  - Check that the DV01 of the trade adds up to $50k DV01
  - 50k = 95,000 x 1.0640 – 51,948 x 0.9832

INFLATION PRODUCTS

Beta calculations, drivers, and uses

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We discuss measurements and trends in betas used in computing nominal effective durations of linkers.

Effective nominal duration of inflation-linked bonds

Measuring the duration of a nominal bond when trying to determine the change in market value for a given change in the nominal yield is a straightforward concept. When it comes to inflation-linked bonds, however, things are not always so simple. We first need to decide whether we are calculating the price sensitivity to a given change in real or nominal yields. If the analysis is on real yields, typically used when comparing one linker with another or trading breakevens, then the approach is still straightforward. However, for any given move in nominal yields, usually part is a change in real yields and part is breakevens, though at times these two factors can move in opposite directions. This means that, typically, breakevens are directional with nominal rates. Investors attempting to take directionality out of a breakeven position or to incorporate linkers into a nominal portfolio might want to use the linker's effective nominal duration. To determine the effect of a change in nominal yields on an inflation-linked bond's market value, though, we first have to decide how much of the move is expected to come from a change in real rates. That relationship between real yields and nominal yields is called beta.

Mechanically, calculating the real duration of a Canadian model inflation-linked bond with respect to changes in real yield is done in the same way as calculating the nominal duration of a nominal bond. For the same maturity, the duration of a linker is likely to be longer than that of a standard nominal coupon bond, as the yield and coupon of the linker are likely to be lower. An example of this is in the US, where in February 2019 the real modified duration of the TII 1% Feb 2048 was 24.9, compared with the nominal modified duration of the nominal T 3% Feb 2048 of 19.0. Although the real duration is useful in itself, for instance in calculating carry effects or approximating the market value effect of a change in real yields, it does not offer an adequate solution for estimating the effective nominal duration of a linker. This effective duration depends on the relative volatilities of real yields and breakevens and the covariance between them, but these are not necessarily stable.

In most circumstances, the effective nominal duration of an inflation-linked bond should be lower than its real duration. This can be seen in the simplest form of the Fisher equation:

Nominal yield (y) = Real yield (r) + Breakeven inflation (bei).

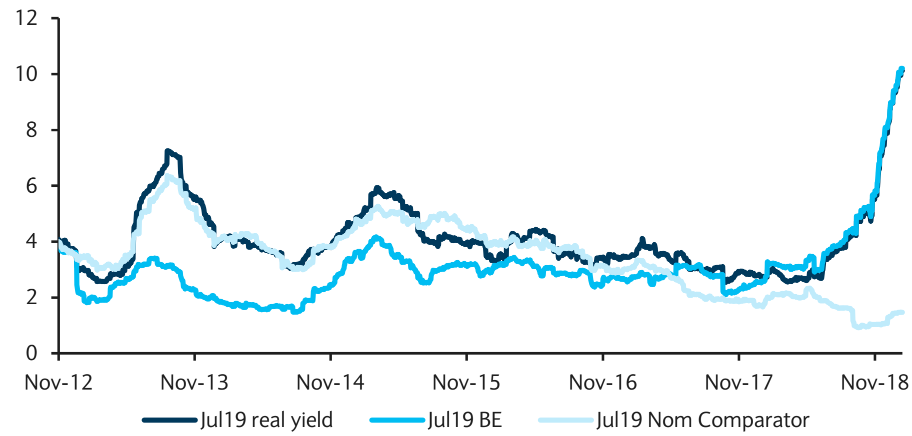
Consider the variances of both sides of this equation:

Variance (y) = Variance (r) + Variance (bei) + {2 x Covariance (r, bei)}

This formula shows that, provided the covariance between the real yield and breakeven inflation is not sharply negative, real yields will be less volatile than nominal yields. Figure 1 shows that this was usually the case on the TIIJul19s until mid-2013, when the "taper tantrum" led to a flight to quality in nominals, in which TIPS did not participate, and again once the issue rolled into the very short end. More recently, the risk-off move at the end of 2018 saw TIPS volatility spike again. In other words, the yield sensitivity, or "beta", of an inflation-linked bond to a change in the equivalent nominal yield will usually, but not necessarily, be less than one. If this beta were always a stable number, it would be easy to calculate the equivalent nominal duration for an inflation bond. However, if it were that easy, then there would be no additional value to inflation-linked bonds as a diversified asset class.

FIGURE 1

Realized volatility (bp/day)



Source: Barclays Research

The only mathematically correct way to report duration for a mixed portfolio of nominals and linkers, in a way that adds useful information, is to drop the standard duration figure and instead show two new numbers: duration with respect to real yield and with respect to inflationary expectations. These are the two main partial derivatives of the Fisher equation. On the other hand, using yield beta as shorthand to convert real yield duration into nominal space is useful as long its limitations are remembered. Figure 2 shows that the pre-crisis covariance between real yields and breakevens was relatively low. However, Figure 3 illustrates that since the crisis began in 2008 (to end 2011), not only has volatility increased, but covariances have been significantly negative. Since 2012, vols have declined.

FIGURE 2

Volatility composition in the US, France, the UK, and Japan (1999-2007)

	US	UK	France	Japan
Vol of nominal yield	5.5	2.7	2.7	1.3
Vol of real yield	3.0	1.6	1.7	1.0
Vol of breakevens	1.9	1.3	1.0	1.0
2 x Covar (RY, BE)	0.7	-0.2	0.1	-0.7

Note: Figures based on monthly changes for 1999-2007, except Japan from April 2004 to January 2008, for inflation-linked indices in each country versus maturity-matched nominal comparators. Variances are in non-annualized bp. Source: Barclays Research

FIGURE 3

Volatility composition in the US, France, the UK, and Japan (2008-2011)

	US	UK	France	Japan
Vol of nominal yield	8.9	4.9	4.7	1.3
Vol of real yield	8.8	4.0	4.9	10.5
Vol of breakevens	10.5	4.4	4.6	10.9
2 x Covar (RY, BE)	-10.2	-3.4	-4.7	-19.7

Note: Figures based on monthly changes for 2008-2011 for inflation-linked indices in each country versus maturity matched nominal comparators. Variances are in non-annualized bp. Source: Barclays Research

FIGURE 4

Volatility composition in the US, France, the UK, and Japan (2012-2018)

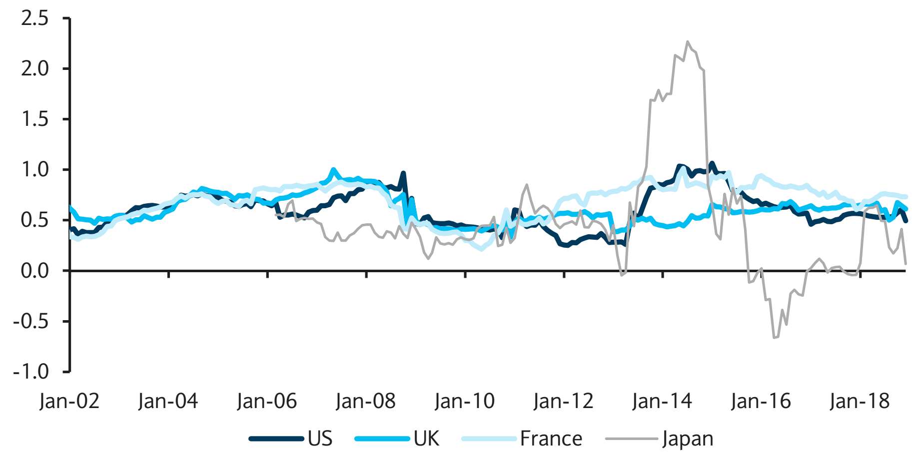
	US	UK	France	Japan
Vol of nominal yield	2.9	3.1	2.9	0.2
Vol of real yield	2.3	1.7	3.0	2.0
Vol of breakevens	1.3	1.2	1.3	2.1
2 x Covar (RY, BE)	-0.7	0.2	-1.4	-3.9

Note: Figures based on monthly changes for 2012-2018 for inflation-linked indices in each country versus maturity matched nominal comparators. Variances are in non-annualized bp. Source: Barclays Research

Rolling regressions using monthly yield change data (Figure 5) show that pre-crisis betas in the US, UK, Europe, and Japan were 0.6-0.8, but have become less stable since the crisis began. The regression is also sensitive to the period covered. Daily or weekly yield change data will give different results for the same period. Another form of beta used widely in the inflation-linked market uses the level rather than the change in yields. Although this is a statistically biased method, it has the advantage of picking up potentially important trend data that are lost in pure volatility analysis, but is not appropriate for the long term, where the bias can become too extreme.

FIGURE 5

Whole market yield betas based on two-year monthly changes



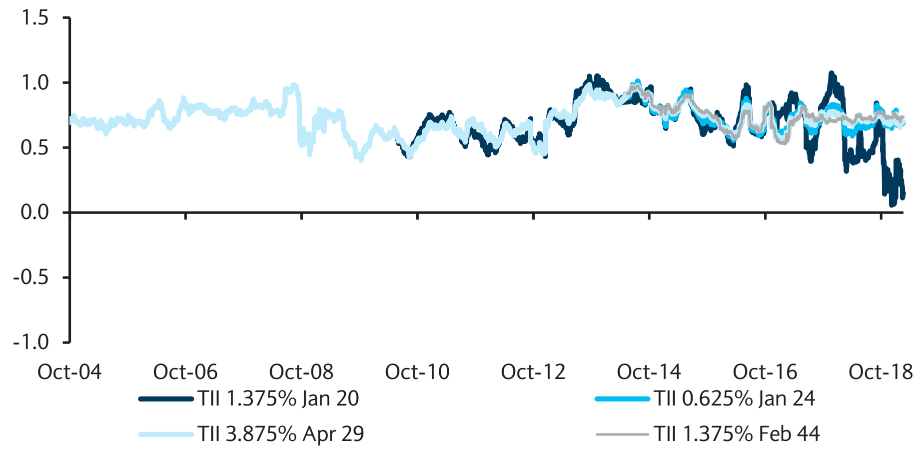
Source: Barclays Research

An alternative measure of beta that is arguably preferable is a calculation based on the volatility of relative returns, rather than yields. This has the benefit of directly including inflation carry data, a particularly important factor when considering shorter maturities but also for longer-term analysis, where inflationary trends can be an important factor. The adjustment to be made from a beta calculated from returns is very different from a yield beta analysis, though, particularly at longer maturities. The yield beta provides an estimate of the multiple that should be applied to real duration to get an equivalent nominal duration, whereas the returns beta provides a direct estimate of the relative volatility of the two bonds (or indices, as appropriate).

The estimate of beta is sensitive to the methodology used, but also to the period and maturity assessed (Figures 6 and 7). Beta should never be considered a stable relationship, but the most appropriate type of beta depends on its use. For a trader looking for a short-term hedge for linker exposure with nominal futures or bonds, a short-term yield beta estimation (eg, based on daily changes over one to three months) may make sense. However, in periods of extreme carry, a returns beta may be more advisable. For active money managers, a three- or six-month yield daily or weekly change beta may be the most representative, and this is also the time horizon over which yield level betas are most commonly used, as stable yield trend regimes typically last three months to a year. For longer-term total return investors, a two-year or longer monthly total return volatility beta is a logical starting point for asset allocation. For those with long-term real return aims or inflation-linked liabilities, real, not nominal, duration should arguably be the more appropriate measure for assessing risk, with a returns beta to compare the two.

FIGURE 6

Three-month yield change betas

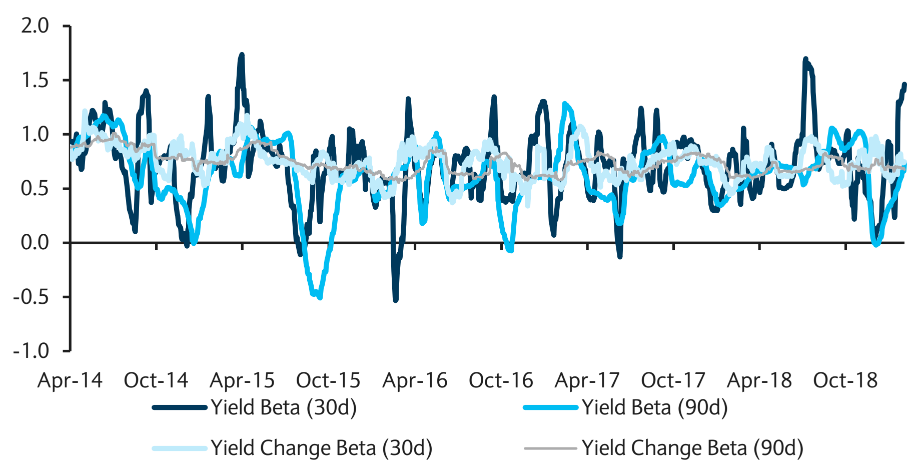


Source: Barclays Research

Betas will vary as a result of many factors, but one of the most significant is the type of investor in the asset class. Betas are usually lowest when real money, real yield investors are predominant. In most markets, these are most prominent at longer maturities, often leading to lower betas at the long end of the curve. At the short end, inflation uncertainty becomes an increasingly significant factor relative to the decline in nominal price volatility; indeed, for very short-dated bonds, betas will often be significantly above 1 or below 0 as a result.

FIGURE 7

Different betas for TIIJan24s



Source: Barclays Research

INFLATION PRODUCTS

The elusive inflation risk premium

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Although inflation risk premia may be difficult to measure, the CPI swap curve and survey expectations can provide a guide to what the market is pricing.

Long-term investors care primarily about the purchasing power, or real value, of their investments. Inflation-linked bonds provide a predictable real return to maturity, while nominal bonds do not; therefore, nominal bonds should be seen as relatively riskier investments from a real return perspective. Long-term nominal Treasury investors then should be compensated for taking on this additional risk by demanding a yield differential above actual expected inflation. This yield differential is known as the inflation risk premium, which, when positive, should lead breakevens to be higher than inflation expectations (elsewhere in this guide, we discuss the liquidity premium differential, which, because nominal Treasuries are more liquid than TIPS, should push down on breakevens and offset the inflation risk premium).

While we generally think of the risk premium as a positive factor that should increase with maturity, it may reasonably be negative at the front end of the curve. Most money managers who invest at the front end of the curve have a nominal return mandate and are therefore taking on risk by investing in real securities. Because short TIPS are correlated to energy prices, they tend to be much more volatile than nominals, whereas front-end investors typically have their money there because they want to avoid volatility. These investors would need to be compensated for this risk and volatility by demanding a higher real yield. This would lead breakevens to be lower than inflation expectations and helps explain why short TIPS usually trade cheap to fundamentals.

Finding the inflation risk premium has always been something of an academic "holy grail." Beware those who claim to have found it, because the path is fraught with difficulties. We do not question the premise that investors might be prepared to pay a risk premium for inflation protection or that the premium may vary through time. That is a logical concept, as is the argument that the premium should be a function of inflation uncertainty, which, in turn, is likely to be correlated with the recent experience of inflation volatility and, even more important, central bank credibility. However, these ideas get us no closer to attaching a value to the premium.

The problem is that true market inflation expectations are not observable. We cannot precisely disaggregate a breakeven inflation rate into its three components: inflationary expectations, the inflation risk premium and the liquidity premium differential between TIPS and nominals. We might have an economists' "consensus" for this year's or next year's inflation (which is usually just a modal forecast rather than a probability weighted one), but there is no guarantee that this is either up-to-the-minute or in agreement with the market's consensus. Some have tried to estimate risk premiums by using survey measures of inflation expectations, such as the 5-10y median inflation expectation component of the University of Michigan consumer sentiment survey or inflation expectations from the Survey of Professional Forecasters. However, the stability in these surveys, in addition to other factors, makes them unreliable indicators of inflation expectations, although they are not without information content.

For an inflation bond market, even considering breakeven inflation rates as representative of the expectations and risk premia of marginal investors is overly simplistic, despite often being used as the starting point for academic studies. This is because issuers, as well as investors, have reaction functions based on their expectations and risk preferences. Because governments can issue either nominal or inflation-linked bonds, the ratio is dependent on their views, even if it can be accepted that their total funding needs are determined exogenously. While this is not likely a factor in near-term issuance in the US, it may be in the longer term and can matter in the near term in countries where governments are openly opportunistic in their issuance patterns. In addition, issuance can weigh on markets into auctions as investors build in a concession. Therefore, in the very short term and in the medium to long term, supply can be a driver of breakevens.

Many inflation-linked bond markets appear to have had breakeven inflation levels that were below what was commonly perceived to be expected future inflation in the relatively early stages of their development. We believe this is because the inflation risk premium was dominated by the liquidity discount relative to nominal bonds. However, it is quite possible to reason how this could occur, even without considering liquidity factors that may skew preferences towards nominal debt. If a government values the portfolio diversification of increasing the amount of its inflation-linked debt, it may be willing to pay a premium to issue it. In addition, the issuer may be willing to accept relatively cheaper issuance in the early stages of a program in order to establish it in the hope of more attractive funding levels in the future. Thus, it may issue at a breakeven rate below the expected inflation level. Even while many investors may be willing to pay a risk premium in this environment, if supply in the short term is greater than that sought by such investors, the market-clearing breakeven level may still be lower than consensus inflation expectations.

An additional computational bias tends to understate inflation expectations using bond breakeven inflation. Convexity means that forward bond curves understate true expectations of the path of rates. Because the value of convexity is a function of volatility and real yields are generally less volatile than nominal yields, there is less convexity effect on the real curve than the nominal curve. Hence, the yield on a long-dated nominal bond is biased down more due to convexity than that of a similar maturity inflation bond. The breakeven inflation implied by the yield spread is, thus, somewhat lower. In practical terms, the effect at shorter maturities is minimal, but for 30y breakevens, it is a factor that should not be ignored.

Despite the problems of convexity, the shape of the breakeven inflation curve may indicate whether there is an inflation risk premium in the market and how it changes over time. In particular, the breakeven slope beyond five years in a liquid market may be a reasonable guide to developments in risk premia because there is unlikely to be a strong belief in the market about inflation trends after the current economic cycle. The slope of the forward breakeven curve beyond five years would be a purer measure, but constructing this for bonds is a relatively complex process that, in practice, can create more distortions than it solves because of the need to fit multiple curves. Instead, we discuss below how one might use the CPI swap curve to catch sight of the "grail," even if not to hold it.

If it weighs the same as a duck…

While we do not claim to be able to measure the inflation risk premium accurately, we believe it is currently lower than pre-crisis levels, but should move higher. This means that if the market's fear of downside risks continues to decline and liquidity continues to improve, breakevens could consistently trade above inflation expectations and the curve could be steeper than it otherwise would be.

One way to approximate the inflation risk premium is to look at spreads of short breakevens in forward space. Arguably, if one looks far enough into the future, inflation expectations should be constant and the spread of forward rates should reflect inflation risk premiums and convexity. For example, it is unlikely to have a view that 1y inflation 15 years ahead will be different than 1y inflation 20 years ahead. Figure 1 shows the spread of different forward 1y rates. The pre-crisis average of these spreads implies that the inflation risk premium on a 10y breakeven had been 25-30bp but is now negative or close to zero (Figure 1).

FIGURE 1

Spread of forward 1y CPI swaps

	Jan 05 - Jul 08 average	As of April 30, 2012	As of Sep 22, 2016	As of Feb 15, 2019
10yF1y-7yF1y	9.8	-3	13	17
15yF1y-10yF1y	15.5	-2	-8	-13
20yF1y-15yF1y	12.6	-2	-5	-5
25yF1y-20yF1y	9.7	-1	3	4

Source: Barclays Research

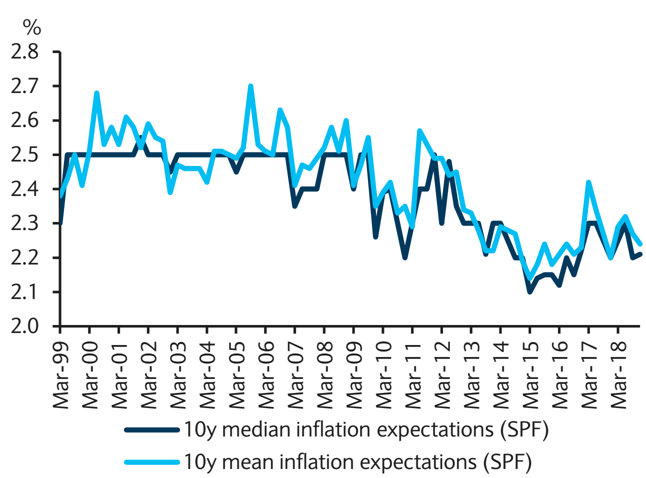
Another way to approximate the inflation risk premium is to use survey measures of inflation expectations, since market inflation expectations are not directly observable. One source for 10y inflation expectations is the Philadelphia Fed's quarterly Survey of Professional Forecasters (SPF). Specifically, we use the mean of that survey because the median at times has been too static to be believable (Figure 2) and the market is more of a mean (though a weighted one) than a median metric. Subtracting the survey measure from 10y breakevens produces a fairly consistent negative value, though this can be because breakevens also contain a relative liquidity discount that tends to offset the inflation risk premium. If we subtract the survey measure from CPI swaps instead, we get a (usually) positive measure (Figure 3). It currently sits at -30bp, up about 5bp since this publication was last updated in October 2016.

Low 5y5y BE implies either that the market expects the Fed to miss its target or that the inflation risk premium is negative

We can also compare forward breakevens with the Fed's target. For example, 5y5y breakevens, using the Barclays measure in our *Inflation-Linked Daily*, is 1.87%. If the market were pricing in exactly the Fed's target of 2% on PCE inflation, the 5y5y BE should be about 2.40%, given the historical CPI/PCE basis. That 5y5y is below this implied means either that the market expects the Fed to miss its target or that the inflation risk premium is negative. Similarly, 10y20y cash breakevens, at 1.93%, imply either that the market thinks inflation will be higher in the longer term than it will be in the medium term or that the inflation risk premium is actually positive.

FIGURE 2

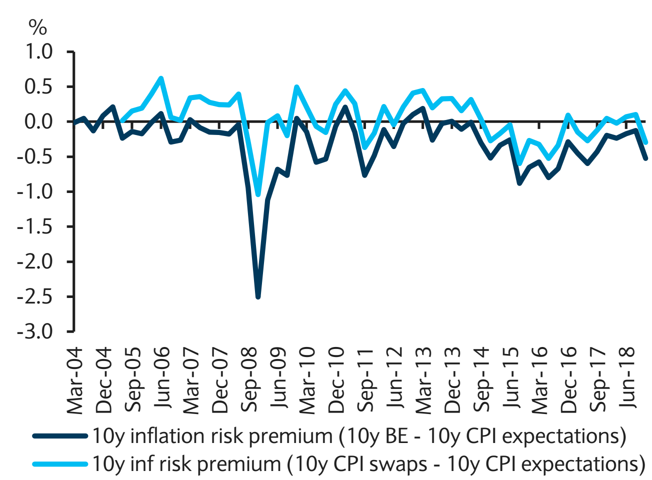
10y inflation expectations from the Survey of Professional Forecasters



Source: FRB Philadelphia, Barclays Research

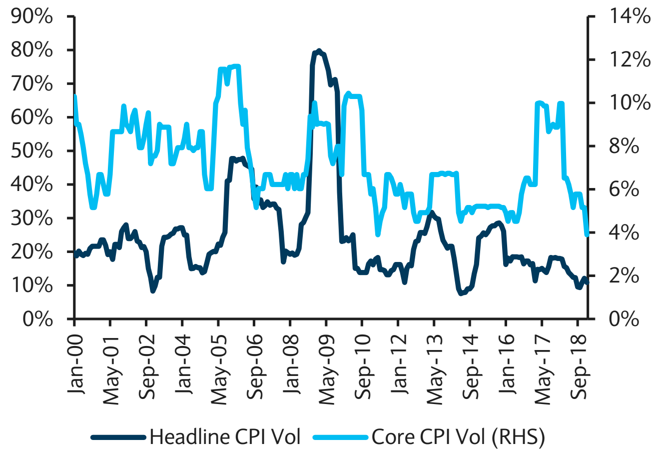
FIGURE 3

10y inflation risk premium



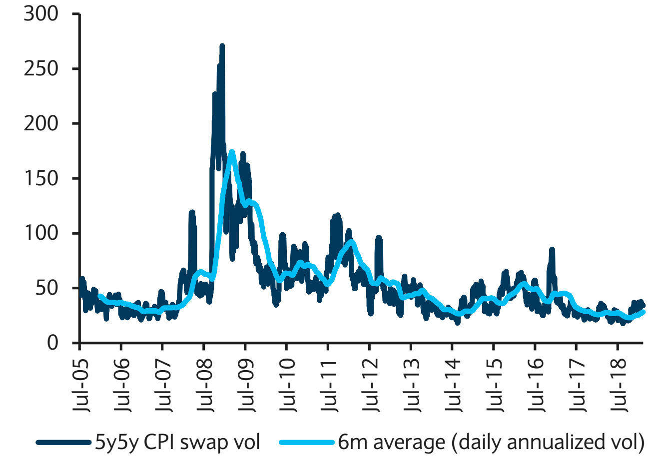
Source: FRB Philadelphia, Barclays Research

FIGURE 4
Headline and core CPI volatility



Source: BLS, Barclays Research

FIGURE 5
5y5y CPI swap volatility is lower

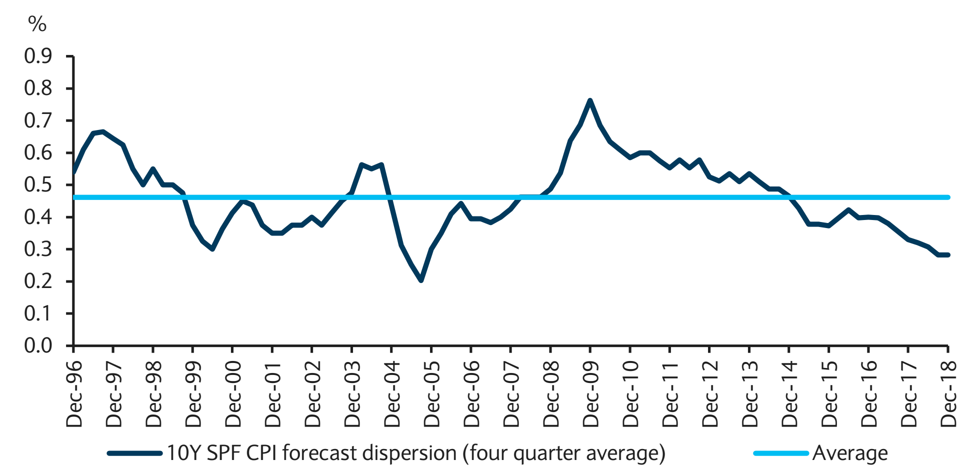


Source: Barclays Research

Low volatility justifies low risk premium

The metrics above all seem to imply that the inflation risk premium has declined and is low or negative. While we think it should be higher because of the uncertainty of a potential policy mistake as the Fed exits its current stance, recent market and inflation trends can explain the low inflation premium. Inflation itself has been low recently; thus, it makes sense that the risk of high inflation is lower on investors' radar screens. Inflation volatility has also been relatively low (Figure 4), and if investors expect this to continue, they should demand less of an inflation risk premium. Uncertainty about the medium-term inflation outlook also appears to have declined recently. This can be seen in realized 5y5y CPI swap volatility (Figure 5), as well as a measure of dispersion within the Survey of Professional Forecasters (Figure 6). Again, if investors have more confidence about the inflation outlook, then it seems logical that they would demand less of a premium.

FIGURE 6
10y SPF CPI forecast dispersion



Source: FRB Philadelphia, Barclays Research

Perfect, now change

We do think there is justification for a decline in inflation risk premium (though perhaps not to negative levels). In the current environment of tight labor markets and a positive output gap, inflation has failed to rise significantly and remains (marginally) below the Fed's 2% target. Until the Fed proves it can stoke inflation from below and let the economy "run hot" for a considerable period, the inflation market is unlikely to be concerned about an overshoot of the target. As a result, uncertainty around the path of future inflation should remain low and so too the inflation risk premium. It will take higher inflation expectations, resulting from higher realized inflation to meaningfully increase inflation risk premium out the curve.

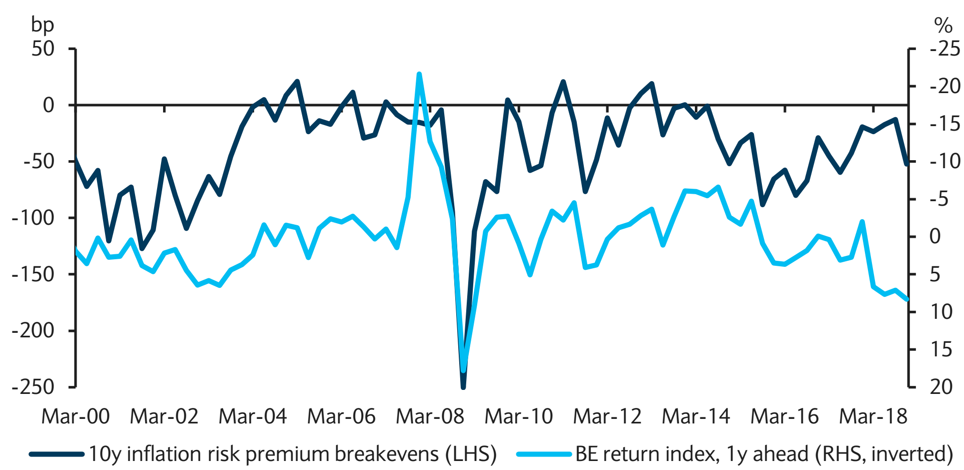
Inflation risk premium and subsequent breakeven returns

The correlation between the inflation risk premium and subsequent breakeven returns is about 60%

In the *2014 US Inflation outlook (page 5),* we highlighted the utility of the real risk premium in forecasting the year-ahead 10y TIPS returns. We concluded that TIPS returns were likely to be more positive than in the previous year, as the real risk premium had risen significantly by late 2013. The real risk premium measure was derived by subtracting the Survey of Professional Forecasters (from FRB Philadelphia) based real rate expectations from the market observed 10y real rates. Specifically, the real rate expectations were derived by subtracting the 3m T-bill return expectations over the next 10 years from 10y CPI expectations. We think a similar approach is useful in forecasting the year-ahead 10y breakeven returns. Figure 7 shows the high degree of correlation between the SPF-based 10y inflation risk premium and the year-ahead index breakeven returns. The correlation between the two series over the shown period has been close to 60%, indicating that the inflation risk premium is useful in forecasting breakeven returns. The inflation risk premium has been lower for the past year, suggesting that breakeven returns are likely to be higher in the coming year.

FIGURE 7

10y inflation risk premium and the year-ahead breakeven return correlation is close to 60%



Source: FRB Philadelphia, Haver Analytics, Barclays Research

INFLATION PRODUCTS

Measuring the relative liquidity premium – The other Holy Grail

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For investors considering the fair value of linkers versus nominals or issuers considering ex-ante costs, inflation risk and relative liquidity premiums are important, but both are difficult to measure. Here, we examine liquidity premiums.

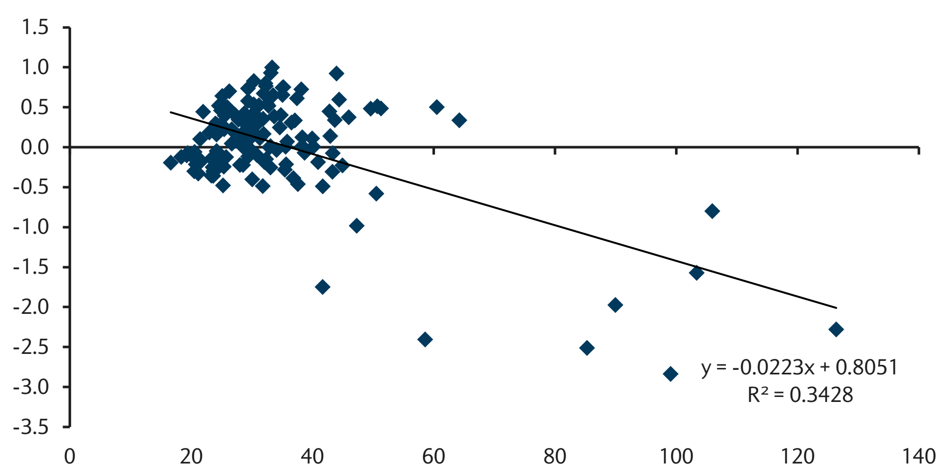
Breakevens are equal to inflation expectations plus a liquidity-adjusted inflation risk premium. We can further break down the second factor into the inflation risk premium and the liquidity premium differential, where the former generally is positive for breakevens while the latter is negative. Because these factors usually push in opposite directions, the liquidity-adjusted breakeven can end up positive or negative and breakevens can be higher or lower than inflation expectations. We focus on the risk premium in "The elusive inflation risk premium" elsewhere in this guide; here, we discuss how much investors are willing to pay for the better liquidity of nominal Treasuries relative to TIPS.

In a working paper[1], Carolin Pflueger and Luis Viceira attempt to estimate the liquidity premium differential component of 10y breakevens – ie, the premium investors are willing to pay for nominal Treasuries relative to TIPS because the former are more liquid. We believe their estimate, in a May 2011 version of the paper[2], of "around 40 to 70 basis points in normal times" is unrealistically high, although it is closer to reality, in our view, than the results in the March 2011 version of the paper[3], in which they estimated it to be about 70bp. Relative asset swaps (a better measure we think) indicate that the premium is closer to 20-30bp, and we believe even this measure overstates the liquidity premium.

In estimating the liquidity premium differential, Pflueger and Viceira run a regression on breakevens against a set of variables, such as the spread between on-the-run and off-the-run nominal Treasuries, which is related to investors' demand for liquidity in nominal Treasuries. Because the variables are related to liquidity preferences, the authors believe they have isolated changes in breakevens caused by changes in the liquidity premium.

FIGURE 1

Correlation between global ISM (y-axis) and nominal/TIPS relative ASWs (x-axis, bp)



Note: Monthly data from September 2006 to December 2018. Source: Barclays Research

[1] *An Empirical Decomposition of Risk and Liquidity in Nominal and Inflation-Indexed Government Bonds*, Harvard Business School, July 2010

[2] *http://www.people.hbs.edu/lviceira/PV-TIPS-20110523_authors_all_and_appendix.pdf*

[3] *http://www.hbs.edu/research/pdf/11-094.pdf*

Instead, because investor preference for liquidity is often related to financial market stress and, over the past several years, financial market stress has been related to concerns about the economy, the liquidity variables end up acting as direct measures of liquidity premiums and proxies for economic concerns. Using relative asset swaps between TIPS and nominals as a measure of financial market distress and using Barclays' Global ISM index as an indicator of economic conditions, Figure 1 shows this strong relationship between financial market and economic stress.

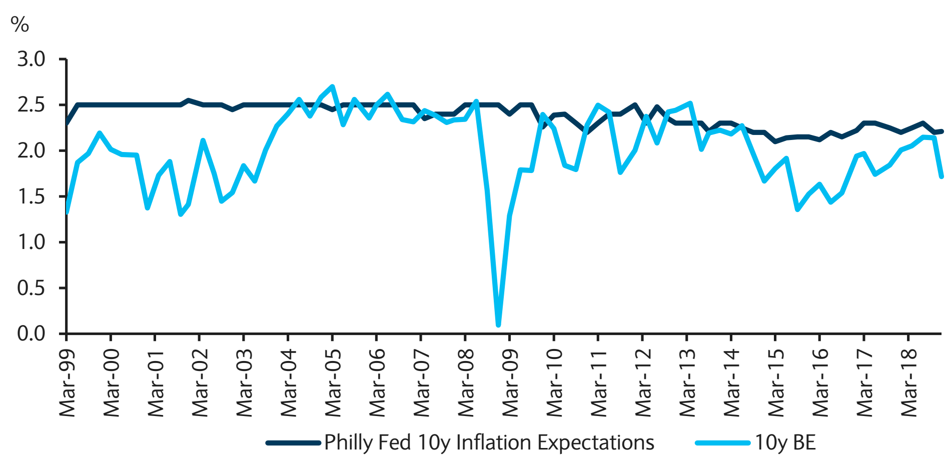
The authors believe they have isolated liquidity because when they add the 10-year forward inflation expectation from the Philadelphia Fed survey of Professional Forecasters, the model coefficients do not change significantly. We believe this is a bit misleading because, in our view, the results of that survey are unrealistically stable. Figure 2 shows that from March 1999 through December 2009, the median 10-year-ahead headline CPI inflation forecast from that survey remained in a 30bp range and was 2.5% in 34 out of 44 quarters over that period. While 10-year forward inflation expectations might be stable because of Fed credibility, we find it unlikely that market inflation expectations for 10-year-ahead inflation were virtually unchanged over a 10-year span that included energy shocks and the great recession. Therefore, we do not agree with the results of Pflueger and Viceira's model, which found that most of the fluctuations in breakevens can be explained by changes in the liquidity-premium differential.

In our view, this "double counting" of liquidity variables – as a measure of liquidity preference and as a proxy for economic concerns – has led to a significant overestimation of the liquidity premium differential between TIPS and nominals. For example, suppose a shock to financial markets causes investors to flock to the liquidity of nominal Treasuries and also leads to a decline in growth and inflation expectations. Also, let's assume that the liquidity premium and inflation expectations change so that each causes a decline in breakevens of the same magnitude. The regression coefficient would be double what it should be if preferences for liquid instruments were not correlated with economic concerns.

Double counting is evident in Pflueger and Viceira's estimation of the coefficient on the relative ASW between TIPS and nominals. We believe this spread is the best direct (though not exact) measure of the liquidity premium differential. They note that the theoretical value of the coefficient should be -1 (when the relative spread widens, breakevens should go down an equal amount); however, the authors find that left unconstrained, the coefficient is -1.6 (when the relative spread widens, breakevens should go down 1.6x the spread

FIGURE 2

10y BE and inflation expectations from the Philadelphia Fed survey of Professional Forecasters



Source: FRB Philadelphia, Barclays Research

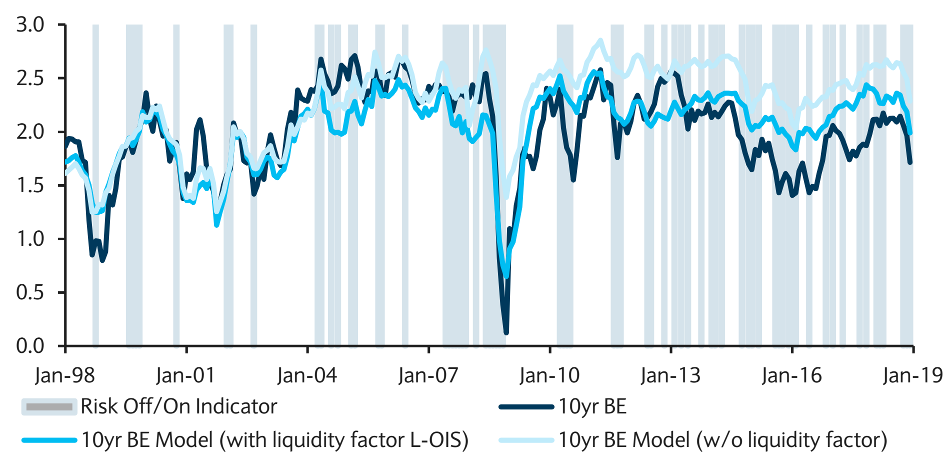
widening). We have run similar regressions and also get an unintuitive coefficient with an absolute value greater than one (Figure 3) when we use only liquidity variables to model breakevens. We ran the model using the Fed's 10y breakeven (which compares an off-the-run nominal curve with a TIPS curve that does not strip out off-the-runs), as the authors did, and using traded breakevens, which are more relevant for measuring liquidity premiums between on-the-run TIPS and on-the-run nominals. However, when we include relative ASWs in our fundamental breakeven model, we get the theoretically intuitive result of -1. Note that when we incorporate ASWs in a fundamental model on 10y CPI swaps, the coefficient is near zero and the t-stat is insignificant. In our view, this indicates that, although not perfect, relative ASWs are a fairly accurate indicator of the liquidity premium between TIPS and nominals. Figure 4 shows the results of our liquidity factor (L-OIS spread)-augmented fundamental model versus actual breakevens over time. It indicates that 10y breakevens are about 28bp cheap, while a model without the liquidity factor indicates close to 57bp of cheapness.

FIGURE 3
Breakeven model results

Dependent variable			Liquidity variables		Economic variables			
	10y		On-/off-the-run spread (%)	Relative ASWs (TIPS minus nominals, %)	Global ISM	FF6-FF1	Ln Gasoline	R^2
Model 1	Fed BE	Coef	-0.01	-0.01				80%
		t-stat	-3.24	-7.03				
Model 2		Coef		-0.010	0.310	0.140	0.368	87%
		t-stat		-5.256	5.031	2.639	3.253	
Model 3	Cash BE	Coef	-0.01	-0.01				84%
		t-stat	-3.97	-7.84				
Model 4		Coef		-0.011	0.323	0.151	0.369	90%
		t-stat		-6.104	5.943	3.227	3.702	
Model 5	ZC CPI Swap	Coef	-0.011	-0.005				53%
		t-stat	-3.07	-2.30				
Model 6		Coef		-0.001	0.292	0.149	0.361	72%
		t-stat		-0.827	5.237	3.091	3.532	

Source: Barclays Research

FIGURE 4
10y breakeven and liquidity factor-augmented fundamental model of 10y breakeven



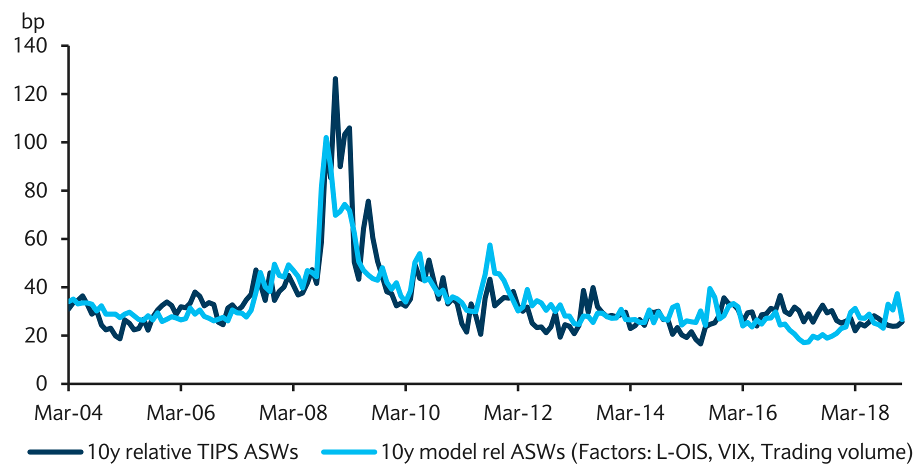
Source: Barclays Research

Modeling relative ASWs

We expect TIPS liquidity to increase over time and, therefore, TIPS relative ASWs to compress. Because of the importance of relative ASWs in measuring TIPS liquidity as highlighted above, we have come up with a fair-value model for TIPS relative ASWs (Figure 5). TIPS relative ASWs show a firm correlation with various liquidity measures such as TIPS trading volume, VIX and L-OIS. The coefficients of this model make sense. For example, the beta of trading volume with respect to relative ASWs is negative, which makes sense because as trade volume rises, TIPS liquidity improves and the relative ASWs compress. There is a positive relationship with the 3m L-OIS spread, which also tends to widen during a crisis. With respect to the VIX index, TIPS have a positive beta, which indicates that as the market volatility increases, relative ASWs widen. At February 2019, the VIX index is trading at a local low, recovering from the recent spike to end 2018, while the L-OIS spread has remained fairly subdued. TIPS trading volumes have been rising steadily, as the Treasury remains committed to the TIPS program. With these factors, 10y relative ASWs fair value is about 27bp, while the market is trading at roughly 26bp. This indicates that relative ASWs are trading right around fair value.

FIGURE 5

10y relative ASWs changes are well explained by TIPS trading volume, VIX and L-OIS spread



Source: Barclays Research

INFLATION PRODUCTS

New linker issue pricing

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We discuss the process of estimating fair value on new inflation-linked issues and the factors that drive the roll.

When a new issue is brought to market there is a price discovery period. Prior to the auction of new US TIPS and launch of European linkers via auction, this price discovery period includes trading in the so-called when-issued (WI) market. In other cases, new linkers may be brought via syndication, with the syndicate of banks involved working in consultation with the issuer to glean feedback on demand prior to and during a book-building process in order to fix an initial price. We consider several factors involved in estimating fair value of a new issue relative to existing bonds, specifically considering US TIPS, and extend the analysis to Europe.

Estimating TIPS rolls

A new issue yield is usually quoted as a spread to the current on-the-run security; this spread is known as the roll. This is true of both nominal and inflation-linked issues, but with linkers there are additional factors to consider. The four main factors that determine the fair value of a nominal roll are: curve, carry, liquidity premium, and adjustment for bad days. For Treasury Inflation Protected Securities (TIPS), the relative contribution of seasonality of inflation accrual and the relative value of the deflation floor premium also need to be taken into account. We discuss each of these factors in detail and, by example, show how we came up with our estimate of the TIIApr23s in April 2018.

Curve

Factors driving the fair value of the roll

In general, investors demand additional yield moving out the curve to compensate for the higher duration exposure. Since the WI issue is a more recent security, its duration exposure is higher (with the potential exception of long bonds if yields have risen sufficiently for the new issue to have a notably higher coupon); therefore, the curve component should generally be positive. This is not always the case; the curve may be downward sloping if the market was expecting a weaker economy or a steady decline in inflation, and this component could therefore be negative. The curve can be roughly estimated using the difference in yields between pairs of similar maturity differences in that part of the curve. For instance, before the announcement of the TIIApr23s, the TIIJan22/TIIJan23 spread was 6.5bp and the TIIJul22/TIIJul23 spread was 7.8bp. One could take an average of the two as a guide to the curve between the TIIApr22 and TIIApr23 issues. However, there are various issues with such an approach that must be kept in mind:

- First, if the curve is highly concave, the shape of the curve may be changing rapidly around the sector in question. Hence, the estimation using previous pairs may misjudge the true curve.
- Second, even if the previous pairs are as equidistant in terms of maturity as the WI and the OTR, they may not be in terms of duration. For instance, if rates moved substantially since the previous auction, the coupon on the WI and the OTR would be very different. If the market had sold off, the coupon would be higher and, therefore, the duration of the WI might not be very different from the on-the-run, despite having a higher maturity.
- Third, part of the difference between these or other pairs could be due to issue-specific relative value. Even annual pairs, where seasonality would not come into play, could be distorted by coupon differentials, liquidity factors or micro richness/cheapness of specific issues.

We believe a superior approach that accounts for these issues is to price the curve value between the WI and OTR issue off a real spline or the swap curve, using the maturity and expected coupon, and compute the difference between the two yields. Computing a nominal Treasury roll using a spline curve is usually sub-optimal to the swap curve because the former might be distorted by liquidity premiums, but this is less of an issue in TIPS. Using the spline curve approach, we found the TIIApr22/TIIApr23 curve to be worth 7.0bp, roughly the average of the other pairs above.

Liquidity premium

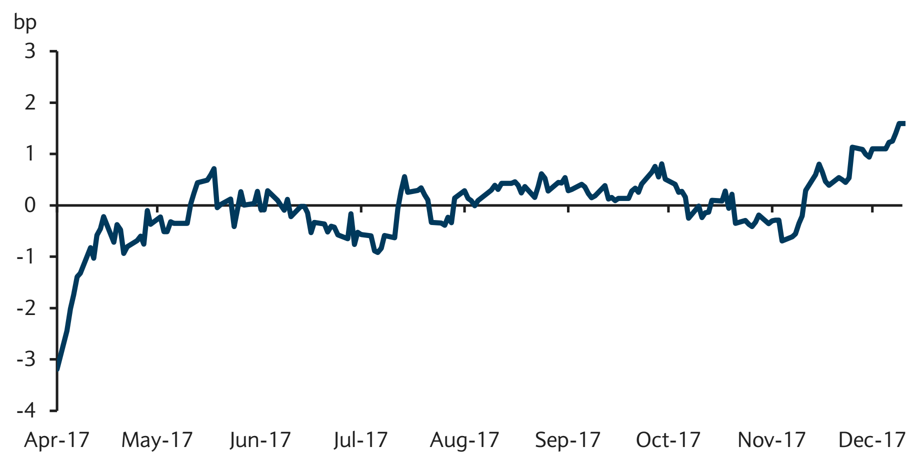
WI issues generally command a liquidity premium

The liquidity premium arises from the preference for owning the more recent issue due to ease of trading; therefore, there is generally a preference to own the WI relative to the OTR. If that is the case, the roll would not be as high as the curve component suggests and should therefore be adjusted downwards to reflect this premium. However, because issue sizes have grown, new issues may initially trade at a discount as the market could take time to absorb a significant amount of supply. While there is no market-traded instrument that can be used to extract the premium directly, we can estimate it from the premium in the current and old OTR pair.

The outright yield spread between the current and old OTRs will have a curve component in addition to the liquidity premium; therefore, it cannot be directly used as an estimate of the liquidity premium. Instead, the spread between asset swap levels should be a good proxy because the curve component that arises from the duration exposure will have been eliminated as fixed cash flows are transformed into floating rate cash flows. What is left should largely be the liquidity premium. We say “largely” and not “fully” because the asset swap curve in itself need not be flat but may have a shape as well.

Another approach to estimating the liquidity premium is to analyze the spread to a seasonally and option-adjusted real yield spline curve for the current OTR at time of its issuance. For the TIIApr23s, that means looking at the TIIApr22s around its issue date (April 2017). Figure 1 shows the bond traded roughly 3bp rich to the spline out of the gate, but quickly cheapened from there. Combining the above approaches, for the TIIApr23s, we estimated that the liquidity premium was worth -1.5bp to the roll.

FIGURE 1
TIIApr22 spread to adjusted real yield curve



Source: Barclays Research

Bad days

An adjustment is needed to account for the relative number of bad days in the WI and the OTR

The roll estimate (true curve + liquidity premium) is applied to the true yield of the current OTR to get the true WI yield at announcement. However, the quoted yields could be different from the true yields; therefore, the quoted roll could be different as well. The *true* yield methodology discounts bond cash flows off of their holiday-adjusted payment dates, which would push the cash flow forward. The *quoted* yield methodology discounts bond cash flows off of their unadjusted payment dates. Since the true yield methodology pushes cash flows forward, the discounting yield should be lower to get the same market price. Hence, if there are "bad days," the quoted yield would be higher than the true yield.

The effect of the roll will depend on which bond has more bad days, the WI or the current OTR. If the WI has more bad days, its quoted yield will be higher than the true yield by a higher amount and the roll will need to be adjusted upwards, and vice versa. In the TIIApr23s example, the bad day adjustment nets to -0.2bp.

Carry

Converting the estimate of the roll at settlement to the roll at announcement

The above analysis gives the roll estimate (curve + liquidity premium + adjustment for bad days) as of the settlement date of the auction, which needs to be translated into a roll at the announcement date, as the roll begins to trade then. The difference arises from the loss (or gain) of carry on the current OTR because the new issue will not settle until sometime after the auction. When an investor buys the roll, the transaction involves buying the WI for forward settle and selling the current OTR for regular settle. If the carry in being long OTR is positive, the investor loses that carry in this transaction and, therefore, should be compensated by being offered a higher yield on the WI. Hence, the roll at announcement should be higher than the roll at settlement if the carry is positive and lower if it is negative. In the current example, the carry on the TIIApr22s from the announcement settlement date of April 13, 2018 to the auction settlement date of April 30, 2018 was 5bp. This is another way of saying the forward (April 30, 2018 settle) yield on the TIIApr22s was 5bp higher than the spot (April 13, 2018 settle) yield on the announcement date of the new issue.

Some more adjustments for inflation-linked securities

The roll factors discussed above are applicable for both nominal and inflation-linked securities. However, one needs to be cognizant of two more factors when looking at linkers: seasonality of inflation accrual and deflation floor premium.

Inflation compensation: TIPS inflation accrual is paid based on the non-seasonal CPI print. CPI prints in the early part of the year are generally above their seasonally-adjusted prints, and those towards the end of the year are lower. Seasonality does not matter if the current on-the-run and to be newly issued TIPS have the same maturity month, as is the case at the 5y point. However, if these are different, one should account for the seasonality patterns. This is currently an issue at the 10y point in the US, because the Treasury issues January and July new 10y TIPS. July issues trade rich to January and April issues, and January issues trade rich to April issues (rich, that is, without accounting for the benefit of seasonality). Hence, the roll (computed versus a January issue) based on a similar analysis as that described earlier for nominal securities should be adjusted downward if the new issue is a July issue and upwards if it is an April issue. The difference between seasonally adjusted CPI (CPI SA) and CPI NSA m/m can provide a starting point to adjust for seasonality. Also, one can look at how consecutive January/April/July issues trade at other maturity points. More detail on computing the effect of seasonality can found in the Seasonality article in this Guide. We generally find this seasonal switch to be close to 5bp, but it can change over time.

Deflation Floor: TIPS and linkers in some other markets have a deflation floor; ie, the face amount returned at maturity will be the maximum of the par amount or the inflation indexed par amount. Hence, over the life of an issue, if the CPI index has declined, the investor will still obtain par even though the inflation-adjusted par will be below 100. Therefore, if the OTR and WI issues' index ratios are at a different distance from 1.0, one needs to take into account the relative value of the deflation floor. For instance, if the CPI index has declined since the most recent auction, the OTR index ratio will be below 1 and its deflation floor will be more valuable. The roll should therefore be adjusted upwards, as the OTR will be trading at a premium. In the current example, we estimated the floor value on the TIIApr22s to be about 1.1bp, whereas the floor value on the TIIApr23s was estimated to be 1.75bp. Therefore, the floor value spread was estimated to be about +0.7bp. This positive spread needs to be subtracted from the roll because, all else equal, investors should be willing to pay this as a premium to own the issue with the more valuable floor. See the separate section in this Guide on Par Floors for further consideration on how floors are valued.

We then need to put all these parts together to come up with an estimated roll. We found the fair value of the roll on this new issue to be about 9.6bp. Assuming 1.75% repo from April 13 settle to April 30, 2018, the carry on April22s is about +5.0bp. The floor on the new issue is worth about +1.75bp (in running terms) while the TIIApr22 floor is worth about +1.1bp, and so the relative difference is about -0.7bp. Using our curve estimate of 7bp, bad days of -0.2bp, and liquidity premium of -1.5bp, we get the total roll of +9.6bp (7.0bp + 5.0bp – 0.2bp – 1.5bp – 0.7bp). As it turns out, initial indications on the roll just after the announcement was +8.5bp (mid), so the market traded roughly 1bp rich to our estimate.

FIGURE 2

Fair value estimate of TIIApr22/TIIApr23 roll

Five-year TIPS Forward Roll	
Announcement Date	4/12/2018
Settlement Date	4/30/2018
Expected Issue Size ($bn)	16
Yield of Current Benchmark (TIIApr22)	0.52%
Financing Rate from 04/13 to 04/30/18	1.75%
Total Financing Days	17
Net Carry (bp)	5.0
Yield Curve (bp)	7.0
Bad Days (bp)	-0.2
Liquidity Premium (bp)	-1.5
Floor Value Spread (TIIApr22-TIIApr23)	-0.7
Seasonality Premium (bp)	0.0
Fair Value Forward Roll (bp)	**9.6**

Source: Barclays Research

Estimating new issue valuations in Europe

In the US, the roll typically starts trading soon after the initial size and coupon of the new issue is announced. In Europe, WI trading is typically less active for initial auctions, in part because the roll is much less well defined, and very rare if bonds are brought via syndication. While the elements already discussed for TIPS pricing are applicable for calculating fair value estimates for European inflation-linked bonds, there are additional complications. In particular, unlike in the US, the concept of on-the-run bonds is not typically seen in linkers, with non-standard initial maturities and regular reopenings of most bonds. Hence, to the extent that WI trading occurs on a roll basis, rather than in absolute yield or breakeven, it is typically to the nearest issue, which can be shorter or longer than the auction stock. For example, ahead of the OAT€i18 launch in April 2012, what limited WI quotes there were referenced the OAT€i20. Even with this consideration, typically the gap on the curve is notably greater than the one year or six months in the US. This significantly increases the uncertainty about pricing such that, for instance, the DBR€i23 spread to the DBR€i20 traded in a range of more than 10bp prior to the initial auction in March 2012.

The methodology for calculating the fair value on real yield curves is fundamentally similar to the US but with some notable differences. Not only are the yield curve gaps larger when considering fair value for European issues than for those in the US, but there are rarely enough bonds to provide a yield curve estimate that does not consider the value of the bond from which the roll is quoted, creating the risk of double counting relative value distortions. The fact that nearby issues are often much older than the new bond can also create significant coupon differences, such that, for instance, the fair value calculation ahead of the sale of the OAT€i18 on a simple yield curve basis produced an estimate 14bp lower than a duration-weighted calculation. As a result of the greater uncertainty, other metrics are more commonly used as valuation cross-checks than for new TIPS issues. In particular, breakeven and relative z-spread asset swap or S-spread metrics are often referenced, given that nominal bond curves and inflation swaps are more completely defined than bond real yield curves.

Another contrast between new issues in Europe and those in the US is that, in Europe, new issues are normally less liquid than their neighbours until their size has been built up via reopenings. More frequent European new issue auctions but for much smaller sizes than in the US give relatively less incentive to investors to switch into brand new issues at initial auctions. Hence, in the euro area it is not unusual for new issues to be launched at a discount rather than a premium, with rolling out of old stocks typically limited. Having relatively old neighbours can also make the relative value of the implied floor of new issues more pronounced; though in France and Sweden new issues can be issued with index ratios above 1 as accretion starts from a full year before the initial coupon, limiting the floor value somewhat. However, lower liquidity also means the floor value of new issues is rarely fully priced unless asset swap investors are the marginal buyers of the paper (in which case the floor element can be extracted), as investors with an interest in allocating into new inflation-linked bonds are unlikely to assign a high probability to a deflation shock.

In the past, new €i issues sometimes referenced issuance from other European countries when there were large gaps in the domestic curve, but given the sharp increase in volatility between countries since 2011, this has not been a common methodology over the past few years. That said, when the DBR€i30 was launched in April 2014, the longest existing point was the DBR€i23. Given that the launch of the DBR€i30 was an extension of the current German curve, any analysis that relied on valuation metrics related to existing German issues was heavily biased by the extrapolation assumption used. Such an approach was inappropriate given that the German linker curve contained only four issues. We turned to the OAT€i curve for guidance but the absolute measures (ie, real yield and asset swap) there were not useful either, as there was a marked difference between French and German linkers. On the other hand, we found that the DBR€i20 and DBR€i23 were more or less in line with the OAT€i curve in terms of incremental forward breakevens and seasonally-adjusted breakevens. There was also a more fundamental reason why the OAT€i breakeven curve could serve as a useful reference, apart from the fact that it was more or less consistent with the two longest DBR€is. While real yields and asset swaps are driven by the specific credit dynamics of the two issuers, the breakeven metric references a variable that is common to both. In practice, this does not mean that breakevens of two €i issuers should be the same, but in that particular case, it did appear that French and German linkers were relatively consistent on that metric. Therefore, we used the OAT€i breakeven curve as the basis for the fair value calculation of the DBR€i30.

FIGURE 3

Fair value estimate of DBR€i30

Estimate based on 2 April 2014 closes	
Announcement Date	8 April 2014
Settlement Date	10 April 2014
Announced Issue Size	€2bn
OAT€i27 breakeven	1.67%
OAT€i32 breakeven	1.884%
Forward breakeven between OAT€i27 and OAT€i32	2.45%
Breakeven of hypothetical OAT€i30 (using constant forward breakeven)	1.81%
Adjustment for seasonality	0.11%
Seasonality-adjusted breakeven of hypothetical OAT€i30	1.70%
Seasonality component of DBR€i30 at issuance	Negligible
Retained fair value estimate for DBR€i30 breakeven	1.70%
Nominal comparator yield (DBR 6.25% April 2030)	**2.20%**
Corresponding real yield	**0.50%**
Real yield spread to DBR€i23	**+45bp**

Source: Barclays Research

Until relatively recently, individual countries in the euro area issued bonds maturing at the same time each year, so there was no seasonality to consider when pricing against same-issuer bonds. This changed when France issued the OATi March 2025 in 2015 and OAT€i March 2021 in 2016. Italy also innovated in 2016 with the BTP€i May 2022. In Sweden, seasonality has been an element that should have been factored in when June-maturing issues were launched, given their less favourable maturity month compared to existing December-redeeming bonds. In practice, the seasonal differences were partly priced, though it was hard to split this factor from floor valuations with no observable inflation volatility. In the UK, new-style issues have both November and less favourable March maturity dates, which are a notable relative value consideration even for the relatively long maturities involved. Recently, 10y and shorter benchmarks have tended to be launched via auction, with syndications used for longer-dated bonds.

INFLATION PRODUCTS

Why should governments issue linkers?

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The number of sovereign issuers of inflation-linked debt continues to grow. We discuss the various reasons why governments might decide to issue.

Taking advantage of excessive market inflation expectations

A government may have more faith than investors in the institutional arrangements in place to maintain an anti-inflationary bias. This was a major factor in the UK's decision to issue linkers in 1981: aggressive monetary and fiscal tightening had been implemented to bring inflation under control, but investors remained unconvinced that there would be a significant long-term reduction. By issuing inflation-linked bonds, the UK Treasury saved billions of pounds when inflation fell sharply and stayed low, ultimately bringing inflationary expectations down as well. Ex-post, some were critical of the underperformance of linkers versus conventional bonds in this phase, but such criticism was unjustified. Nominal bonds had enjoyed a windfall gain due to what was, for the market, unexpectedly low inflation.

In most developed economies, this factor is notably less important than it has been in the past. With independent and transparent monetary policies, the gap between market and government expectations of inflation is likely to be small. While there may be times when divergences of expectations encourage issuance, this mismatch is unlikely to be the primary concern. For more recently developing countries with less established monetary and fiscal institutions and capital markets, there may still be occasions when governments perceive that the markets' expectations of price increases are too high, particularly when institutional changes have been made to fight inflation more directly. The substantial increase in issuance in Brazil in 2006 may have been partly motivated by such considerations, as may have the resumption of issuance in Turkey in 2007.

Positive credibility feedback

A closely related benefit of inflation-linked bond issuance is that it can create a positive credibility feedback. If a government really has taken steps to bring down long-term inflation, it is in its interest to issue inflation-linked bonds while inflation expectations remain high. The market may be more willing to believe in the institutional changes made to bring down inflation if the government is seen to be 'putting its money where its mouth is'. The more inflation-linked debt a country issues, the less incentive it has to reflate the economy and reduce the real value of the debt stock. The longer the expected lifespan of a particular government or policy regime, the more beneficial the strategy may be. This is another argument that is not particularly relevant for developed economies with totally independent monetary policies. It may be very significant for transitional economies that have undergone periods of high inflation, though; Turkey is a clear example of where this may apply, while it may also have been a factor behind the significant increase in issuance in South Africa in 2009.

Saving a risk premium

A popular early argument for inflation-linked issuance was that if government inflation-linked bonds really were risk-free financial assets, a government could save an inflation risk premium by issuing them in place of nominal debt. If investors are primarily interested in maintaining the real value of their savings, they should be prepared to pay an insurance premium for the privilege of owning a risk-free inflation hedge. In practice, it is debatable to what extent such a premium has been seen in the major markets, except when substantial liabilities are linked to inflation, as for instance in the UK. However, this consideration tends to gain increasing emphasis when monetary policy credibility comes under pressure. Early in the development of some of the major markets, there appear to have been negative inflation risk premia, or at least positive effects were more than offset by negatives, eg, liquidity. Conceptually, the risk premium benefit of inflation-linked issuance is likely to be more pronounced at longer maturities as the inflation protection element becomes more valuable. Empirically, in most markets, forward breakeven spreads between inflation-linked and nominal bonds usually increase at longer maturities, while long-term survey measures of inflation are normally relatively static with respect to maturity, suggesting that risk premia are indeed more favourable for inflation-linked issuance at longer maturities.

The appropriate nature of liabilities

The future expenditures and revenues of a government are almost all essentially real flows. Its major future 'asset' is its entitlement to a (real) stream of tax revenues, which will reflect inflation and real economic activity. Having at least a portion of liabilities linked to inflation should offer risk reduction benefits to the government borrower, matching its debt-servicing costs with its revenues. If revenues tend to grow faster than expenditures as prices rise, this may be an incentive to issue inflation-linked bonds. While ex-post the costs of inflation-linked bonds may be higher to issuers than nominal bonds would have been if there were higher-than-expected inflation, the government is better placed to cover this cost. This argument is stronger in the event of a higher percentage of taxation from income and consumption taxes, as corporate taxes tend to be less dependent on domestic price levels. The argument is weakened for countries that have significant inflation-linked liabilities, for instance, pension commitments linked to inflation that are liable to grow more quickly than inflation-linked tax revenues.

Cyclical benefits

Issuance of inflation-linked bonds can have significant cyclical, as well as long-term, liability benefits for a government. When growth is strong, there is little pressure on public finances, but inflation is likely to be higher. Equally, when growth is weak, prices are unlikely to rise quickly. Servicing linker costs should, thus, tend to be a fiscal stabiliser compared with servicing nominal debt. The fiscal effect of a deflationary downturn on a country with a significant stock of inflation-linked bonds ought to be less severe than one with only nominal debt. The UK DMO puts particular emphasis on the fact that inflation and the government's budgetary situation are likely to be highly correlated. Other than a stagflation scenario, the main risk to this hypothesis is late in the economic cycle, when after a strong growth period, inflationary pressures may continue to grow even when output is already falling away, but the counter-argument is that tax revenue also tends to lag output growth. Conversely, issuing inflation-linked at the start of an economic upswing may be optimal timing, as it is likely that during such a phase, inflation risk premia will be high until policy acts to contain inflationary pressures. It is also a time when funding needs are high, so it is advantageous to extend the average life of the debt portfolio.

Risk diversification

Even governments with no natural preference for either real or nominal liabilities should regard it as appropriate to have some inflation-linked liabilities within their debt, unless they assign no probability to inflation being lower than the market expects. A government is better off having a balanced liability portfolio in the face of economic uncertainty, in our view. This diversification benefit can mean that it is in a government's interest to issue inflation-linked bonds, even when implicit inflation is lower than its inflation expectations. As it is sometimes easier to sell longer-dated real return bonds than nominal issues, a benefit also arises from reducing the exposure to short-term cash flow pressures.

Maximising investor reach

Clearly, there is potential for a government that issues inflation bonds to reach investors who would not buy nominal government bonds and to tap new money that would not have been allocated to nominal debt. The largest issuers, including the US Treasury, have stressed this point. For example, US state and local government pension funds hold only a small proportion of their assets in government bonds; however, they are more natural buyers of inflation-linked bonds, as there are relatively few competing sources of inflation-linked supply, while their liabilities are linked to the cost of living. Similarly, in the euro area, where there is particularly high competition between government issuers, the ability to reach an additional set of investors is a highly regarded prize. A broader investor base can not only cheapen funding on average, but also reduce the reliance on particular sources of funds, again reducing risk.

Duration and cash flow benefits

A standard inflation-linked bond has smaller nominal cash flows in the early stages than later on if the price level rises. An inflation bond is, in nominal terms, being issued at a discount if inflation is expected over the life of the issue. This benefit may be a factor worth considering for transitional countries that have short-term cash constraints but ultimately sound finances. In addition, for a country looking to extend the duration of its debt, issuing inflation-linked bonds can offer an attractive proposition. It is less important in developed countries, where governments are required to account for inflation as it accretes in linkers, while extending average duration via the nominal market is relatively straightforward, if so desired.

In several Latin American countries, long-dated maturities have been issued in inflation-linked before the nominal market was sufficiently developed for long nominal issuance, due to the fear of inflation eroding the value of nominal debt. Even when, such as in Mexico, nominal curves have eventually extended to maturities as long as those of inflation-linked bonds, the duration of the long linkers has remained notably longer due to the back-ended nature of linker cash flows. South Africa has undergone a similar extension of its debt since the introduction of inflation-linked bonds.

Social benefits

The existence of inflation-linked bonds may provide benefits to society beyond the funding considerations. The ability to discern markets' inflation expectations easily may aid policy setters. In particular, there may be considerable benefits if breakeven spreads between inflation-linked and nominal bonds help avoid inflationary monetary and fiscal policy errors. With central banks making no secret that they observe both spot and forward inflation-linked breakevens, relatively stable spreads may also provide a self-reinforcing credibility tool for inflation targeting. After the US FOMC indicated that the main market-based series of inflationary expectations on which it focuses is the breakeven implied by 5y5y forward TIPS, this series stayed in a tight 40bp range until the strong inflation volatility of 2008-09. While it can be difficult for central bankers to ascertain how much of breakevens is from true inflationary expectations and how much comes from a risk premium, to the extent that the series itself becomes tied to policy credibility, this differentiation becomes less important. Since the start of the sovereign debt crisis, it is doubtful, though, that much information about genuine inflation expectations can be sustainably extracted from euro area bond breakevens. Breakevens there have, to a large extent, been driven by risk-on/risk-off moves and have been distorted, for instance, by the ECB's excluding BTP€is from its Securities Markets Programme. Being less subject to distortions, inflation swaps have therefore increasingly been seen as more representative of expectations.

To provide a significant benefit to policymakers, an inflation-linked market needs to be seen as relatively representative. One of the major reasons put forward within Japan for an inflation-linked bond programme was that the resultant implied inflation rate would be a useful policy gauge, with this argument also influencing the decision not to offer a deflation floor. However, without a broad acceptance of the asset class by domestic investors, this role failed to gain traction. Experience elsewhere also suggests that it can take several years before there is sufficient liquidity and acceptance of the asset class for the implied inflation to be a reliable enough guide to be a major benefit.

Having a market-based reference of inflation expectations from linkers may also be useful for economic agents in making decisions. The existence of inflation bonds could theoretically reduce inflation uncertainty. This could encourage more savings, either directly into inflation-linked bonds or indirectly into assets for which there is a clearer real value if there are inflation-linked assets for comparison. Putting a price on such benefits is difficult, but as there seem to be few clear differences in behaviour between economic agents in similar countries with and without inflation bond markets, it is unlikely to be very large.

Drawbacks of inflation-linked issuance

In our view, criticism suggesting inflation products are less liquid than their nominal equivalents is fair, with such differences exacerbated following market dislocations in the six months from September 2008. In the euro area, the sovereign debt crisis has also affected the linker market to a greater extent than the nominal one. In the US, however, since the 2008 shock, the liquidity gap has become notably lower than it was prior to the middle of the decade. The reason for the lower relative liquidity of linkers globally has a lot to do with the product matching long-term needs better than nominals. Partly, it is the price of success for meeting specific needs so well, which means that much less day-to-day trading is needed. While liquidity is lower, a less frequent need to trade means that the relative cost of turnover is not that high. Nonetheless, liquidity is a concern that a new government issuer has to overcome in order to sell inflation-linked bonds at attractive levels. In addition, the issuance of inflation-linked bonds should not be viewed in isolation. For a sovereign with a very small debt, which needs to keep a liquid nominal market to help the overall market function and in case circumstances become less favourable, there is an argument for not issuing inflation-linked. This was the situation in Australia, where government supply ceased after 20 years in 2003, despite substantial domestic pension fund demand. In this case, increasingly active quasi- and non-government supply developed, along with inflation swaps trading, with government issuance restarting in 2009 as funding needs rose.

One persistent criticism of governments issuing inflation-linked bonds is that any form of inflation indexation can be damaging in the long run. If bonds are linked to inflation, there will be increased pressure for other items to be linked to inflation as well. The danger is that if the cost of inflation is made less painful for individuals by widespread indexation, it may increase until it reaches levels that are once again damaging. This line of reasoning was particularly prevalent in Germany, where, after multiple periods of hyper-inflation, it was made illegal during the period of the Deutsche Mark for any debt to be indexed. While there is some evidence to support the risks of creeping inflation from widespread indexation, and countries such as Israel and Iceland have tried to wean themselves off indexation as a consequence, this is a long way from saying that it is the fault of inflation-linked bonds. There is no reason why bonds cannot be linked to inflation without general indexation elsewhere. It should be relatively easy for a government to keep financial funding and other price-setting at arms' length. If monetary policy is independent and can respond to the inflationary effects of any indexation, the signalling benefit from inflation-linked bonds is likely partially to offset the inflationary bias.

An extension to the dangers of indexation is that if there is a substantial risk premium in inflation-linked bonds and the implied inflation rate in the market is used as a basis for agents' behaviour when setting prices and wages, there may be an inflationary bias created that is a negative social externality. On the other hand, appropriate monetary policy should be able to address this observable element, while the lower fiscal pressure resulting from a government funding with inflation bonds when there is a significant inflation risk premium ought to be deflationary.

Inflation Derivatives Products

INFLATION DERIVATIVES PRODUCTS

Inflation swaps and forwards

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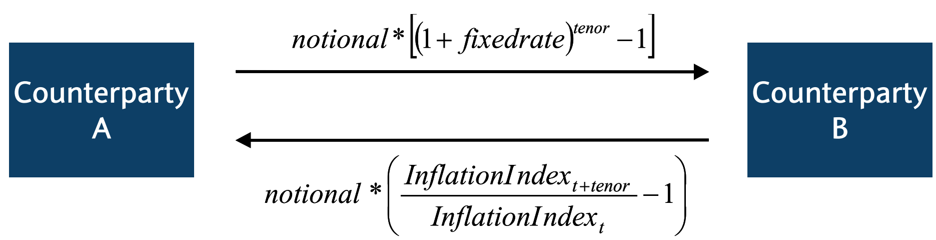
Zero-coupon inflation swaps form the building blocks of the inflation derivatives market and are now established products. Although the cash flow structure of zero-coupon inflation swaps is very simple, their valuation is not always trivial. Other types of swaps exist, but they are priced off the more liquid zero-coupon instruments.

Zero-coupon inflation swaps

A standard zero-coupon (ZC) inflation swap is a pure inflation instrument. In a bilateral transaction, cash flows between the two parties occur only at maturity and involve the exchange of a notional adjusted for inflation that has accrued over a specified period against the notional capitalised at a fixed rate. The fixed rate, agreed at inception, reflects expected future inflation; it is therefore the "price" of expected inflation over the period of the swap and is quoted as an annualised rate. The leg depending on accrued inflation (referred to as the inflation, or the floating, leg) will vary solely on the basis of the final price index reference value at the end of the period of the swap. The cash flow on the fixed leg is predetermined by the quoted swap rate and is effectively a breakeven inflation rate; both parties will break even on the trade (ie, the net cash flow at maturity will be nil) only if annualised average inflation over the swap's period is equal to the initial fixed rate.

Inflation swaps are now clearable for the main inflation swaps markets. Both counterparties in a cleared trade would effectively face the clearing house (eg, LCH), but the "economics" of the transaction would be similar to those of a bilateral non-cleared trade.

FIGURE 1
Zero-coupon inflation swap structure



Source: Barclays Research

One issue to be aware of is the potential for confusion over the terminology used when trading inflation swaps. Paying or receiving in inflation swap parlance normally relates to the inflation leg. The receiver/payer in an inflation swap will receive/pay accrued inflation and pay/receive the fixed rate. This is opposite to the convention in the nominal swap market where the receiver/payer is understood to receive/pay the fixed rate. Alternatively, a long/short position in an inflation swap implies receiving/paying inflation (ie, the floating element) versus paying/receiving the fixed leg, which is again the opposite of nominal swap parlance. Stating exactly which leg is being received and paid clears any confusion.

As with inflation-linked bonds, the inflation indexation mechanism in a swap is subject to a lag, although the lagging principles may differ from the bond market. Furthermore, the move to the cleared format as the standard in many markets has led to changes in some conventions. For example, before clearing became widespread, the price index reference value for standard FRCPIx (French CPI ex-tobacco) swaps was calculated on the same three-month lag and interpolated principle as in their corresponding bond markets. However, for clearing, standard FRCPIx swaps now trade on a non-interpolated basis, similar to euro HICPx and UK RPI swaps. The lagging principles for non-interpolated swaps are notably different from the cash market, with a two-month lag in the UK and a three-month lag in the eurozone. This means a euro HICPx swap traded on any given day of a particular month will have the same starting index reference value, which will be the published index value three months prior. For example, all standard euro HICPx swaps traded during March 2019 pay inflation accruing from December 2018 – referred to as the base month. A 10y swap would therefore pay inflation accruing on the index from December 2018 to December 2028. In April 2019, the base month for all standard euro HICPx swaps shifted one month and changed to January 2019. The lagging mechanism is therefore "stepwise."

The move toward clearing has not changed the lagging principles under which euro HICPx and UK RPI swaps normally trade, but it has changed their standard settlement conventions. Cleared swaps typically settle on the 15th day of the month in which they are initiated, even if the trade date is after the 15th; that is, some trades back-settle. Fixing the settlement to the 15th has no significant implications for the "economics" of a euro HICPx or UK RPI trade relative to previous conventions (which were typically T+2 and T+0, respectively). For example, for a 10y euro HICPx trade held to maturity, it simply fixes (subject to the relevant date-rolling rule) the cash flow payment date at maturity to the 15th of the month 10 years after the initial settlement date, rather than 10 years after the initial T+2 settlement date. The time variables that actually matter to determine the cash flow payment amount at maturity remain the base month and the final reference month. These are determined by the relevant lagging principles only (independent of settlement date) and, as stated above, they have not changed. For trades unwound before maturity, the only change relative to previous standard conventions would be an unwind discount factor calculated over a slightly longer or shorter period.

FIGURE 2

Illustrative terms for a typical clearable 5y Euro HICPx zero-coupon inflation swap

Trade date	22 March 2019
Swap start	15 March 2019
Swap end	15 March 2024
Notional amount (EUR)	EUR 25mn
Payer of fixed rate coupon	**Counterparty A**
Fixed rate zero-coupon	$(1+1.03\%)^5-1$
Coupon payment date	15 March 2024
Payer of euro HICPx coupon	**Counterparty B**
Euro HICPx zero-coupon	(Euro HICPx Month End / Euro HICPx Month Start)-1
Month end	December 2023
Month start	December 2018
Reference rate	European HICP excluding Tobacco (NON REVISED)
Reference source	First publication of euro HICPx by Eurostat
First fixing	104.10
Coupon payment date	15 March 2024

Source: Barclays Research

At the time of writing, standard US CPI swaps, despite being clearable, still trade on their historical interpolated convention. To illustrate, we consider a 5y ZC US CPI swap traded on 22 March 2019. The start date from which inflation accrues on the swap is 26 March 2019, as the settlement date is T+2. The price index reference value for 26 March 2019 is calculated as an interpolation between the December 2018 and January 2019 CPI values, in the exact same way as for US TIPS. The final price index reference date will be 26 March

2024, with the reference calculated as an interpolation between the December 2023 and January 2024 CPI values.

The practical advantage of a non-interpolated convention is that a standard swap traded in a particular month can later be unwound and offset with a standard swap if the unwind date is in the same month. This is because the base month would not have changed. The convenience here in the unwind process is the transparency and tight bid-offers that standard screen-quoted swaps usually offer. As a result, the non-interpolated convention makes short-term "in-and-out" trading within the same month relatively easy. In the interpolated case, the fact that the index reference dates change every day implies that standard swaps on two different days will not be perfectly offsetting. The quoted market for non-interpolated swaps remains consistent during a month, enabling an easy reading of how the market is moving that month. Note that when the base month changes, however, there is a discrete jump in quoted swap rates, mainly because of seasonality. Although there are no discrete jumps in interpolated swaps, the interpolation imposes a drift on quoted rates, which also makes the interpretation of data relatively difficult.

FIGURE 3

Standard conventions across main zero-coupon inflation swap markets for clearable trades

Index	US CPI	Euro HICPx	FRCPIx	UKRPI
Currency	USD	EUR	EUR	GBP
Interpolation method	Interpolated	Non-interpolated	Non-interpolated	Non-interpolated
Lag	2-3 months	3 months	3 months	2 months
Spot date	T+2	15th of trading month	15th of trading month	15th of trading month
Calendar	NYK	Target	Target	London
Bloomberg Index codes	CPURNSA	CPTFEMU	FRCPXTOB	UKRPI

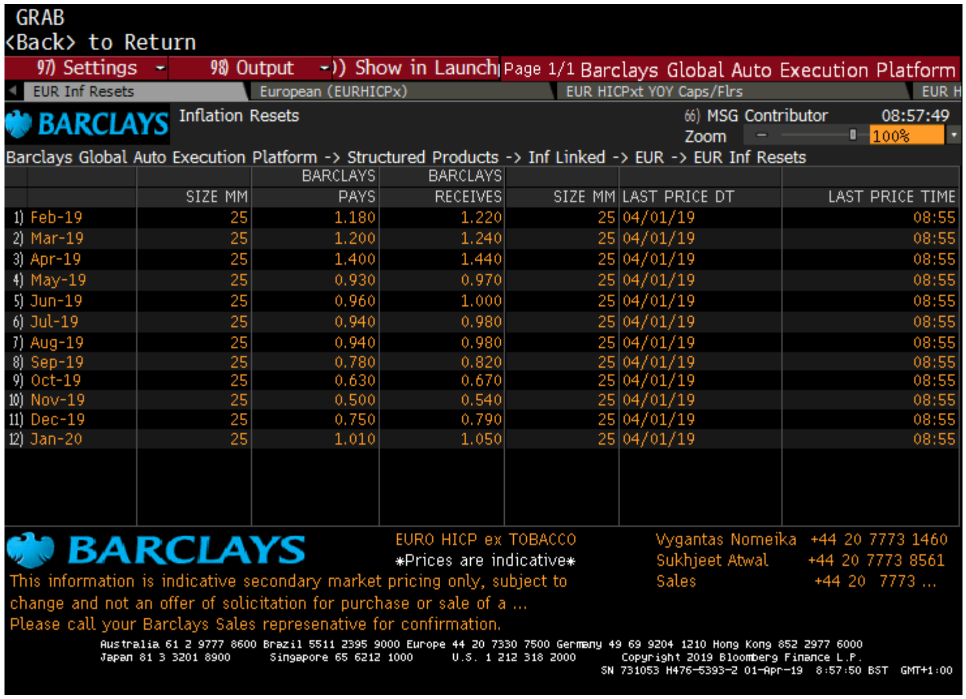
Source: Barclays Research

Resets/fixings market

Activity in the sub-1y part of the curve was, in the past, very limited, despite attempts to kick-start an inflation futures market. However, the large swings in the volatile components of inflation during and after the 2007/2008 crisis highlighted the risks that dealers held in short-end positions, including in fixings within 1y. The euro HICPx resets market was the first to take-off. Liquidity there is sometimes comparable to benchmark tenors such as the 5y or 10y in notional terms. The number of market participants is notably lower than in the longer end, and comprises mainly some dealers and tactical investors. However, with most of those participants having their own full bottom-up inflation forecast models, there is ongoing interest to trade based on perceived mispricings versus models. The market therefore acts as useful aggregator of information and views when there is uncertainty about specific factors that may drive inflation in the near term. This is particularly relevant for the euro area market, where there are frequent changes that affect short-term inflation prints or the seasonality pattern (e.g changes in regulated prices, methodological changes, etc.). Over the past few years, the resets markets for RPI and US CPI has also gained in traction, although they remain less well-defined and active as in the euro area.

FIGURE 4

Barclays Trading's Euro HICPx Inflation Resets indicative quotation page on Bloomberg


GRAB
<Back> to Return
97) Settings 98) Output) Show in Launch Page 1/1 Barclays Global Auto Execution Platform
EUR Inf Resets | European (EURHICPx) | EUR HICPxt YOY Caps/Flrs | EUR H
BARCLAYS Inflation Resets 66) MSG Contributor 08:57:49
Zoom 100%
Barclays Global Auto Execution Platform -> Structured Products -> Inf Linked -> EUR -> EUR Inf Resets

	SIZE MM	BARCLAYS PAYS	BARCLAYS RECEIVES	SIZE MM	LAST PRICE DT	LAST PRICE TIME
1) Feb-19	25	1.180	1.220	25	04/01/19	08:55
2) Mar-19	25	1.200	1.240	25	04/01/19	08:55
3) Apr-19	25	1.400	1.440	25	04/01/19	08:55
4) May-19	25	0.930	0.970	25	04/01/19	08:55
5) Jun-19	25	0.960	1.000	25	04/01/19	08:55
6) Jul-19	25	0.940	0.980	25	04/01/19	08:55
7) Aug-19	25	0.940	0.980	25	04/01/19	08:55
8) Sep-19	25	0.780	0.820	25	04/01/19	08:55
9) Oct-19	25	0.630	0.670	25	04/01/19	08:55
10) Nov-19	25	0.500	0.540	25	04/01/19	08:55
11) Dec-19	25	0.750	0.790	25	04/01/19	08:55
12) Jan-20	25	1.010	1.050	25	04/01/19	08:55

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Source: Bloomberg, BXSW pricing source, Barclays Research (intraday, 1 April 2019)

Building a CPI curve from zero-coupon inflation swaps

Zero-coupon inflation swaps provide the building blocks for the construction of a projected CPI curve from which other inflation-linked derivatives can be priced. On each trading day, annual tenor swap quotes effectively provide the projected increase in the price index from a start index reference date and over whole-year periods. However, unlike in nominal swaps, it is insufficient to interpolate between annual points because interpolation assumes the price index will grow at a constant rate over a year. This is unlikely, given the seasonal behaviour of price indices. The second step, therefore, consists of an adjustment for the estimated seasonality during each month. We illustrate the calculations involved in constructing a projected CPI curve for Euro HICPx.

- Trade date: 22 March 2019
- Base index reference month: December 2018
- Euro HICPx for December 2018: 104.10
- 5y zero-coupon Euro HICPx swap: 1.03%
- 6y zero-coupon Euro HICPx swap: 1.07%

We want to calculate the projected Euro HICPx value for February 2024.

We first calculate:

Projected Euro HICPx for December 2023: 104.10*(1+1.03%)^5 = 109.572733…

Projected Euro HICPx for December 2024: 104.10*(1+1.07%)^6 = 110.964567…

We calculate the annual "trend" of inflation between December 2023 and December 2024. This trend is the 1y in 5y euro HICPx priced by swaps.

Trend = (110.964567…/109.572733…)-1

= 1.2702…%

Using this annual trend, we calculate a first-stage projection for the February 2024 index value. Note that there are two months from the end of December 2023 to the end of February 2024.

First-stage projection February 2024 index

= Projected index December 2023*[(1+1.2702…%)^(2/12)]

= 109.572733…*[(1+1.2702…%)^(2/12)]

= 109.803487…

This first stage approximation assumes the price index grows at a constant rate between December 2023 and December 2024, but this is unlikely to be the case given seasonality in monthly inflation.

We use a hypothetical cumulative seasonality vector, with December normalised at 1.

FIGURE 5

Hypothetical cumulative seasonality vector

January	0.988361709
February	0.990403086
March	0.998667822
April	0.999926584
May	1.001658259
June	1.00116898
July	0.995576907
August	0.996059673
September	0.999327218
October	1.000283364
November	0.998557554
December	1

Source: Barclays Research

We apply the adjustment for seasonality to the first-stage projection.

Projection for February 2024 index

= First stage projection for February 2024*Ratio of February and December seasonal factors

= 109.803487…*0.990403086/1

= 108.74971….

Using the method above, the future euro HICPx index values can be projected for each month as far as zero-coupon swap quotations allow. Once projections for future monthly index values are derived, future daily index references can also be calculated by interpolation in the same way as in bond markets. This is necessary, for instance, in the projection of a linker's future cash flows when performing asset swap calculations.

The detailed computation steps to construct a projected CPI curve are formalised in Figure 6 for a swap market that trades on a non-interpolated basis (eg, euro HICPx). For markets that trade on an interpolated basis (eg, US CPI swaps), the base index reference will not necessarily correspond to a monthly point. In that case, a zero-coupon rate will project a specific daily index reference, rather than the index value for a month. For example, on 22 March 2019, the base index reference for zero-coupon US CPI swaps corresponds to the daily index reference calculated for 26 March 2019 (T+2 settlement). Therefore, a 5y and

and 6y zero-coupon swap will give projections for the daily index reference of 26 March 2024 and 26 March 2025. To calculate projections between those two dates, the same principles as in the non-interpolated case (ie, the determination of an annual inflation trend and the application of a seasonal adjustment) apply, although the calculations steps would differ slightly.

FIGURE 6

Computation steps for constructing a projected CPI curve

We use the following notations:

CPI_0: CPI index value for start index reference date

$PRCPI_t$: projected CPI for index reference date *t* years after the start reference date

$PRCPI_t^m$: projected CPI for index reference date *t* years and m months after the start reference date

ZC_t : quoted annualised ZC swap rate with maturity *t* years

SF_m: seasonal factor of the month which is *n* month(s) after the start reference month

We have: $PRCPI_t = CPI_0 * (1 + ZC_t)^t$

To interpolate between $PRCPI_t$ and $PRCPI_{t+1}$, we calculate the annual trend factor of inflation between t and t+1 (using logarithms for ease of presentation) :

$$\ln(PRCPI_{t+1}) - \ln(PRCPI_t)$$

We then approximate $PRCPI_t^m$, before applying the seasonality overlay, as:

$$PRCPI_t^m = PRCPI_t * \exp\left\{[\ln(PRCPI_{t+1}) - \ln(PRCPI_t)] * \frac{m}{12}\right\}$$

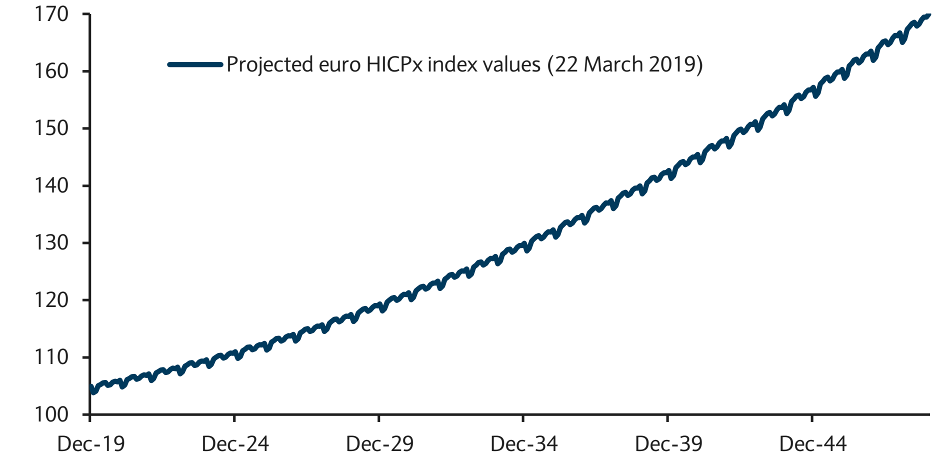
After applying the seasonality overlay, we have:

$$PRCPI_t^m = \ PRCPI_t * exp\left\{[ln(PRCPI_{t+1}) - ln(PRCPI_t)] * \frac{m}{12}\right\} * \frac{SF_m}{SF_0}$$

Because of the seasonality adjustment, the segments between two annual points on a projected CPI curve will not be straight lines but will instead have an oscillatory pattern. This is illustrated in Figure 7, in which projected annual Euro HICPx values are computed from closing mid-levels of Euro HICPx swaps on 22 March 2019 and intermediate values calculated via interpolation plus a seasonality overlay using the vector above. From the projected CPI curve, a complete ZC swaps curve can be built by calculating the annualised rate of growth of the index from the starting reference date to each future reference date. The magnitude of the oscillation related to seasonality on the projected ZC curve will naturally decrease in longer maturities because the ZC rate is expressed as an annualised rate, as in Figure 8. We point out that Figures 7 and 8 show curves for the 1y and longer. For the months up to the traded 1y euro HICPx swap, projections from the resets market rather than calculations based on interpolation and seasonality overlay should be used. If the resets market is well defined beyond the 1y, it may be preferable to use levels from there as much further out as is justified.

FIGURE 7

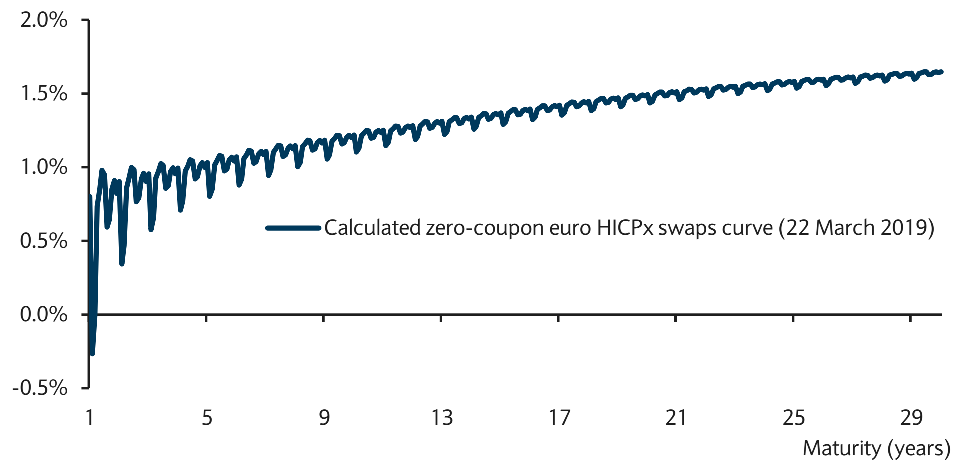
Projected euro HICPx values after interpolation and seasonality overlay



Source: Barclays Research

FIGURE 8

Euro HICPx swaps curve after interpolation and seasonality overlay



Source: Barclays Research

P&L on existing ZC swap positions

In a zero-coupon inflation swap, the only unknown among the parameters determining the cash flows is the end index value reference. The unwind value of a zero-coupon inflation swap trade therefore varies essentially on the basis of changes in the projected index value for the final inflation reference date (although changes in the nominal discount factor may also have a small effect if the swap already has value). As an illustration, we assume a 5y ZC Euro HICPx swap traded in February 2019. This swap will pay inflation accreting from November 2018 to November 2023 versus an annualised fixed rate (breakeven rate). This rate can be used to compute the projected index value for November 2023 at inception date. If the swap is unwound later, the new annualised rate corresponding to what the market is pricing as inflation between November 2018 and November 2023 is needed. If the base month for standard Euro HICPx swaps has changed, then this rate will not be readily available from market quotations. Therefore, the projected index value for November 2023 may need to be computed using an interpolation plus seasonality overlay method analogous to the one detailed above. The difference between the notional inflated using the new projected index value for November 2023 and using the projection at inception date gives the expected future net cash flow at maturity of the swap. This expected cash flow is then discounted by a zero-coupon nominal discount factor to give the current value of the swap position. Figure 9 details the computation steps for the P&L calculation.

FIGURE 9

P&L calculation on a seasoned ZC inflation swap position

Trade date: 22 March 2019
Settlement date: 15 March 2019

Index traded: Euro HICPx
Tenor: 5y
5y ZC swap rate: 1.03%
Notional: € 100mln

Trade end-date: 15 March 2024

Base month on standard swaps on trade date: December 2018
Published December 2018 Euro HICPx value: 104.10

Swap pays inflation accruing from December 2018 to December 2023

Projected index value for December 2023 at trade date = 104.10 * (1.0103^5)
= 109.572…

Trade unwind date: 4 April 2019

At the unwind date, we have:

Base month on standard swaps: January 2019
Published January 2019 Euro HICPx value: 102.73

4y ZC swap rate: 1.06%
5y ZC swap rate: 1.08%

Projected index value for January 2023 = 102.73 * (1.0106^4)
= 107.155…

Projected index value for January 2024 = 102.73 * (1.0108^5)
= 108.398…

Trend rate of inflation between January 2023 and January 2024 = ln (108.398…) – ln (107.155…)
= 1.15…%

We assume the following m/m seasonality vector as above.

At the trade unwind date, the projected index value for December 2023:

= Projected index value for January 2023 * (exp (Trend inflation * 11/12)) * Seasonal factor for December / Seasonal factor for January
= 107.155…* (exp (1.15…% * 11/12)) * 1/0.988361709
= 109.5696…

To calculate the P&L on the position, we compare the notional capitalised on the basis of the two projections for the December 2023 index value.

Notional capitalised using projection on trade date = (Projected index value for December 2023 on trade date / December 2018 index value) * Notional
= (109.572…/104.10) * €100mn
= €105.257…mn

Notional capitalised using projection on unwind date = (Projected index value for December 2023 at unwind date / December 2018 index value) * Notional
= (109.5696…/104.10) * €100mn
= €105.254…mn

The capitalised notionals calculated correspond to the cash flows at maturity on the fixed leg of swaps paying inflation accruing from December 2018 to December 2023. The maturity is 15 March 2024.

The difference in the cash flows is -€2997... This has to be discounted to the trade unwind date by the prevailing zero-coupon discount factor (we use OIS discounting), which is about 1.007 for a cash flow on 15 March 2024. This means that if one went long inflation on the 5y swap on 22 March 2019 and unwound it with an equivalent swap on 4 April 2019, the P&L (excluding transaction costs, and using our assumptions above) would have been -€2997 times 1.007 – ie, -€3018.

Risk on ZC swap positions

By definition, the fixed rate of a ZC inflation swap is set at inception such that the value of the swap is nil. Hence, at inception, the swap has no sensitivity to the nominal discount factor – ie, zero nominal DV01 (delta value of 1bp). On the other hand, the position will be sensitive to changes in the ZC inflation swap rate; this sensitivity is known as the inflation DV01. We consider the following example:

10y ZC euro HICPx swap traded on 5 February 2019, with settlement on 15 February 2019 (assuming cleared swap) and a notional of €100mn. We assume it is a long position in the swap – ie, inflation is received.

Fixed rate of swap: 1.30%.

The cash flows on that transaction are set to occur on 15 February 2029. We assume the nominal discount factor for a cash flow occurring on that date is 0.95.

At inception, by definition, the projected value of the cash flow on the leg that depends on inflation is equivalent to that of the fixed leg and is given by: $[(1+1.30\%)^{10}-1]$*€100mn = €13,787,473. Its present value is given by: €13,787,473*0.95 = €13,098,100.

Given that the value of the swap is nil at inception (both projected cash flows are expected to be the same), its value has no sensitivity to the changes in the nominal discount factor. Thus, the nominal DV01 is nil.

We assume the fixed rate on the swap increases 1bp to 1.31% just after the inception of the swap. This means that the market has changed the projected value of the cash flow on the leg that depends on inflation. The new projected value is given by: $[(1+1.31\%)^{10}-1]$*€100mn = €13,899,850. The cash flow (profit) that is now expected to be received at maturity is no longer nil and is equal to €13,899,850 minus €13,787,473, ie, €112,377. The present value of that expected profit is €112,377*0.95 = €106,758.

Thus, the DV01 of the position equals €106,758; this is the change in the value of the swap if zero-coupon swap rates move up by 1bp. The DV01 can also be calculated for a 1bp move lower, in which case the value of the swap would change by -€106,663, with the absolute value very close to the +1bp case. When a swap starts to acquire value, it starts to have some nominal sensitivity. For example, if the nominal discount factor curve is bumped by 1bp, then the €112,377 will be discounted by a different rate such that value of the swap will change.

A seasoned swap trade is likely to have acquired value, eg, because breakevens have changed or because realised inflation levels have been different from the levels implied by the swap at inception. To determine the inflation DV01 on a seasoned trade, the same principle as above is applied. The zero-coupon swaps curve is bumped by 1bp. A new end index reference value is projected for the swap, and the value of the swap is calculated under this new projection. For seasoned trades that have acquired significant value, the nominal DV01 may not be negligible, although, in general, this nominal duration is usually a minor second-order consideration.

Inflation swap rolls

As set out above, non-interpolated/stepwise inflation swaps roll on the first trading day of the month. The roll is a change in the base month. For example, in May 2016, the base month of standard euro HICPx swaps was February 2016 (ie, a lag of three months). Therefore, the inflation leg of a 1y ZC euro HICPx swap was referencing the change in the index from February 2016 to February 2017. A 2y swap referenced the change from February 2016 to February 2018, and so on for the 3y, 4y etc. In June, the base month changed to March 2016. For instance, a 1y then referenced the March 2016 to March 2017 period. Therefore, monthly rolls mean that the inflation swap rate for a specified tenor cannot be compared from one month to the next. We explain how the monthly roll is computed, using the roll for a 1y swap from the last trading day of March to the first trading day of April as an example:

$$\boldsymbol{1y\ euro\ HICPx\ swap\ rate\ on\ last\ trading\ day\ of\ March\ 2016}$$

$$= \frac{Projected\ Dec\ 2016\ euro\ HICPx\ index}{Dec\ 2015\ euro\ HICPx\ index\ (known)} - 1$$

$$= \frac{Jan\ 2016\ euro\ HICPx\ index\ (known)}{Dec\ 2015\ euro\ HICPx\ index\ (known)} * \frac{Projected\ Dec\ 2016\ euro\ HICPx\ index}{Jan\ 2016\ euro\ HICPx\ index\ (known)} - 1$$

$$\boldsymbol{1y\ euro\ HICPx\ swap\ rate\ on\ first\ trading\ day\ of\ April\ 2016}$$

$$= \frac{Projected\ Jan\ 2017\ euro\ HICPx\ index}{Jan\ 2016\ euro\ HICPx\ index\ (known)} - 1$$

$$= \frac{Projected\ Dec\ 2016\ euro\ HICPx\ index}{Jan\ 2016\ euro\ HICPx\ index(known)} * \frac{Projected\ Jan\ 2017\ euro\ HICPx\ index}{Projected\ Dec\ 2016\ euro\ HICPx\ index} - 1$$

The roll on the 1y swap is quantified by the difference between the two rates, while keeping the euro HICPx curve unchanged between the close on the last trading day of March and the opening on the first trading day of April. After rearranging the terms, we get:

$$\boldsymbol{1y\ euro\ HICPx\ swap\ roll\ on\ 1st\ trading\ day\ of\ April\ 2016}$$

$$= \frac{Projected\ Dec\ 2016\ euro\ HICPx\ index}{Jan\ 2016\ euro\ HICPx\ index\ (known)} *$$

$$\left(\frac{Projected\ Jan\ 2017\ euro\ HICPx\ index}{Projected\ Dec\ 2016\ euro\ HICPx\ index} - \frac{Jan\ 2016\ euro\ HICPx\ index\ (known)}{Dec\ 2015\ euro\ HICPx\ index\ (known)}\right)$$

$$= \frac{Projected\ Dec\ 2016\ euro\ HICPx\ index}{Jan\ 2016\ euro\ HICPx\ index\ (known)} *$$

(Projected Jan 2017 m/m euro HICPx – Known Jan 2016 m/m euro HICPx)

The roll in April was, therefore, essentially determined by how the market's projection for January 2017 m/m inflation compared to realised m/m inflation in January 2016 (the ratio of projected December 2016 to January 2016 just acts as a scaling factor). Projected January 2017 m/m euro HICPx would have been computed from the trend inflation between the 1y and 2y points (under the old base) and the seasonality for January inflation. Typically, if the 1y/2y slope is not particularly steep or inverted, large rolls arise when realised m/m inflation in the new base month has been affected by factors other than normal seasonal influences. For example, in January 2016, one factor that contributed to very low m/m inflation was the sell-off in oil. Therefore, the realised m/m change in the index in January 2016 was much lower than what seasonal factors would have implied. However, in its projection for January 2017 m/m inflation, the sharp drop in oil was unlikely to have been replicated as it is not a seasonal phenomenon. As a result, the roll from March to April was a very positive one; that is, the standard constant-maturity euro HICPx 1y swap opened mechanically much higher on the first trading day of April. The roll was also positive for longer tenors but lower in bp terms as swap rates are expressed in annualised terms.

Figure 10 shows the standard 1y euro HICPx swap rate from the beginning of 2016 in a candle chart series to illustrate how the rate adjusts mechanically on the first trading day of a month. We find it striking that much of the rise in the 1y swap from the end of February has been driven by roll effects. To show how the 1y rate has optically exaggerated the apparent rally, we also show the series of the October 2016 y/y reset/fixing market rate. The 1y rate actually corresponded to the October 2016 y/y reset rate in January (because the base month was October 2015). As the 1y rolled and moved higher in the subsequent months, the rise in the October 2016 y/y reset rate was contained relative to the constant maturity 1y swap.

FIGURE 10

1y euro HICPx swap driven mechanically higher

Source: Bloomberg, BXSW pricing source, Barclays Research

Zero-coupon real rate swaps

In a ZC inflation swap, the cash flow depends only on the traded breakeven level and final inflation print; a real rate swap involves a real, inflation-linked, cash flow versus a floating leg – for example, a compounded Libor rate. In most developed markets, the majority of investors choose to separate decisions on nominal duration and inflation exposure, even though most liabilities are in a real format, although real rate swaps do also trade. In most emerging markets, real rate swaps are much more commonly quoted than inflation swaps. Real rate swaps are usually quoted in a zero-coupon format in markets in which ZC inflation swaps are established, but can also trade in coupon format in most of these markets.

The effective duration of a ZC real rate swap is relatively long because the appropriate discount factor is real rather than nominal. Generally, investors matching liabilities who trade real rates will mostly trade ZC, but value investors, particularly those concerned about convexity of forward positions, often trade real rate swaps with fixed real rate coupons. In

Latin America, almost all single-currency real rate swap activity is in coupon form. The parallel currency format of Latin American linker markets other than Brazil makes this kind of position, a quasi-cross currency swap, relatively straightforward.

Forward zero-coupon inflation swaps

Forward inflation swaps, here understood as the forward between two maturities on the curve, can be calculated from spot market levels and are traded in the most liquid markets. Forwards provide a measure of the market's expectations for inflation beyond the short term and are an important element in the analytical framework for the most developed inflation markets. Market-based measures of five-year inflation in five years time are being particularly closely watched, having been referenced explicitly by central bankers in the US and the euro area. In the US, the liquidity and definition of the bond breakeven curve make it relatively easy to bootstrap and derive measures of forward inflation. However, maturity gaps in the linker curves of other markets mean that it is less straightforward elsewhere. In the euro area for instance, the existence of several issuers also means that breakevens are not always comparable because their valuations may be biased by the credit rating of the relevant issuers. Thus, measures of forward inflation there are typically analysed in the swaps market. Also, other considerations such as liquidity apart, swaps are a more natural instrument to look at forward inflation pricing than bonds because the commonly traded structure in inflation swaps is a zero-coupon one, such that a 'clean' forward rate can be bootstrapped from the curve without any distortion from coupon payments.

The generic formula to calculate an inflation swap rate with a tenor S, at a forward date F is:

$$\sqrt[S]{\frac{(1+Y)^{F+S}}{(1+X)^{F}}}-1$$

Where: Y is the zero-coupon rate for a spot starting swap of tenor F+S

X is the zero-coupon rate for a spot starting swap of tenor F

Alternatively, expressed in terms of CPI Index values, the above formula can be rewritten as:

$$\sqrt[S]{\frac{E(CPI_{F+S})}{E(CPI_{F})}}-1$$

Where: $E(CPI_{F+S})$ is the expected value of the CPI Index in F+S years

$E(CPI_{F})$ is the expected value of the CPI Index in F years

However, the above formula is not equivalent to the strict theoretical computation for a forward rate. If expressed in CPI values, the forward rate is theoretically expressed as:

$$\sqrt[S]{E\left(\frac{CPI_{F+S}}{CPI_{F}}\right)}-1$$

In other words, the theoretical computation of a forward inflation swap rate is related to the expectation of the ratio of future CPI values. The generic formula, on the other hand, computes a ratio of expectations. Mathematically, they are not equivalent given that the future CPI values are not independent variables. A convexity adjustment therefore needs to be applied to the 'naïve' forwards calculated from the generic formula. The need for this adjustment is evident when pricing y/y structures that are effectively portfolios of instruments priced from forward starting swaps. Caps and floors on inflation are such instruments. In their market model for inflation, Belgrade, Benhamou and Koehler provide a convexity adjustment formula when computing the forward value of the CPI ratio.

For an intuitive grasp of the notion of convexity in forward inflation swaps, we look at the dynamic hedging of a forward swap position. We assume a 5y5y forward swap trade in which an end-user goes long inflation (ie, pays the compounded quoted fixed rate and receives accrued inflation at maturity). The other counterparty (typically a bank) will hedge the 5y5y forward position through a combination of 5y and 10y zero-coupon inflation swaps at the inception of the trade; the hedge will be a long position in 10y and a short position in 5y swaps. By definition, a forward starting swap should have no accretion from realised inflation before the forward date. Therefore, the notional on the 5y and 10y swaps should be equal to immunise the inflation accretion before the forward date. While this may seem straightforward, the delicate element is setting the initial notional on the swaps. Assuming a €100mn notional on the 5y5y trade and positive inflation over the five years preceding the forward start date of the swap, then setting the notionals on the 5y and 10y at €100mn is likely to result in overexposure to the 5y5y forward rate. After five years, the initial 5y swap would have expired, but the initial 10y swap will have a remaining term of five years and its notional will have accrued with actual inflation and risen above the €100mn that needs hedging. Hence, if positive inflation is expected over the first five years, the notional on the swaps in the hedge portfolio should be set at less than €100mn. The €100mn notional of the forward swap thus needs to be discounted with inflation that is expected over the initial 5y forward horizon. In practice, the 5y zero-coupon inflation rate at inception is the 'best guess' for this expected inflation. However, unless actual inflation proves to be equal to the expected inflation, the notional will still need to be rebalanced if inflation overshoots or undershoots initial expectations. This rebalancing mechanism illustrates the convexity effect at work.

Let us assume that after inception of the hedging strategy, inflation is effectively significantly higher than initially discounted. This would point to a potential over-hedge at the end of the forward horizon. The hedger will therefore need to reduce the notional on the 5y and 10y swaps by effectively unwinding part of the hedge. The likelihood is that the unwind will be done at a profit, excluding transaction costs, given that breakevens tend to rise with higher-than-expected inflation. Assuming a higher breakeven curve, a profit will be made on the partial unwind of the 10y swap, but a loss will be made on the 5y leg. However, given the higher inflation PV01 of the 10y leg, the net effect should be a profit unless the curve flattens significantly and/or the discount factor on the longer swap is significantly lower. On the other hand, if actual inflation undershoots initial expectations, then the notional on the hedge will need to be increased. In this case of lower-than-expected inflation, the breakeven curve will tend to move lower, which implies that the increase in the hedge notional is likely to be done at cheaper than initial levels. In this case, too, this is positive for the hedger. Hence, there is a positive convexity effect in hedging a short position in forward inflation swaps. This effect comes from the likely positive correlation between actual inflation and expected inflation (ie, breakevens). If this convexity is passed on to the buyer of forward inflation, then the quoted forward rate should be lower than what is implied by the 'naïve' forward. This convexity effect will work the other way around for a seller of forward inflation.

It is, however, difficult to re-adjust a hedge portfolio frequently to take into account the convexity effect, given that the magnitude of the latter tends to be relatively small compared with bid/offer spreads on swaps. Typically, because of transaction costs, rebalancings related to convexity are rarely done more than once a year.

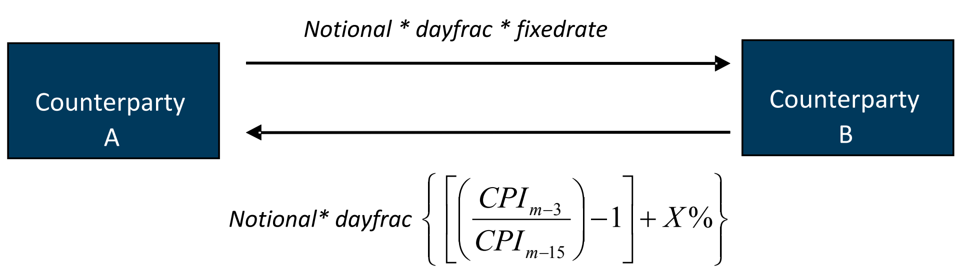
Although the hedging of a forward swap position may not be straightforward conceptually, taking positions is relatively easy in the developed swaps markets. What is effectively traded is a fixed rate against the inflation measured by the change in the index reference between two dates. The difference relative to a normal spot starting swap is that, in the forward case, the base index reference for the swap is also unknown. Therefore, the mark-to-market value of the forward swap over its life is determined by the projection of two index references. Risk measures are also determined by taking into account the fact that the inflation leg is determined implicitly by two unknown elements. Nevertheless, the mark-to-market or risk calculations principles are similar to the spot case.

Forward positions are directional ones, with an added exposure to the curve, as in the nominal rates space. This is obvious from the generic forward formula above. Other things being constant, an inflation swap with a tenor of S years, starting in F years, has a positive sensitivity to the spot swap rate with a S+F year tenor. This is the directional element. Although the sensitivity to the curve is less straightforward formulaically, a steepening/flattening curve move will tend to increase/decrease the forward rate. Hence, the best configuration to enter a long/short forward trade is when bullish/bearish expectations are blended with a steepening/flattening view. However, given that the slope of the curve tends to be inversely related to the level of breakevens, the directional element has historically been the strongest driver of forward swaps. Forward strategies therefore seem better suited to fade unjustified relative value distortions on the curve rather than targeting curve slope moves.

Year-on-year inflation swaps

A format of inflation swap that used to be widely quoted in many markets but is now less common is the year-on-year (y/y) structure. This used to be the standard format for swapped corporate inflation-linked bonds sold to investors for whom the back-ended cash flows of government-style issues were not tax efficient and, hence, was more prevalent than the zero structure in the early days of the euro market. The y/y structure involves one counterparty agreeing to receive an annual coupon determined by the y/y rate of inflation in return for paying a fixed rate. The fixed rate is the quoted rate and is analogous to a breakeven inflation, although not in as pure a sense as in a ZC format. The yearly inflation period lags the payment dates in a way similar to the zero structure. In the US, y/y inflation swaps tend to be quoted in the monthly cash flow format, as this is the most tax-friendly structure, whereas in Europe the cash flow frequency is normally annual. Sometimes, the non-inflation leg of the swap will be floating Libor with a spread rather than a fixed rate.

FIGURE 11
Year-on-year inflation swap periodic payments



Source: Barclays Research

Although not quoted nearly as often on dealer screens as the zero-coupon structure, indicative y/y rates are easily derivable from the zeros in the same way as coupon interest rates from zero-coupon interest rates. For longer maturities, convexity distortions can become relatively large, but most structured notes are quite short. The most common use of the y/y swap remains for hedging structured products, both new exposure and unwinds of old bonds that have been sold back to issuing banks. The floating leg of a y/y inflation swap is equivalent to a collection of consecutive forward inflation rates; therefore, the y/y structure can be useful for hedging inflation caps and floors, either on a stand-alone basis or as features within structured products.

INFLATION DERIVATIVES PRODUCTS

Linker asset swaps

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Linker asset swaps are structured in a format similar to conventional bonds, but their valuation is less straightforward. We present a detailed calculation methodology for common asset swap metrics and full worked examples. Discounting is now a significant consideration for asset swap valuation.

Asset swapping connects inflation-linked bond and swap markets. The appetite for linker asset swaps typically stems from the fact that they often offer a pickup relative to equivalent nominal bonds. An inflation-linked asset swap is a transaction in which the cash flows on the linker are exchanged against Libor-based cash flows. The pricing principles are similar to those for a nominal bond. However, there is an extra step in linker calculations: as the future cash flows – ie, coupon payments and principal repayment at maturity – are inflation-linked and therefore unknown, they need to be projected. As stated in the "Inflation swaps and forwards" chapter, zero coupon inflation swaps are used to project the future values of the CPI and daily index references (DRIs). This curve of projected DRIs can then be used to project the linker's cash flows. The asset swap spread, which is a fixed spread applied to the nominal floating rate (eg, Libor, Eonia etc.) cash flows, is then determined such that the present value of the whole structure at the start is nil. Linker asset swaps trade in two main formats: par-par and proceeds. The Z-spread asset swap is non-tradable but is a better relative value measure than par-par and proceeds. The S-spread measure is now commonly used for relative value analysis, as it avoids some of the biases from credit that are inherent in z-spread calculations.

Par-par asset swap

In a par-par asset swap, the investor implicitly pays par for the bond and pays out all the bond's cash flows to the other party. We assume that the nominal floating rate is Libor. The floating leg is then Libor plus a spread, paid on par, with par also received at maturity. The cash flow components can be broken down as follows:

At inception: The investor buys the bond at the market settlement price. In the swap transaction, the investor receives the settlement price and pays par (100). This means that the deviation of the bond settlement price (inclusive of accrued interest and inflation uplift) P from par has to be factored in. If, for example, P is above 100, it is treated as a positive cash flow for the investor at the start.

Over the life of the bond: The investor receives Libor plus a spread on par and pays out the coupon payments from the bond.

At maturity: The investor pays out the inflation-uplifted principal on the bond and receives par, the notional of the swap.

If the principal at maturity has a deflation floor, it is assumed that the value of the floor is subtracted in the calculations from the price P above.

From the point of view of the investor (and therefore for the counterparty), the total present value of all the cash flows above must sum to zero, and the spread to Libor is adjusted so that this condition is respected. The present values of the different cash flows (on a principal/notional of 100) are:

1. $P - Floor\ Value - 100$ (at inception)

2. $100 * \sum_i (Libor_i + PP\ ASW) * DCF_i * df_i$

   where $Libor_i$ corresponds to the projected Libor fixings, PP ASW is the par-par asset swap spread, DCF_i is the day-count factor applying to Libor payments and df_i is the discount factor giving the present value of each Libor payment.

3. $-\sum_j C * IR_j * df_j$

   where C is the coupon before inflation adjustment on a principal of 100 and IR_j corresponds to the projected index ratios on coupon payment dates.

4. $-100 * IR_M * df_M$
   corresponds to the present value of the projected inflation-adjusted principal paid out at maturity.

5. $100 * df_M$ corresponds to the present value of par being received back at maturity.

The frequency of cash flows from the linker will not necessarily be the same as for the swap leg.

PP ASW is then derived from the equation:

$$P - Floor\ Value - 100 + \sum_i 100 * (Libor_i + PP\ ASW) * DCF_i * df_i$$
$$-\sum_j C * IR_j * df_j - 100 * IR_M * df_M + 100 * df_M = 0$$

So, we have: PP ASW=

$$\frac{-(P-100) + Floor\ \ Value + \sum_j C * IR_j * df_j + \ \ 100 * IR_M * df_M - \sum_i 100 * Libor_i * DCF_i * df_i - 100 * df_M}{100 \sum_i DCF_i * df_i}$$

In the past, it was very common to use the same curve to project Libor-based flows and calculate discount factors (self-discounting). This is not typically the case now, with the discounting assumption usually dependent on the collateral agreement between the two counterparties. Figure 1 illustrates par-par asset swap (vs 6M Euribor) calculations for the DBR€i23. The value of the floor at maturity is taken into account. We calculate the asset swap under an OIS-discounting assumption. The par-par asset swap is not a particularly logical calculation to use for inflation-linked bonds, which will tend to deviate from nominal par over their lifetime as they gain inflation accretion, but it is relatively straightforward and became convention in the euro area when most asset swaps were on short-maturity bonds with limited history. Implicitly, a par-par asset swap does not fully consider the underlying investment risk on the linker.

FIGURE 1

Illustrative par-par asset swap calculation for DBR€i23 (29 March 2019 settlement date)

Trade date	27 March 2019
Settlement date	29 March 2019
Bond notional (Euros)	100
Clean unadjusted price	106.72000
Full settlement price	113.5479

Bond Invoice: A	113.5479
Swap notional: B	100
Floor value: C	0.002

Bond cash flow indexation dates	Effective bond cash flow dates	Bond cash flows before indexation	Projected index ratios	Projected bond flows	Discount factor (df)	Discounted projected bond flows
15-Apr-19	15-Apr-19	0.1	1.06325	0.106325	1.00019	0.106345
15-Apr-20	15-Apr-20	0.1	1.07441	0.107441	1.00395	0.107865
15-Apr-21	15-Apr-21	0.1	1.08571	0.108571	1.00748	0.109383
15-Apr-22	19-Apr-22	0.1	1.09672	0.109672	1.00977	0.110743
15-Apr-23	17-Apr-23	100.1	1.10847	110.957847	1.01048	112.120971
			Sum discounted projected bond flows: D			112.555308

Swap pay dates	Notional repayment	Day count fraction (DCF)	Rate	Discount factor (df)	Discounted Projected swap flow (flat)		100*DCF*df
15-Apr-19	-	0.04722	-0.2014%	1.00019	-0.009513		4.723126682
15-Oct-19	-	0.50833	-0.2278%	1.00205	-0.116025		50.93739583
15-Apr-20	-	0.50833	-0.2287%	1.00395	-0.116714		51.03396266
15-Oct-20	-	0.50833	-0.2129%	1.00582	-0.108839		51.12934921
15-Apr-21	-	0.50556	-0.1638%	1.00748	-0.083451		50.93388856
15-Oct-21	-	0.50833	-0.0940%	1.00881	-0.048190		51.28141764
19-Apr-22	-	0.51667	-0.0105%	1.00977	-0.005504		52.17144043
17-Oct-22	-	0.50278	0.0680%	1.01032	0.034524		50.79658511
17-Apr-23	-	0.50556	0.1542%	1.01048	0.078793		51.08550796
17-Apr-23	100	-	-	1.01048	101.048258	**Sum 100*DCF*df: F**	414.0926741
		Sum Discounted Projected swap flow: E			100.673337		

Par/Par ASW = [-(A-B)+C+D-E]/F	**-40.2 bp**

Source: Barclays Research

Proceeds asset swap

In a proceeds asset swap, the investor buys the linker at the market settlement price (ie, inclusive of accrued interest and inflation uplift) P, and the notional on the swap is equal to P. Therefore, at inception, there is no deviation from the price P to take into account. The present values of the different cash flows on the transaction are therefore:

1. Floor value (note: UK linkers do not have a deflation floor)
2. $P^* \sum_i \left(Libor_i + PR\ ASW\right) * DCF_i * df_i$

   where $Libor_i$ corresponds to the projected Libor fixings, PR ASW is the proceeds asset swap spread, DCF_i is the day-count factor applying to Libor payments and df_i is the discount factor giving the present value of each Libor payment.
3. $-\sum_j C * IR_j * df_j$

   where C is the coupon before inflation adjustment and IR_j corresponds to the projected index ratios on coupon payment dates.
4. $-100 * IR_M * df_M$

   corresponds to the present value of the projected inflation-adjusted principal paid out at maturity. This can be floored at par.
5. $P * df_M$

   corresponds to the present value of par being received back at maturity.

PR ASW is then derived from the equation:

$$- \text{Floor value} + \sum_i P * \left(Libor_i + PR\ ASW\right) * DCF_i * df_i - \sum_j C * IR_j * df_j$$

$$-100 * IR_M * df_M + P * df_M = 0$$

So, we have: Proceeds ASW=

$$\frac{Floor\ \ Value + \sum_j C * IR_j * df_j + \ \ 100 * IR_M * df_M - \sum_i P * Libor_i * DCF_i * df_i - P * df_M}{P \sum_i DCF_i * df_i}$$

Proceeds asset swap spreads are generated in a similar manner to par-par calculations, with some minor differences. In a proceeds spread, there is no exchange of cash flows upfront, as the swap notional is set to be equal to the bond's dirty price. Therefore, the biggest difference is that the bond premium or discount (P-100) must be discounted from the maturity date, reflecting the fact that the swap notional will be different from 100 at the final maturity of the asset swap. Proceeds asset swaps avoid any issues with historical accretion and, hence, are more appropriate for markets in which bonds have been accreting inflation for years. This was the case for most TIPS when asset swapping became a feature of US inflation markets, but even more so in the UK, where many 8m lag issues have been accruing inflation since the 1980s. A par-par asset swap tends to exaggerate the value of the asset swap for a bond trading above par, which bonds with inflation accretion will usually be. For comparison, we consider the proceeds asset swap on the same DBR€i23 below, although this bond would normally trade in a par-par format.

FIGURE 2

Illustrative proceeds asset swap calculation for DBR€i23 (29 March 2019 settlement date)

Trade date	27 March 2019
Settlement date	29 March 2019
Bond notional (Euros)	100
Clean unadjusted price	106.72000
Full settlement price	113.5479

Bond Invoice: A	113.5479
Swap notional: B	113.5479
Floor value: C	0.002

Bond cash flow indexation dates	Effective bond cash flow dates	Bond cash flows before indexation	Projected index ratios	Projected bond flows	Discount factor (df)	Discounted projected bond flows
15-Apr-19	15-Apr-19	0.1	1.06325	0.106325	1.00019	0.106345
15-Apr-20	15-Apr-20	0.1	1.07441	0.107441	1.00395	0.107865
15-Apr-21	15-Apr-21	0.1	1.08571	0.108571	1.00748	0.109383
15-Apr-22	19-Apr-22	0.1	1.09672	0.109672	1.00977	0.110743
15-Apr-23	17-Apr-23	100.1	1.10847	110.957847	1.01048	112.120971
			Sum discounted projected bond flows: D			112.555308

Swap pay dates	Notional repayment	Day count fraction (DCF)	Rate	Discount factor (df)	Discounted Projected swap flow (flat)		Swap notional*DCF*df
15-Apr-19	-	0.04722	-0.2014%	1.00019	-0.010802		5.363011162
15-Oct-19	-	0.50833	-0.2278%	1.00205	-0.131744		57.83834328
15-Apr-20	-	0.50833	-0.2287%	1.00395	-0.132527		57.94799289
15-Oct-20	-	0.50833	-0.2129%	1.00582	-0.123585		58.05630232
15-Apr-21	-	0.50556	-0.1638%	1.00748	-0.094757		57.83436085
15-Oct-21	-	0.50833	-0.0940%	1.00881	-0.054719		58.22897282
19-Apr-22	-	0.51667	-0.0105%	1.00977	-0.006250		59.23957501
17-Oct-22	-	0.50278	0.0680%	1.01032	0.039201		57.67845566
17-Apr-23	-	0.50556	0.1542%	1.01048	0.089467		58.0065215
17-Apr-23	113.5479	-	-	1.01048	114.738174	**Sum Swap notional*DCF*df: F**	470.1935355
		Sum Discounted Projected swap flow: E			114.312460		

Proceeds ASW = (C+D-E)/F	**-37.3 bp**

Source: Barclays Research

Z-spread asset swap

Neither par-par nor proceeds asset swaps are an ideal valuation measure to compare inflation swaps with bonds. The back-ended cash flows of inflation-linked bonds mean that the value of a floating basis point now is less than that of an inflation-linked bond discounted on its own real yield curve. Hence, a 1bp change in real yield moves the linker asset swap by more than a basis point in either of these methodologies. Deviations of asset swap levels away from Libor flat will tend to become more distorted the longer the maturity of the linker. In an extreme case, a 50y bond may have an expected average principal in present value terms about twice its current level; hence, a 1bp move in the real yield of the bond with no move in the inflation swap curve would move the asset swap about 2bp. It is, thus, relatively difficult to compare tradable asset swap levels across inflation-linked bonds and particularly difficult to compare them with asset swap levels of nominal bonds. For this reason, we prefer to use a z-spread asset swap methodology for assessing relative value.

Z-spread asset swaps are a widely used analytical tool within nominal bonds to smooth out micro distortions and compare relative value, but they are more important for linkers because the distortions are notably larger. The calculation of the z-spread asset swap is done so that, by construction, a 1bp change in the real yield of the bond will move the asset swap 1bp as well. By construction, a z-spread asset swap differential between a nominal and an inflation-linked bond thus provides a consistent measure to the richness of bond versus swap breakevens at that maturity. The calculation involves taking the cash flows of a linker in a similar way to a proceeds asset swap and calculating their present value. The next step is to adjust the uplift factor affecting the bond cash flows iteratively in a parallel fashion until the present value matches that of the same cash flows priced from the swap leg. The amount that the swap curve has to be changed to match the value of the bond cash flows is the z-spread asset swap. It will be narrower than asset swaps calculated by the other methods, substantially so in the case of long maturity bonds.

An example of a z-spread calculation is trivial to construct in Excel using the solver function to equalise the value of the discounted bond flows with the settlement price of the bond. However, the results of this method can be biased by rounding errors; as such, the discounted value of the bond cash flows may not match the dirty price exactly.

FIGURE 3

Illustrative Z-spread asset swap calculation for DBR€i23 (29 March settlement date)

Trade date	27 March 2019
Settlement date	29 March 2019
Bond notional (Euros)	100
Clean unadjusted price	106.72000
Full settlement price	113.5479

Bond Invoice: A	113.5479

Bond cash flow indexation dates	Effective bond cash flow dates	Bond cash flows before indexation	Projected index ratios	Projected bond flows	Discount factor (df)	Bumped discount factor	Discounted (no bump) projected bond flows	Discounted (with bump) projected bond flows
15-Apr-19	15-Apr-19	0.1	1.06325	0.106325	1.00019	1.00029	0.106345	0.106356
15-Apr-20	15-Apr-20	0.1	1.07441	0.107441	1.00395	1.00624	0.107865	0.108111
15-Apr-21	15-Apr-21	0.1	1.08571	0.108571	1.00748	1.01198	0.109383	0.109872
15-Apr-22	19-Apr-22	0.1	1.09672	0.109672	1.00977	1.01650	0.110743	0.111482
15-Apr-23	17-Apr-23	100.1	1.10847	110.957847	1.01048	1.01941	112.120971	113.1121
			Sum discounted projected bond flows (without and with Z-spread bump)				112.555308	113.5479
								= Bond invoice price

Calculated Z-spread (by iteration)	**-21.3 bp**

Source: Barclays Research

Refining asset swap measures: the S-spread

The z-spread is calculated as a flat spread versus the Euribor curve and, as such, does not properly account for the credit component factored into the nominal curve. This implies that the relative z-spread asset swap would tend to be biased when credit considerations are significant. As a result, since the credit of sovereign linker issuers in the euro area (particularly Italy) has come to the forefront, a new measure has evolved. It is commonly referred to as the S-spread. As with the z-spread, it involves projecting the cash flows of the linker using the corresponding inflation swaps curve (for instance, euro HICPx). A nominal curve is then built using a set of nominal bonds from the issuer, preferably liquid issues and including (but not only) those that are normally used as nominal comparators. Nominal discount factors are then extracted from this constructed curve. The S-spread is the spread that needs to be applied to that curve such that the sum of projected linker cash flows discounted using the shifted curve is equal to the linker price. Given that it is calculated directly off a "stripped" nominal curve (hence the "S"), the S-spread measure isolates the valuation differential between a bond breakeven and the inflation swaps curve from credit considerations. It is therefore a cleaner measure of relative valuations between bond breakevens and inflation swaps than the linker versus nominal z-spread differential metric.

Calculating carry and roll-down on a proceeds ASWs position

In Figure 4, we provide an example of calculating effective carry on a TIPS proceeds ASW position. Carry on a position is the benefit less the cost of holding the position. To understand the carry/roll-down implications for any given period, one needs to observe the relative flows from an asset swapper's perspective.

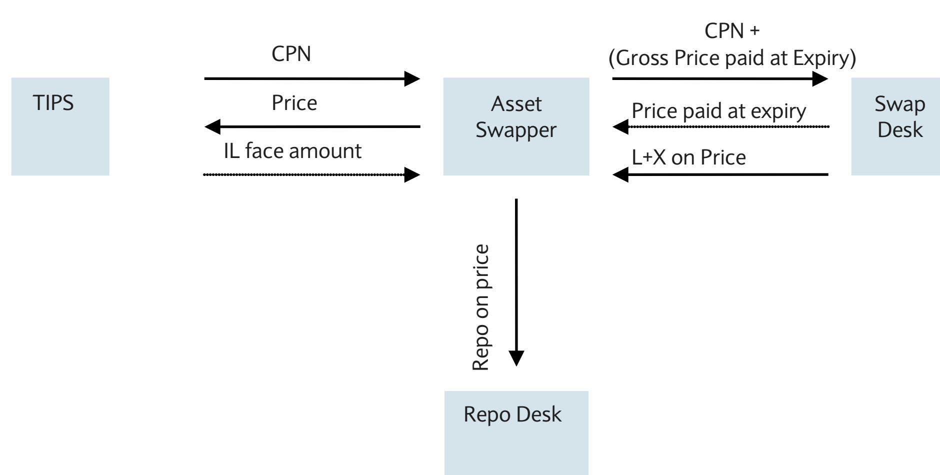
From the perspective of proceeds asset swapper:

1. Buy an inflation-linked bond
2. Finance at the funding cost (account for repo, collateral agreement)
3. Pay the TIPS (inflation-linked) cash flows to a dealer/swap desk
4. Receive L + spread from the swap desk on the dirty price of the bond.

The spread to Libor is calculated as shown in Figure 2. With the aid of Figure 4, we explain how to calculate carry on a proceeds position

FIGURE 4

TIPS Proceeds ASWS Transaction Diagram



Note: Price is the dirty price of the bond at inception. Source: Barclays Research

10y proceeds ASWs 3m carry

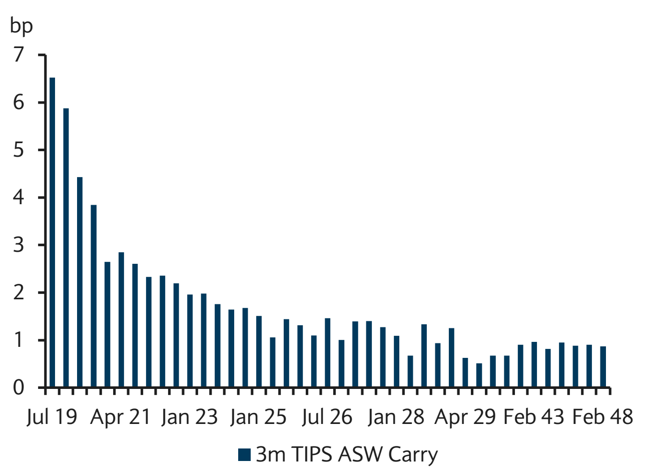
- 3m TIPS ASWs carry = (3m Libor + Spread – Funding Cost) * DCF/ TIPSPV01; here, DCF is about 0.25
- For example, 10y TIPS ASWs (TIIJan29s) were trading at 3m Libor + 28bp as of 28 March 2019
- Assuming a 3m funding cost of 240bp (an investor can assign a CSA-based funding cost in this calculation)
- Assuming 3m Libor of 260bp
- TIIJan29s PV01: 9.7
- 3m TIIJan29s ASWs Carry = (260bp + 28bp – 240bp)*0.25/9.7 = 1.24bp carry

Figure 5 shows TIPS ASW carry across the curve based on this methodology.

To calculate the roll-down, an investor assumes that the ASW curve remains static; that is, how much marked-to-market position change P&L one would get if the ASW curve did not change and the position shortened in maturity. There are multiple ways to do this. One approach is to build a z-spread ASW valuation (for each bond) shortened by a 1y holding period. Then, look at spot z-spread ASWs minus a 1y shorter ASW and divide by 4 to estimate a 3m ASW roll-down. Looking at a 1y shorter ASWs allows investors to avoid any seasonality issues, as y/y seasonality sums to zero. Another approach is to look at bonds 1y shorter in maturity and use that to calculate the roll-down (3m roll-down = 0.25 *(Spot z-Spread – 1y shorter z-spread)). This would be an approximate market-based 1y roll-down. One can divide these numbers by 4 to arrive at a 3m roll-down. In the market-based approach (Figure 6), relative distortions (rich vs. cheap) of 1y-apart securities being rich/cheap will show up.

FIGURE 5

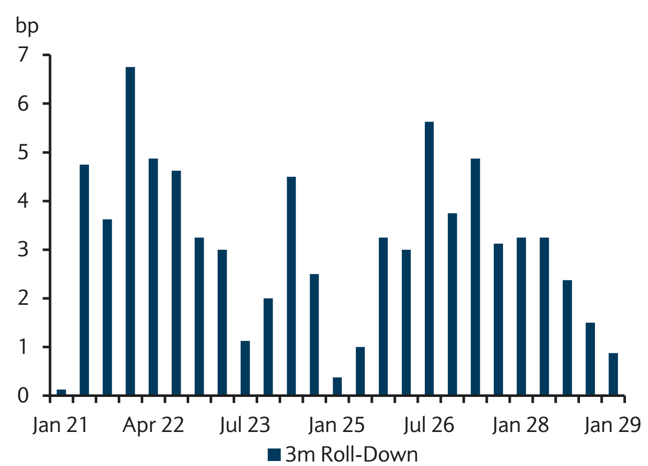
TIPS ASWs carry (3mL+spread-funding)*DCF/PV01



Source: Barclays Research

FIGURE 6

Market-based 3m TIPS roll-down



Source: Barclays Research

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Bond breakevens versus inflation swaps

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Market participants had been used to seeing a close relationship between bond breakevens and inflation swaps. However, recent crises have shown that cash and swap markets can diverge significantly, with each market driven by its specific dynamics such as funding costs in the US. Asset swapping activity should theoretically hold the two markets together, but such activity is usually not sufficient to offset diverging forces in stressed market conditions.

Inflation swaps and bond breakevens, in essence, measure the same economic variable. Although they vary in technical detail – one product is based on a coupon-bearing instrument while the other is in zero-coupon format – both should be driven mainly by markets' expectations of future inflation. However, inflation swaps and inflation-linked bonds make up two distinct markets with different participants. The mechanism that effectively holds the inflation swaps and cash markets together is asset swapping, so if asset swaps do not trade in sufficient volume, then the tendency for swaps and cash breakevens to trade close to each other may not be strong. Furthermore, one market may be subject to stresses that do not necessarily have a major effect on the other, and again valuations may diverge. As we explain in "Linker asset swaps", we use the relative z-spread asset swap between a linker and its nominal comparator or its S-spread as an analytical measure of the richness/cheapness of a linker's breakevens versus the inflation swaps curve.

Relatively recent history illustrates how the cash and swaps markets can be disconnected. Before the crisis in 2008, differentials were small and evolved within a relatively tight range. In summer 2008, though, the market started focussing on disinflation risks. This led many market participants to exit long breakeven positions, but this coincided with a period when balance sheet constraints were increasing. In September 2008, the collapse of Lehman Brothers triggered a wave of linker asset swap unwinds. Those unwinds essentially meant that the market was no longer receiving inflation in swap format; this effectively led to a massive richening in inflation swaps versus bond breakevens. That said, over that period, both bond and swap breakevens dropped significantly. There were common drivers pushing them lower: the economic outlook was bleak, focus had turned to deflation and dealers were scrambling to delta-hedge short positions in floors. At the same time, tactical investors continued to exit long breakeven positions at a time when banks' balance sheets could not accommodate such exposures. Those balance sheet constraints meant that linkers were initially affected to a much greater extent. In the euro area, when banks' delta hedging of short floor exposures became the dominant factor, specific cheapening pressures intensified on swaps and bond breakevens staged a sharp correction of their prior relative cheapening. However, they gave back much of this correction in the first two months of 2009 and it was not until asset swap demand for linkers emerged in March 2009 that bond breakevens corrected and stabilised versus swaps.

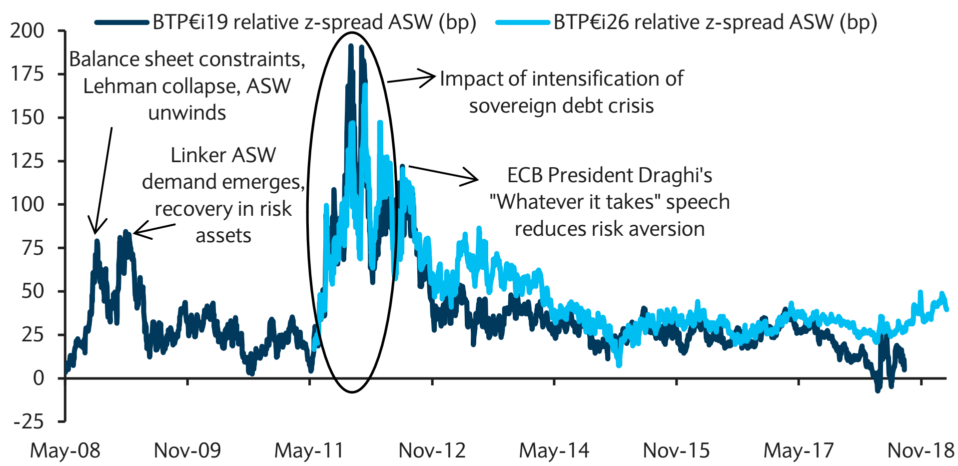
The sovereign debt crisis in the euro area provides another example of how linker and inflation swap markets may diverge. From a general perspective, the crisis has had a notably different effect on cash breakevens relative to swaps. Indeed, typical real money investors in the linker market tend to be more risk averse than those in the nominal market. With the extreme volatility in sovereign spreads during the sovereign debt crisis, real money activity in European linkers fell significantly, even when valuations relative to the nominal market stood out as economically very attractive. To a large extent, the individual European linker markets became more volatile versions of their respective nominal markets. Breakevens cheapened on risk-off periods but, even at attractive levels, failed to attract demand in sufficient size. The situation can be interpreted as one where the linker and nominal markets each have their separate dynamics; in some way, the differential between them is no longer viewed as a meaningful measure that should reflect inflation expectations. Euro HICPx swaps, on the other hand, are not directly affected by stresses in peripheral debt market and have been relatively well-behaved over that period. The crisis also had more "mechanical" effects on relative valuations. For instance, unwinds linked to Greek linker asset swap positions were very supportive for swaps, while the positive effect on the cash market was marginal. Also, the ECB, within its Securities Market Programme, was buying nominal BTPs but not BTP€is. This created a strong (mechanical) cheapening bias which affected mainly BTP€is, and this compounded with the underlying threat that BTP€is would fall out of Bloomberg Barclays' main indices at some point. As a result, and unsurprisingly, relative z-spread asset swaps in most BTP€is cheapened significantly. President Draghi's "Whatever it takes" speech in July 2012 thereafter initiated a gradual compression in peripheral spreads. BTP€i relative z-spreads came down alongside the tightening in absolute spreads.

In general, since summer 2012, bond breakeven versus swap valuations in the euro area have tended to keep within a tighter range. More contained levels in absolute asset swap levels have contributed to this. There are two other factors which, in our view, have driven the swaps and cash market valuations to be more aligned. First, bank treasuries/liquidity portfolios have become major players in the asset swaps market, taking advantage of the discount offered versus nominals when it is deemed attractive. Second, linkers were included in the ECB's QE programme, and this actively limited the scope for cash breakevens to build a large discount versus swaps.

That said, bouts of increased volatility coupled with spread cheapening still tend to have a cheapening effect on relative asset swaps in the euro area. For example, in summer 2018, the sharp cheapening in BTP spreads caused BTP€i asset swaps to cheapen too, but to a notably lesser extent than in 2011-2012.

FIGURE 1

Bond breakevens versus swap valuations less volatile in recent years

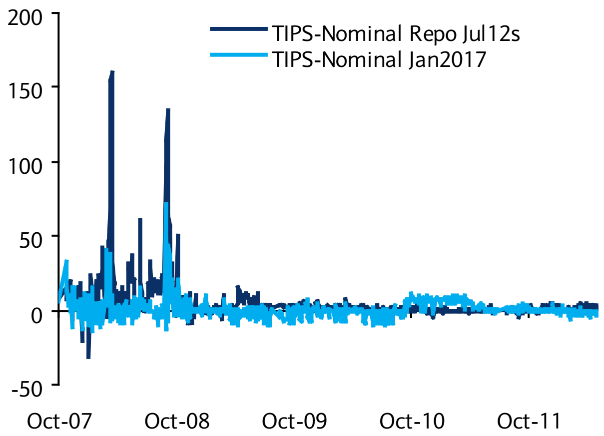


Source: Barclays Research

In the US, we believe the gap between inflation swaps and bond breakevens can be explained primarily by funding costs embedded in a CPI swap, whereas cash breakevens are quoted pre-funding costs and are driven, in part, by the lack of payers in the derivatives market. Since most end-user investors using CPI swaps want to receive inflation, dealers hedge their risk using an offsetting leveraged breakeven position in the repo markets. The dealer is then exposed to the repo bid/offer, repo rate differential risk, and balance sheet charges (including relative liquidity and haircuts). While most of the time repo rate differentials are relatively

FIGURE 2

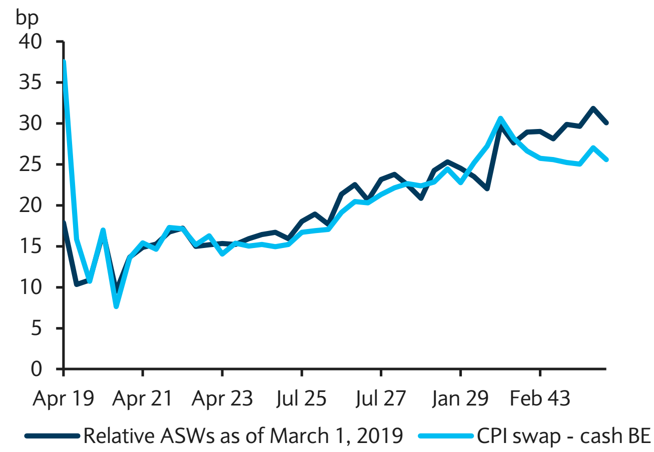
Repo differential TIPS and nominals



Source: Barclays Research

FIGURE 3

TIPS minus nominal ASWs roughly equal to CPI swaps minus cash BEs



Source: Barclays Research

insignificant, dealers need to price in the potential for the differential to widen. This was evident in 2008 in the US market when TIPS repo rates increased significantly relative to nominal Treasuries (Figure 2). These costs are then embedded in the inflation swap rate, making it higher than the corresponding bond breakeven, other things being equal. Figure 2 shows that during the height of the crisis in 2008, 4y TIPS and 10y TIPS repo differential widened to 150bp and 75bp, respectively. One can price this as a risk-premium/option on top of a breakeven position as there is uncertainty over how long this type of condition may persist. A 10y CPI swap hedged with 10y breakevens (assumption: held to maturity) has more time to experience this type of funding differential relative to a 1y CPI swap hedged with 1y breakevens. Therefore, one would expect the difference between CPI swaps and cash-breakevens to be wider as you go further out in the curve.

In terms of the balance sheet cost, one can see that TIPS ASWs trade cheaper than nominal ASWs. This is another way to show the balance sheet cost of holding TIPS versus nominals. Figure 3 shows that the relative ASWs differential, that is TIPS ASWs – Nominal ASWs, are roughly equivalent to (matched-maturity) CPI swaps minus cash breakeven at every point. To summarize, this means that when TIPS breakevens are adjusted for floors and the relative ASWs differential is added, a synthetic CPI swap position is created.

TIPS Breakevens (adjusted for floors) = TIPS breakevens + Short par floor.

CPI Swap ~ TIPS Breakevens (adjusted for floors) + TIPS ASWs – Nominal ASWs.

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Par floors in linkers

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Par floors embedded in linkers had been, for a long time, of little relevance from a valuation perspective. However, when the market started pricing deflation, especially in the US, it became crucial to understand how they affect the valuation of different bonds.

Canadian-style linkers usually contain an embedded deflation floor at maturity such that the principal reimbursed cannot be below par. In short, at maturity, the investor gets the greater of par or the inflation-adjusted principal. The floor on a linker usually applies only to the principal at maturity; coupon payments can be and have been paid off an inflation-adjusted principal below par. Since the inflation-adjusted principal is the par amount times the index ratio (of the reference CPI to the base CPI), this is another way of saying that at maturity, the index ratio is floored at 1 as it is applied to the principal. The payoff on the principal amount at maturity can be written as:

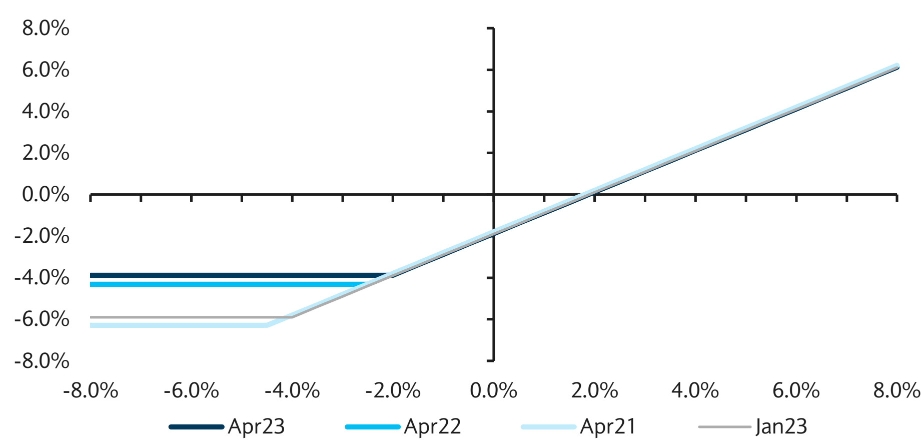
Par Deflation Floor Payoff at Maturity: Max {Par, Par X IndexRatio}

Four factors affecting the floor value of a linker are:

1. **Accrued inflation (and the strike for the deflation floor):** One can think of the deflation floor on a linker breakeven position as a protective put on a stock option. The more inflation a bond has accrued, the further out of the money the protective put is relative to the current stock price. Thus, the bonds that have accrued the least amount of inflation are closest to ATM. Bonds that have accrued significant inflation have more downside, as their deflation floor strike (or protective put) is very OTM. Naturally, any newly issued linkers have the least amount of accrued inflation. Hence, for instance, the newly issued 5y, 10y and 30y TIPS would be closest to ATM. Figure 1 shows that the newly issued 5y issues protect the most against deflation, or need the least deflation (about 30bp annualized deflation) to maturity, for the floor to kick in.

   On March 1, 2019, the TIIApril23 index ratio was 1.01163 (accrued inflation 1.2%), while the Jan23 index ratio was 1.08863 (accrued inflation 8.9%); thus, relative to Jan23s, April23s are close to being ATM par floor. This is why as of March 1, 2019, the April23 par floor was worth about 1.9bp, while the Jan23 par floor was worth about 0.4bp.

FIGURE 1
April23s floor protection kicks in before older issues

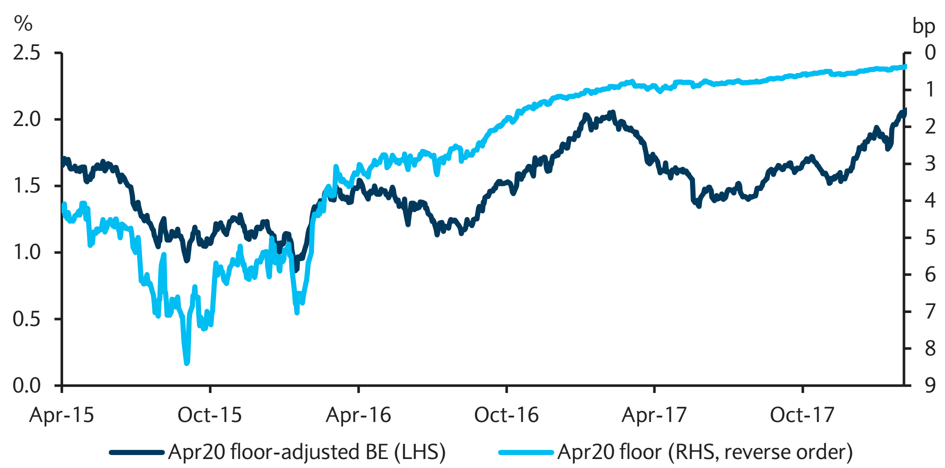


Source: Barclays Research

2. **Remaining time to maturity of the bond:** Bonds with a longer maturity are more likely to be OTM at maturity. This can be due to the fact that central banks usually have an implicit or explicit inflation target. For example, over the medium term, the Fed has a 2% inflation target, while the ECB has a similar target on euro HICP. Over the longer term, it is therefore reasonable to expect the Fed and ECB to do everything in their power to avoid a deflationary spiral. This is why in 2008 near-term floors richened significantly relative to longer-term floors. With this precedent, we would expect the newly issued 5s (TIIApr23s, TIIApr22s and TIIApr21s) to be the target for par deflation-floor premium-led bids relative to the 10y or 30y floors.

3. **The level of breakevens:** This determines the extent to which the floor is considered in the money. Figure 2 shows that when breakeven levels decline, the floor value picks up. A fall in the bond's breakeven brings the implied maturity-index ratio closer to par, and its theoretical value can increase substantially. Along with implied vols, this is the most significant driver of the option value. Also, implied vols are directional with the decline in breakevens. That is, when breakevens are lower, implied vols are typically higher (Figure 3). In this sense, it is better to buy floors when breakevens are high.

FIGURE 2
Apr20 floor moves with the changes in Apr20 BE



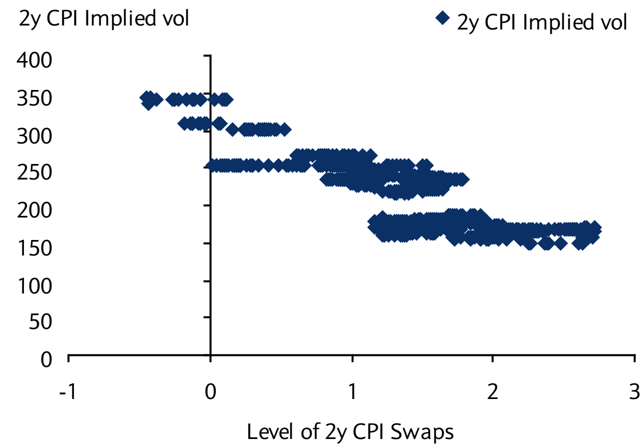
Source: Barclays Research

4. **Implied volatility of breakevens:** In our experience, implied vols are (similar to equity markets) inversely related to the level of breakevens (Figure 3). That is, when breakevens are low, implied vols tend to be higher. And as with all options, an increase in the implied volatility of the underlying forward CPI expectations increases the probability of the option being in the money. In the most recent crisis, implied vols increased, as did the corresponding deflation floor option values.

Going into the 2008 financial crisis, broker/dealers were likely still short deflation floors through structured notes. A typical inflation-linked structured note has an embedded deflation floor, struck at 0% inflation to maturity. Thus, dealers become short when they issue these notes. In the US, one of the ways broker/dealers hedge their short optionality is via long floor rich TIPS issues (eg, TIIApr23s or TIIApr22s) versus nearby issues whose floor is deeply OTM (an alternative to shorting CPI swaps). This sort of hedging is what exacerbated the bid for TIIApril13s in September-October 2008 (Figure 4). An increase in realized vol would likely increase implied vols in these structures, making dealers more sensitive/exposed to the underlying optionality, thus further increasing a relative bid to the ATM TIIApr22s versus TIIJan22s at the time of market stress (Figure 5).

FIGURE 3

Level of implied vol higher when CPI swaps are lower



Source: Barclays Research

FIGURE 4

2008 financial crisis richened April13s to Jul13s about 200bp as the 5y deflation floor became more valuable

Source: Barclays Research

FIGURE 5

TIIApr22s tends to richen relative to TIIJan22s during a period of market volatility

Source: Bloomberg, Barclays Research

Estimating deflation floor premium from the market

One way to value a deflation-floor premium is to look at the CPI options market. Given that these options markets are not very liquid, investors can also compare the traded proceeds ASWs (quoted by the broker/dealers and which include the floor premium on a security) on linkers with their own calculated proceeds ASWs. This is particularly true in the US TIPS market. For example, at the height of the 2008 financial crisis, April13s (Figure 4) traded rich. Thus, when an investor calculated proceeds ASWs, it showed up as rich. In the quoted proceeds ASWs market, the dealer would take into account all of the TIPS cash flows, including the floor premium, to arrive at a price. Thus, the difference between the traded versus calculated proceeds ASWs should include an estimate about the floor premium value:

TIPS Floor Premium ~ Market-based Proceeds ASWs - Calculated Proceeds ASWs

Assumption: Market-based proceeds ASWs include the trader's valuation of the floor premium on any given security.

As noted in the implied volatility primer, we primarily use the Black log-normal model on the forward index ratio to price floors. The implied vol estimates are input directly from the CPI options market.

Calculating the deflation probability

Prior to the announcement of QE 2, Fed Chairman Ben Bernanke cited that the probability of deflation had increased to about 30% and that to avoid a deflationary spiral and stimulate aggregate demand, it was necessary to engage in quantitative easing. Specifically, he cited floor premiums in the TIPS market as a gauge for the deflationary probability. Below, we estimate CPI floor values via estimation from the TIPS market and/or direct inputs from the CPI options, using options math to back out the implied probability of exercise. In the case of 0% CPI floors, this translates into deflation probability through the maturity of the option.

Specifically, we use a Black log-normal model on forward index ratios to calculate the probabilities of a CPI option being exercised. We assume a log-normal distribution for index ratios as the index ratios cannot go below zero. To calculate forward index ratios, we use zero coupon CPI swap rates to the maturity of the options. In general, in the CPI options market, the zero coupon CPI swap rate is used as the underlying because from an option sellers perspective, the CPI swap is used as the underlying for pricing.

The Black formula is akin to the Black-Scholes formula for pricing stock options, except that the forward price is used instead of the spot price. Below, we summarize the equation for calculating the put option on forward index ratios and the probability of exercise.

*Inflation Index Ratio-Based Put Option Premium = D (T) * [K * N (-d2) – F * N (-d1)]*

$$d1 = \frac{\ln(F/K) + (\sigma^2/2) * T}{\sigma\sqrt{T}}$$

$$d2 = d_1 - \sigma * \sqrt{T}$$

N () is the cumulative distribution function of the normal distribution

T = Time to maturity

D (T) = Discount rate to maturity, we use the nominal swap curve

F = Spot Index Ratio pushed forward by the zero coupon CPI swap rate of the respective maturity,

$$F = \text{Spot Index Ratio} * (1 + \text{ZC\_CPI\_Swap})^T$$

K = Strike, is the expected inflation index ratio at maturity

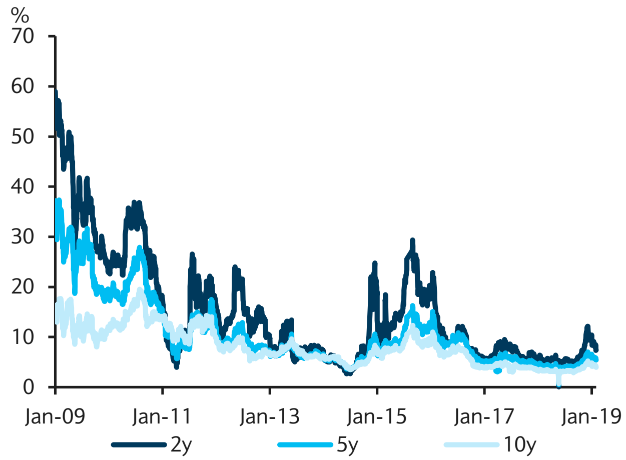
σ = Volatility of the inflation index ratios

For a put option, the probability of exercise is N (-d2) or (1 – N (d2)). For the intuition behind this probability, one can look at the derivation of the Black or Black-Scholes formula for a digital option (the payoff is 1 if the option expires in the money and 0 if it expires out of the money) using a statistical approach.

For a digital put option, the premium is equal to D (T) * N (-d2), in other words, to the discounted expected value of the maturity pay-off. For a digital, since the expected value at maturity is either 1 or 0, N (-d2) is just the probability of the option's expiring in the money. Here, it would mean the probability of the forward index ratio being below the strike index ratio.

FIGURE 6

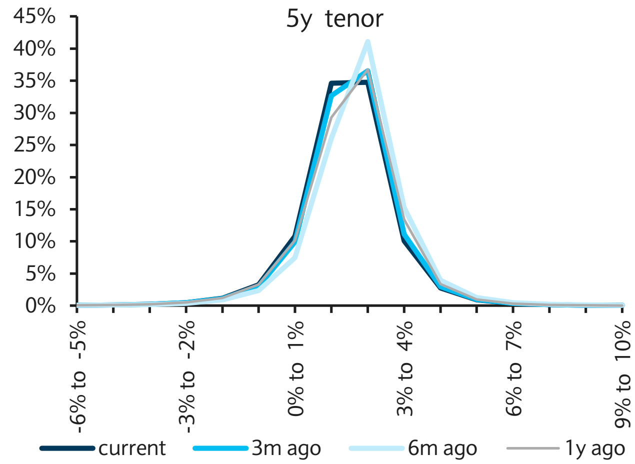
Probability of deflation as implied by the CPI options market



Source: Barclays Research

FIGURE 7

Implied inflation distribution from the CPI options market



Source: Barclays Research

Thus, the probability of the inflation index's being in the money (for a put option) is N (-d2). Figure 6 shows the deflation probability through maturity implied by 2y, 5y and 10y cumulative CPI deflation floors (where the forward index ratio strike is 1).

For a digital call option, the premium is equal to D (T) * N (d2), in other words, to the discounted expected value of the maturity pay-off. For a digital, the expected value at maturity is just the probability of option expiring in the money (if it does, the pay-off is 1, else it is 0; the expected value is 1 * Pr (F > K) – 0 * Pr (F < K). Here, it means the probability of the forward index ratio being above the strike index ratio.

Thus, the probability of the inflation index's being in the money (for a call option) is N (d2).

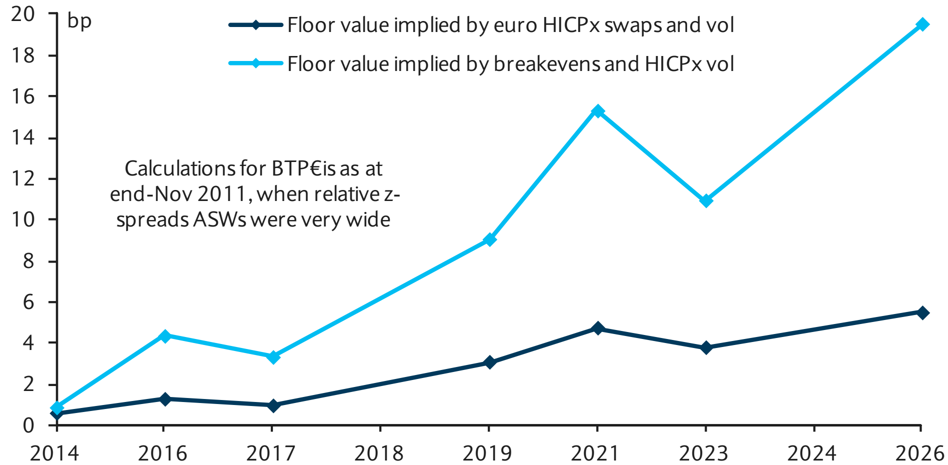
In terms of exact calculations, we look at the market premiums for all inflation options, back out the flat volatility and then calculate the probability of option exercise. Figure 7 shows the probability of exercise for all 5y expected inflation ranges as of March 1, 2019.

The effect of wide relative z-spread asset swaps on par floor values

When valuing the floor embedded in a bond, the degree to which it is in or out of the money is typically determined by the inflation swaps curve; ie, the ATM strike for any maturity is determined by what the swap market is quoting. To some extent, this makes sense, as the implied vol input would also be based on floors for which the traded underlying would be inflation swaps. However, one can easily realise that determining the moneyness of a par floor on a linker with respect to the inflation swaps curve is acceptable only if the breakeven on the linker is not significantly different to what the swaps curve is implying. In other words, if the absolute value of the relative z-spread on a bond is very high, determining the value of the embedded floor using the inflation swaps market as the underlying would create an internal inconsistency with the bond's pricing. We illustrate this with BTP€is. Breakevens in BTP€is dropped to very low levels amid the sovereign debt crisis, below zero on some issues. Euro HICPx, on the other hand, stood at much higher levels. For a BTP€i with a breakeven that is significantly below euro HICPx swaps, using swaps as the underlying would make its par floor appear far more out of the money than if its own breakeven were used as the ATM strike.

FIGURE 8

Floors notably more valuable if ATM is determined by bond breakevens when relative z-spreads are very wide



Source: Barclays Research

INFLATION DERIVATIVES PRODUCTS

Inflation volatility products

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Activity in y/y caps and floors developed due to structured note issuance, well before trading in zero coupon options started. Activity and liquidity in both the zero-coupon and y/y volatility markets have nevertheless been very subdued over the past couple of years, limiting the involvement of tactical investors.

Zero-coupon cap/floor basics

A zero-coupon CPI cap/floor is essentially a call/put option on the inflation index or, more precisely, on the change in the inflation index over the tenor of the contract. Its underlying for pricing is therefore a zero-coupon inflation swap, making it very different from y/y caps/floors. The market for zero-coupon CPI caps grew alongside the zero coupon floor market, although the latter has typically been more active because liquidity benefits, to some extent, from the existence of par floors in linkers. A few years ago, it was relatively straightforward to get quotes for caps on US CPI and euro HICPx, but the market there is now much less defined. As liquidity and activity dried up over the past few years, any activity in the volatility market has been mainly around low strike floors because of activity in asset swaps.

We use the US market to illustrate the mechanics of a zero-coupon CPI cap and floor, although the principles would be similar for the European market. Typically, in US CPI caps/floors, the underlying CPI NSA is 3m lagged and progresses via stepwise interpolation (unlike CPI swaps and/or cash TIPS, in which the CPI interpolation method is linear for daily accrual). On the other hand, in euro HICPx caps/floors, the underlying follows the same index reference date conventions as standard swaps. The zero-coupon CPI cap pays the difference between realized CPI at maturity and a pre-specified CPI strike if that difference is greater than zero, and nothing otherwise. The latter is typically quoted in annualized inflation terms from the 3m-ago CPI print. The zero-coupon CPI floor pays the difference between a pre-specified CPI strike and realized CPI at maturity if that difference is greater than zero, and nothing otherwise.

As we have done for the pricing of CPI floors (in the "Par floors in linkers" section), we employ a Black Model in valuing CPI caps as a starting point.

$$C = D(T) * [K*N(d_1) - F*N(d_2)]$$

$$P = D(T) * [K* N(-d_2) - F*N(-d_1)]$$

$$D_1 = \frac{\ln(F/K) + (\sigma^2/2)*T}{\sigma * sqrt(T)}$$

$$D_2 = \frac{\ln(F/K) - (\sigma^2/2)*T}{\sigma * sqrt(T)}$$

The index ratio at the option maturity can be viewed as a random variable with a log-normal distribution. As far as pricing is concerned, typical variables for options pricing matter, such as volatility, time to maturity, relative skew, etc. The same can be applied to calculating the floor value.

Applications and uses of zero-coupon CPI caps/floors

Hedging

- CPI caps and floors are well suited as hedging instruments for partial indexation schemes.
- A payer/receiver of inflation on an inflation swap can limit the uncertain inflation payoff by buying a cap/floor. One would pay a premium to buy this cap/floor, but would receive a guarantee that the exposure is not above/below a certain pre-agreed strike.

Investing/trading

- As with all options, CPI caps and floors can be used to leverage a view on headline CPI.
- An investor can combine selling an OTM CPI cap with a cash-breakeven or zero coupon CPI swap position for a long covered cap or covered breakeven to gain a better entry point into a long inflation position (while capping gains beyond a certain inflation strike). A protective floor can be used to protect the downside of a CPI swap/breakeven.

For reference, an inflation cap-floor parity should be satisfied at any time in this market.

Zero coupon CPI cap (strike: X) – Zero coupon CPI floor (strike: X) = Payer inflation swap.

Y/y cap/floor basics

The y/y inflation cap and floor market has historically been most active in euro HICPx, having gravitated around structured note activity in Europe. A cap/floor is a series of caplets/floorlets on y/y inflation. A 10-year y/y cap/floor, for instance, will be a structure of 10 caplets/floorlets with a pre-determined strike rate. Each year, the caplet/floorlet will pay a cash flow if y/y inflation is above/below the strike rate, with the cash flow equal to the notional multiplied by the difference between the realised y/y and the strike rate. For standard euro HICPx y/y caps and floors traded in the broker market, the index reference date conventions are the same as the underlying swap market: for example, trading on ZC euro HICPx swaps in July occurs with an April base month. This means that euro HICPx caps traded in July will have cash flows determined by April y/y inflation rates over the life of the cap. It is notable that the US y/y cap/floor market also trades in terms of base months, similar to euro HICPx, even though the US CPI swaps market trades on an interpolated daily index reference. One element to highlight is that unlike in nominal caps/floors, the cash flow on the first inflation caplet/floorlet is not known in advance at the trade inception date.

Quotations for y/y caps and floors are typically in premium terms. In the US, traders are accustomed to quoting y/y CPI caps and floors for monthly resets of y/y CPI, but they also quote yearly resets of y/y CPI.

Outside the US, particularly in Europe, these structures have annual payments, which means the y/y inflation caps/floors are typically quoted in annual forms in Europe. Given that the cumulative seasonality over a year is zero, the annual reset form of quoting removes a lot of the idiosyncrasies in quoting m/m seasonality in inflation.

Y/y euro HICPx caps and floors are most commonly quoted at strikes with increments of 50bp (ie, 0.0%, 0.5%). In the past, the development of the range accrual market in particular has helped better define the cap/floor vol smile, as the strikes on these notes occurred at a varied range, usually at 1-1.75% on the floors and 2.5-3.25% on the caps. It has become common also for quotes in the euro HICPx cap/floor market to be expressed in running premium terms.

Limited Price Indexation (LPI) swaps

LPI swaps are effectively a combination of a standard inflation swap with a series of caplets and floorlets. This structure is common in the UK, where historically the largest stock of defined benefit pension liabilities have been indexed to the Retail Prices Index (RPI) capped at 5% and floored at 0%. Paying fixed and receiving LPI can be thought of as receiving RPI (i.e., paying fixed on the inflation swap) combined with a short position in a cap and long position in a floor. LPI is calculated as an index, on which a swap can then be written, in a similar format to RPI swaps. The usual format is for LPI to be traded as a zero coupon swap with appropriate collateralisation, though a ‘pay as you go’ format is also feasible.

We model LPI recursively to provide an estimate of market valuations:

$$LPI_t = LPI_{t-1}.\left[1 + RPIYoY_{t-1}^{t} - Caplet_{t-1}^{t} + Floorlet_{t-1}^{t}\right]$$

Where $LPI_0 = RPI_0$, RPIYoY is the y/y RPI rate priced by the swap market for the period of interest, and caplet and floorlet prices are expressed in future value and % notional terms. As LPI is a path-dependent swap, this simple model is an approximation to the actual structure as it fails to account for correlation between the RPI swap forwards. Usual market practice is to apply a convexity adjustment to account for this, though there is no clear consensus as to how best to price it. Modelling LPI can be challenging for many market participants given the need for extensive cap and floor prices and RPI forwards, many of which may not trade frequently in the market in isolation. Indeed, historically, it has been more common for LPI swaps to trade in the broker market (typically quoted as a basis point spread to zero coupon standard RPI swaps) than for the underlying caplets or floorlets to trade in isolation.

LPI swaps are usually of interest to those who require a very precise hedge for specific inflation liabilities. UK linkers do not have an embedded principal deflation floor unlike their US and euro counterparts, so there is no related supply of inflation floors to the RPI market from asset swapping activity. This means that 0% strike floors have in the past tended to trade rich on the vol surface; while in the current macroeconomic environment this skew might not seem unreasonable, it nevertheless leaves most LPI swap structures more expensive than an equivalent linear RPI swap hedge. Trading LPI swaps is also extremely capital intensive and given the path-dependent nature of the swap they should usually be considered as a long-term buy-and-hold structure. In recent years activity has dwindled notably alongside a broader industry trend towards simpler, clearable derivative products. Unless an active, cleared market in LPI develops, we do not realistically see much chance of a resurgence in interest for this product line.

Development of the inflation volatility market

Caps and floors related to structured notes issuance have traditionally been the most important flows. In Europe, activity in structured inflation notes took off in 2003, with coupon typically set as a fixed rate *X*% plus y/y inflation rate. Coupons were usually floored at zero, but floors set at the fixed rate *X*% were not uncommon either. 2004 saw the emergence of leveraged notes, which typically paid a multiple of y/y inflation or a fixed rate plus a multiple. The leverage factor amplified not only the effect in the swaps space but also the implicit notional on any embedded floors. By 2007, the market had started to reach a point at which flows unrelated to underlying product were becoming almost as important, especially in the euro area. In 2006-07, inflation-range accruals took centre stage in inflation-linked structured note issuance. Those structures typically aimed for the y/y inflation to remain in a tight range around the ECB’s target of inflation close to but below 2%. Range accrual notes helped push down cap/floor vol in the euro area significantly, but investors in these bonds suffered when actual inflation started to move well above the upper end of the ranges offered towards the end of 2007. With realised inflation pushing towards 3% in 2007, cap/floor implied volatility drifted higher as some assumptions in pricing models were changed but also because of some unwinding of the loss-making range accrual notes.

In 2008, the fear of high inflation boosted demand for inflation-linked structured notes from retail investors. Products paying inflation with leverage once again became widespread. Many of these notes were structured with higher leverage than before and with floors above zero. Issuance also thrived in the first half of the year as banks in particular took advantage of expensive credit/funding for financials. Even though implied vols and swaps surged to unprecedented levels, the high funding levels meant that sufficiently attractive pay-offs could easily be structured to cater for the retail investor base. After the summer of 2008, issuance dried up as focus turned to deflation, while a surge in volatility made the cost of floors embedded within most structures extremely expensive. Issuance started to recover in Q2 09 after global central banks had engaged in quantitative easing strategies, which increased inflation fears significantly despite negative realised inflation, but leveraged notes were scarce. Since then, activity has picked up but with relatively simple structures.

In the euro area, the y/y vol market reached, at some point, a degree of maturity at which activity was sometimes independent of structured note issuance. However, even then, it was difficult to know if occasional bouts of activity were not in fact related to a dealer reshuffling exposures to risk that was previously warehoused on the back of issuance. Activity over the past couple of years has shrunk significantly and is now almost non-existent. Asset swapping in peripheral euro area linkers sometimes creates activity around low-strike zero-coupon floors but this is far from sufficient to animate the vol surface and drive broader interest.

Some pricing considerations for y/y caps and floors

Following the Fisher equation, an analogy with the foreign exchange market seems to be an obvious starting point when in inflation models: the nominal yield corresponds to the domestic currency, the real yield is analogous to the foreign currency, and CPI is the exchange rate between the nominal and real yields. This analogy is the starting point of the model developed by Jarrow and Yildrim.

The model consists of a three-factor framework comprising the nominal, real, and inflation rates. The nominal and real interest rates are assumed to follow an HJM diffusion process. The CPI is driven by an instantaneous inflation rate defined as the difference between the nominal and the real interest rates. The Jarrow-Yildrim model provides arbitrage-free conditions between the three components. In their paper, the authors obtain the nominal and real rate term structures by applying standard stripping techniques to nominal US Treasuries and TIPS. Volatility parameters for the nominal and real forward rates are computed from historical data on TIPS and nominal US Treasuries, while the volatility of the inflation rate is derived from the CPI time series. Finally, estimates of the correlation parameters between the three components are calculated through sample moments using historical inflation, real, and nominal interest rate data.

Advantages of this model are its simplicity and intuitiveness and the fact that its framework is easy to implement. Also, in the particular case where the CPI process is linked to an instantaneous inflation rate, it provides closed form solutions for inflation swaps and Black-Scholes formulas to evaluate inflation options, whether they have a zero coupon or a y/y format. However, its main drawback is that it is particularly suited to markets in which calibration is necessary for data on the bond market. This is especially problematic for the euro area inflation options market, where the more natural curve for data calibration would be the inflation swap curve. To this end, other models that fall under the 'market models' category have emerged as more suitable candidates.

One such approach has been developed by Belgrade, Benhamou and Koehler. They link the zero-coupon and the y/y inflation derivatives in the European inflation swap and options markets through a market model. Forward values of the CPI are modelled. The authors provide a convexity adjustment formula when computing the forward value of the CPI ratio, where the forward value of the ratio is what effectively determines the expected value of a caplet/floorlet. They show that the forward value of the ratio is the respective forward CPI multiplied by an adjustment that is an explicit function of the forward CPIs, the forward zero coupon bond and the correlations between them. Unlike in the Jarrow-Yildrim framework, the availability of the CPI forward is considered to be sufficient such that real rates are not used as an input. As for the nominal curve, an HJM-type diffusion is assumed. The calibration to market data is done using money market and swap prices for the nominal zero coupon term structure. Traded optional instruments are used to define the nominal volatility structure. The authors give closed formulas for the valuation of breakeven swaptions and numerical integration for options on real yields.

Sophisticated models are needed to cater for the complexity in volatility products. For example, the LPI swap is a relatively common product but complex in terms of pricing. To value the product, a simulation of annual inflation rates is needed up to the maturity of the swap. The simulation needs to be carried out within an inflation model. The simulation of nominal rates can be implemented through a usual HJM framework.

In the euro inflation market, traders build the inflation volatility term structure (vol as a function of expiry) for individual ATM caplets/floorlets (not quoted in the market) so that they can match ATM cap/floor straddles (quoted in the market). The SABR (stochastic volatility) model seems to be a natural choice as a calibration tool for inflation smiles. The SABR parameter is set and inflation volatilities implied from option prices are then calibrated in the SABR model, in which the correlation (an inflation rate versus its volatility) and the vol-of-vol (volatility of inflation volatility) parameters determine the "skewness" (asymmetry) and the "smileness" (curvature) of vol smiles.

INFLATION DERIVATIVES PRODUCTS

Total Return Swaps

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We examine the basics of total return swaps (TRS) as they apply to inflation products. We discuss their applications and dealers' valuation perspectives, as well as the risks of such transactions.

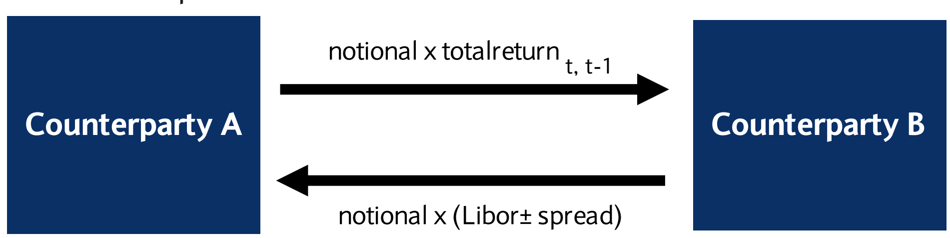
One way for investors who are interested in getting real returns without taking inflation-linked securities on their balance sheets is to execute an over-the-counter inflation-linked based total return swap (TRS) with a dealer.

Total return swap: What is it?

A TRS is an OTC transaction in which an investor (asset total return receiver) receives all cash flows (including coupons and market value changes) related to a referenced asset (for example, a TIPS index or particular TIPS security) in return for periodically paying a floating leg (typically Libor) plus/minus a fixed spread (Figure 1). In other words, the investor does not own the underlying asset on its balance sheet but receives returns associated with the asset by paying a fee. The notionals and maturities (term or maturity of the swap) are set at the trade's inception. The maturity is typically one month to one year. The underlying asset can be any instrument(s) (eg, a single bond, a portfolio of bonds, index, etc). Investors can take a long or a short position with respect to the reference asset in such a transaction.

The spread applied to the floating side of the swap is required to compensate the dealer for the balance sheet cost of holding the asset or assets underlying the agreement. The credit rating of the institution offering the swap can also have a bearing on the pricing, with those with a lower rating potentially requiring less spread to hold the assets. There is a counterparty credit risk involved in a total return swap, but this can be mitigated by ISDA plus CSA agreements or frequent resets.

FIGURE 1
Total return swap structure



Source: Barclays Research

Structure and hypothetical example

- To conduct a TRS trade, ISDA and CSA are required.
- Tenor: Flexible; can be as long as one year. 1m to 1y generally.
- Resets: Flexible; typically monthly or quarterly, with semi-annual also possible.
- Price: Typically quoted as Libor + X (bp spread, includes funding and replication costs)
- Early termination/notional adjustment: Possible, usually subject to early unwind charges. Notional adjustments are subject to negotiations.

The hypothetical example in Figure 2 shows the mechanics of a 6m maturity TRS at each point. The underlying reference asset is the US TIPS index.

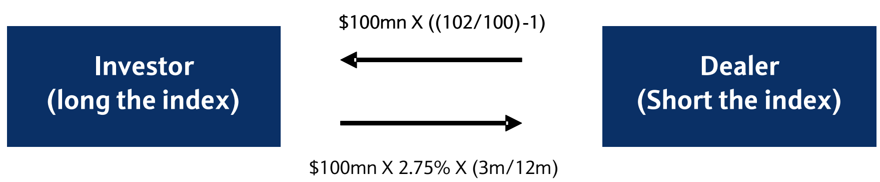
FIGURE 2

Mechanics and cash flows of a TRS, as of February 25, 2019

Parameter	Value
Inception	February 25, 2019
Reference Index	US TIPS Index
Initial Notional	$100mn
TRS Tenor	6m
TRS Reset	Quarterly
Initial TIPS Total Return Index Fixing	100
Initial 3m Libor Fixing	2.65%
Spread over 3m Libor (bp)	10

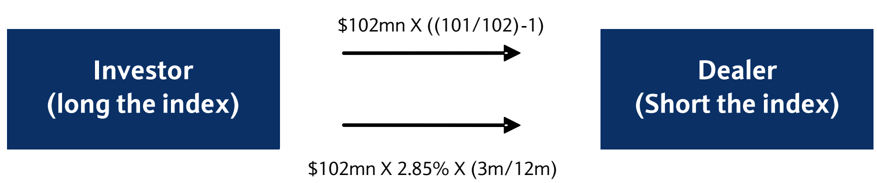
Source: Barclays Research

- Inception TIPS TR Index value: 100
- Assume TIPS TR Index at the end of 3m: 102
- Libor reset plus 10bp spread from previous date: 2.65% + 0.10% = 2.75%
- Investor receives index return of 2% and pays 68.75bp of quarter period Libor on a $100mn notional.



At maturity:

- Previous TIPS TR Index value: 102
- Assume maturity Index value: 101
- Libor reset plus 10bp spread from previous date, assuming Libor reset of 275bp: 2.75% + 0.10% = 2.85%
- Investor pays index return of 0.98% to the dealer and pays 71.25bp of quarter period Libor on a $102mn notional.



Range of TRS usage in inflation product

Total return swaps need not be linked to a particular security. Indeed, swaps on indices are more common than on individual bonds in the inflation-linked space, and are often on specific maturity subsets rather than on whole-market indices. TRS are used for individual bonds and indices in US TIPS and UK linkers and for euro area inflation-linked, including country and maturity, sub indices. They can also be used as a means to gain access to less liquid inflation markets, with bond-specific and broad index allocations. Note that the floating rate referenced in a TRS need not necessarily be in the same currency as the underlying asset. Indeed, total return swaps can be based on index returns spanning various markets (eg, global inflation-linked indices including the Barclays Emerging Market Tradable Inflation-linked Bond Index). TRS are also used to gain exposure to the performance of an inflation-linked bond in asset swap without having to own the underlying bond, though usually the TRS on the bond and the real rate cash flows are considered separately in such positions.

Valuation perspective

TRS valuations versus Libor tend to reflect the funding value of the underlying assets plus a spread embedding transaction expenses and the cost of using the counterparty's balance sheet. As of February 25, 2019, the US TIPS index-based TRS was trading at indicative levels of Libor + 10bp (offer) for a one-year period. In essence, a total return payer can hedge the inflation-linked TRS by buying the underlying security and funding it on balance sheet and selling it at the swap maturity. The funding cost for the total return payer will drive the spread for the TRS. When a TRS is made with a portfolio of bonds or an inflation-linked index, the payer will have to buy the underlying index. However, the bid-offer will typically be lower than replicating individual bonds because the TRS dealer would aggregate positions across his/her portfolio, thereby reducing relative hedging costs. The index swap dealer is also likely more comfortable taking on outright market risks and basis risks than an investor who is trying to outperform/match a benchmark.

Uses of a TRS: Portable alpha, leverage, exposure …

- One of the attractions of a TRS is leveraging a dealer's balance sheet. For example, a buyer can be long $100mn worth of TRS without having to buy the assets for that money, but simply paying a fee on the notional. It also enables investors to obtain off-balance-sheet exposure to assets in which they might not be able to invest directly.

- Buying and selling index swaps may be cheaper than individually trading in and out of an asset class operationally and in terms of bid/offers.

- In terms of trading, TRS allow a payer to short an asset without actually selling it. This may be useful for someone who is managing a portfolio against an index but expects near-term underperformance. Moreover, customization in terms of maturity and underlying security selection allows for a better synthetic structure.

- Investors can also benchmark their portfolios to standard inflation indices and reduce tracking error.

- Most important, using TRS to source a benchmark "beta" return frees up capital to pursue alpha opportunities. For example, receiving TIPS index returns in a TRS has the potential for outperformance, as long as the investor can earn better than the financing rate he/she pays on the Libor leg of the transaction.

Users of TRS

Typical TRS users include pension funds, asset managers, insurers, hedge funds, foundations/endowments, and index tracker funds/ETFs. The reasons for usage vary significantly, even within the same type of investor, as the flexibility that they offer is attractive to most who are able to trade them. Typically, pension funds, endowments, and ETF managers are focused on getting exposure to benchmark indices in an efficient manner. In Europe in particular, pension funds often focus on the effective leverage that can be added through TRS, particularly when the underlying assets have low expected returns but improve liability matching. Asset managers and insurers tend to focus on achieving beta returns in a single off-balance-sheet transaction, to allow them to focus on active management for alpha generation. TRS provide the flexibility for them to create products using asset classes away from their core competencies. Hedge funds tend to focus on accessing markets that are otherwise inaccessible, saving costs on custodial accounts and using the flexibility that TRS offer in terms of maturity, payout currency, and leverage.

Risks of TRS

- In an unfunded format, a TRS allows for significant portfolio leverage, which could be risky for overall asset management.
- A total return swap is an OTC contract and exposes the investor to the credit risk of the counterparty dealer. To some extent, this can be mitigated by monthly resets and collateralization of the NPV, in line with the CSA agreement between the investor and the dealer.
- Last, the investor is exposed to resets on floating-leg spreads. This becomes important if one wants to get long-term exposure to an asset class.

Inflation Markets

INFLATION MARKETS

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The US Treasury began issuing inflation-linked bonds, commonly known as TIPS, in 1997. By 2000, TIPS had overtaken UK inflation-linked bonds to become the largest market of its type, by notional outstanding, reaching a total market value of $1.46trn by March 2019. Nearly 50% of it is held by foreign accounts and about another 10% by the Fed. As of April 2019, TIPS comprise 44% of the Series-B Bloomberg Barclays World Government Inflation Bond Index. The Treasury has varied its issuance pattern over time and currently issues at the 5y, 10y and 30y maturities in monthly auctions. At the end of 2018, TIPS made up 9% of outstanding marketable Treasury debt, and we estimate they will make up about 8% of net Treasury coupon issuance in 2019. Despite the depth of the TIPS market and the commitment from the Treasury, there is little corporate issuance, and inflation derivative activity is relatively limited, although the use of swaps and asset swaps has increased.

The Inflation Index: CPI-U

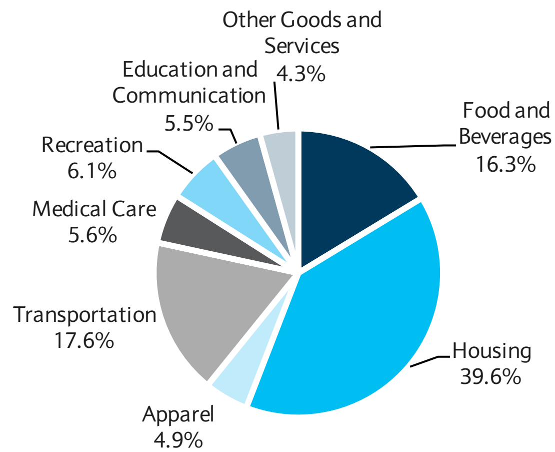
The Inflation Index used for TIPS is the not seasonally adjusted US City Average All Items Consumer Price Index for all Urban Consumers (CPI-U), which measures price changes for urban consumers of a fixed basket of goods and services of constant quality and quantity. Prices are collected from 85 urban areas, which include 21,000 retail and service establishments. Rent data, which are also used to compute owners' equivalent rent, are gathered from 40,000 landlords and tenants. Prices are collected for more than 200 categories, which are classified under eight major groups.

Breakdown of CPI-U components

The basket of goods and services and the item weights are determined from the Consumer Expenditure Survey (CES) and updated every two years. Because the CPI is a fixed-weight index, the implicit weights remain the same from month to month. A related concept is the relative importance of an item. This means, in essence, that if the price of a particular item rises by more than the average price increase of all items in the basket, the relative importance of that item increases. To illustrate, the price of crude oil, as measured by the WTI, rose from about $20 per barrel in January 2002 to near $140 per barrel in June 2008. One result is that the relative importance of energy rose from 6.2% to 12% during the same period, and then fell to 6.4% in early 2016 as energy prices declined. Figures 1 and 2 highlight the change in the relative importance of the eight major categories between 1997 and 2019. Relative importances are typically released monthly, with a one-month lag.

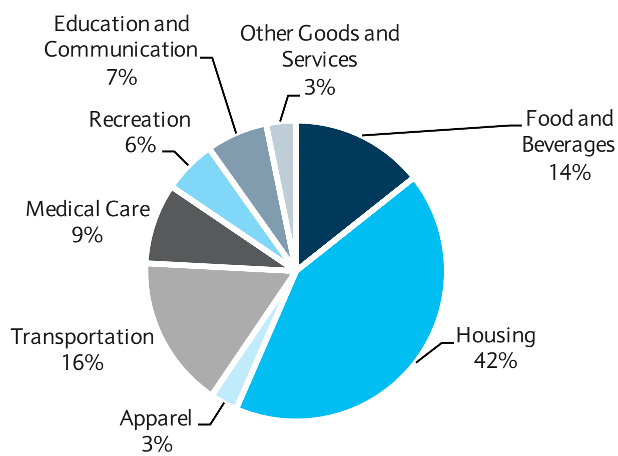
As can be seen from Figure 2, one of the most significant categories in terms of weights is housing, over half of which is an imputed measure called "Owners' equivalent rent of primary residence" (OER), which attempts to capture price changes if those consumers who own their home were to rent instead. BLS measures the change in implicit rents by matching owner units to actual renter units with similar characteristics. The characteristics include location; structure type; and other general traits such as age, number of rooms and type of air conditioning. As owners pay for utilities separately, BLS calculates the "pure" rent of the matched renters by removing the value of any landlord-provided utilities and furniture. As utility prices tend to fluctuate more than actual rents, imputed pure rents can be negatively correlated with utility prices, primarily natural gas prices. Before 1983, the BLS used an asset price approach in computing the shelter component of CPI; because this method was driven by interest rates and house prices, it was much more volatile than the current method, and core CPI volatility has declined since. A common misperception is that OER inflation is determined by homeowners' answers to the question: "How much do you think you would pay in monthly rent if you rented rather than owned your house?" This question is asked on the CES and helps determine the weight of OER, but not its inflation rate.

FIGURE 1
1997 CPI-U relative importances



Source: Haver Analytics, Barclays Research

FIGURE 2
2019 CPI-U relative importances



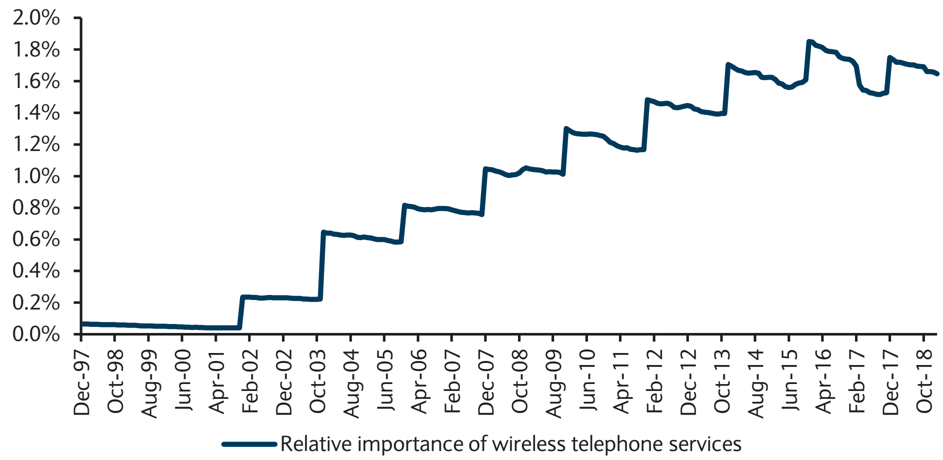
Source: Haver Analytics, Barclays Research

Energy prices can also have a significant effect on m/m CPI prints and are historically responsible for more than 50% of their volatility. Energy currently comprises c.7.2% of the total CPI basket. This weight has fluctuated significantly since TIPS were first issued: energy was more important when oil peaked in mid-2008, but has fallen in recent years. The relative importance changes from month to month with relative NSA prices, so as seasonal factors affecting Energy CPI are at their worst in December, the BLS relative importance data understate the average weight of energy. Gasoline (Motor Fuel) is the most important component of Energy CPI, because its weight is higher and because it tends to be more volatile than the other components: electricity, home fuel oil and utility gas service (natural gas).

Another way to understand the difference between the weights, which come from the CES, and relative importance, is via the CPI wireless services component. The general price trend of wireless phone services is one of deflation. Therefore, once the weight is fixed, the relative importance tends to decline because consumers are spending less for the same amount. However, because cell phone use has increased, the weight step-jumps with every bi-annual CES update (Figure 3).

FIGURE 3

Cell phone service: more users at lower prices



Source: BLS, Haver Analytics

TIPS market history

Although officially called Treasury Inflation-Indexed Securities (TIIS), the name more commonly used by market participants (including the Treasury) is Treasury Inflation-Protected Securities (TIPS). In this article, we use TIPS, given that it is the market convention. The US Treasury first issued inflation-protected securities in 1997 in order to broaden its investor base, diversify and potentially reduce its debt service costs and create liabilities that were more closely aligned with the government's main asset – tax revenues. Initial issuance was in 5y, 10y and 30y securities, and after many changes to the calendar, the Treasury has come full circle and has been issuing at those maturity points since 2010. TIPS are structured such that they pay a fixed coupon on a principal amount, which is adjusted for inflation. The inflation index used is the not seasonally adjusted headline CPI. There is a par floor on the principal at maturity, so the investor is protected from deflation from issue date to maturity, but not in between. A historical synopsis of the TIPS program is presented in Figure 4.

FIGURE 4

TIPS program historical milestones

Date	Event
5/16/1996	Treasury Secretary Rubin announces the intention to issue Treasury inflation-indexed securities
9/25/1996	President Clinton and Treasury Secretary Rubin announced the terms and conditions of the first Treasury inflation-indexed security
1/29/1997	First 10y TIPS auction
4/9/1997	First 5y TIPS auction
4/8/1998	First 30y TIPS auction
6/30/1998	Final rules on fungible inflation-indexed STRIPS were published
9/1/1998	Treasury begins selling series-I savings bonds
9/29/1998	Treasury announces regular quarterly schedule for TIPS and discontinues 5y TIPS
1999	Fed conducts first TIPS pass
11/30/2000	TIPS are stripped for the first time
10/31/2001	Treasury eliminates 30y TIPS because of lower borrowing needs
7/15/2002	First 5y TIPS matures
4/18/2002	Treasury conducts TIPS buyback
4/30/2003	Treasury expands 10y TIPS auctions to four per year with two new issues per year

Date	Event
2/8/2004	CPI futures begin trading at CME
5/5/2004	Treasury announces the introduction of 20y TIPS and reintroduction of 5y TIPS
7/27/2004	First 20y TIPS auction
10/26/2004	First reintroduced 5y TIPS auction
1/15/2007	First 10y TIPS matures
1/22/2008	TIPS index market value hits $500bn
2/29/2008	5y real yield goes negative for the first time
11/20/2008	10y breakevens touch zero during financial crisis
1/18/2009	Fed includes TIPS in "QE1"
2/22/2010	First reintroduced 30y TIPS auction
11/3/2010	Fed includes TIPS in "QE2"
2011	Treasury moves to monthly TIPS auctions
9/21/2011	Fed includes TIPS in “Operation Twist”
4/30/2012	Treasury provides data on foreign ownership of TIPS in its annual TIC holdings report
12/12/2012	Fed includes TIPS in "QE3"
4/11/2013	FRBNY begins to break out TIPS trading volume and primary dealer positions by maturity
May/June 2013	Fed ‘taper-talk’ causes a 100+bp rise in 10y real yields
4/11/2014	TIPS index market value hits $1trn
7/1/2014	Oil begins a 75% decline, pushing breakevens sharply lower
2/3/2016	Treasury cuts issuance by $2bn at each monthly auction
10/31/2018	Treasury announces increased issuance and the addition of a second 5y cusip (with an October maturity) starting in 2019

Source: US Treasury, Barclays Research

There was limited initial support for TIPS, as investors used them mainly as a tactical trading vehicle. The small number of participants resulted in low trading volumes and a low beta to nominal yields. Breakevens were generally the main catalyst for investment decisions. In November 2000, the iSTRIPS market was launched when the TII08s became the first TIPS to be stripped. iSTRIPS allow investors to trade the TIPS coupon and principal components separately, where the principal component carries the floor, although to date there has been only scarce interest in iSTRIPS. While they have not been a success, it was important that the Treasury encourage stripping activity to signal its commitment to the TIPS program when many observers were questioning the durability of the asset class. Despite this, the Treasury reduced TIPS issuance commensurate with reductions in the nominal calendar until only an annual 10y note, with just one re-opening auction, existed in 2001 (Figure 4).

With five years of history and the 5y TIPS issued in 1997 having matured in 2002, the TIPS market finally started to gain broader acceptance. Consultants to pension funds began recommending TIPS in earnest, and due diligence and approval processes were introduced. There was also increased interest in real return mutual funds and other funds tied to the TIPS Index as investors began to make diversification allocations into TIPS as a new “asset class.”

Rising demand led to significant growth in 2004; the Treasury issued nearly as many TIPS that year as it did in the previous three combined. It also announced a major expansion of the program to include two 5y auctions and two 20y auctions per year, in addition to the existing quarterly 10y note auction cycle. Alongside growth in the cash market was a developing inflation derivatives market. CPI futures began trading at the CME in early 2004, and volume in the CPI swaps market rose notably, as did issuance in inflation-linked corporate notes. The US inflation market continued to develop in 2005, particularly in derivatives and structured notes.

From 2005 to mid-2008, average daily trading volume leveled off on increased demand from structural investors, including pension funds and insurance companies, whose investments tend to be passive. Related to this was significant growth in Inflation-Linked Total Return Swaps activity from investors looking to receive the return of the TIPS Index or a Global Inflation-Linked Index in a passive way.

The TIPS investor base began to shift considerably in H2 08. After comprising about 50% of TIPS market flows in 2007, hedge funds largely exited the asset class during the financial crisis. After the market cheapened following this deleveraging process, real money investors began to boost structural allocations significantly. Foreign central banks began to buy because of diversification benefits and as a *de facto* currency hedge. As of June 2013, foreign official institutions held about 24% of the TIPS market. Domestic real money increased structural allocations in part because of medium-term inflation risks associated with stimulative fiscal and monetary policy, and partly because of a realization by many that the right allocation to TIPS within a well-diversified portfolio is not zero. However, retail fund flows began to turn negative in autumn 2012, and this accelerated when real yields sold off sharply on remarks by Fed officials in May and June 2013 that the Fed was likely to taper its QE3 asset purchases. The Fed had been buying (and selling) TIPS as part of its Treasury open market operations, known as QE1, QE2, Operation Twist and QE3, though those purchases ended in 2014. The Treasury has responded to rising structural investor demand by raising gross issuance from $58bn in 2009 to $155bn in 2013. As a result, the market value of the TIPS index breached $1trn in April 2014.

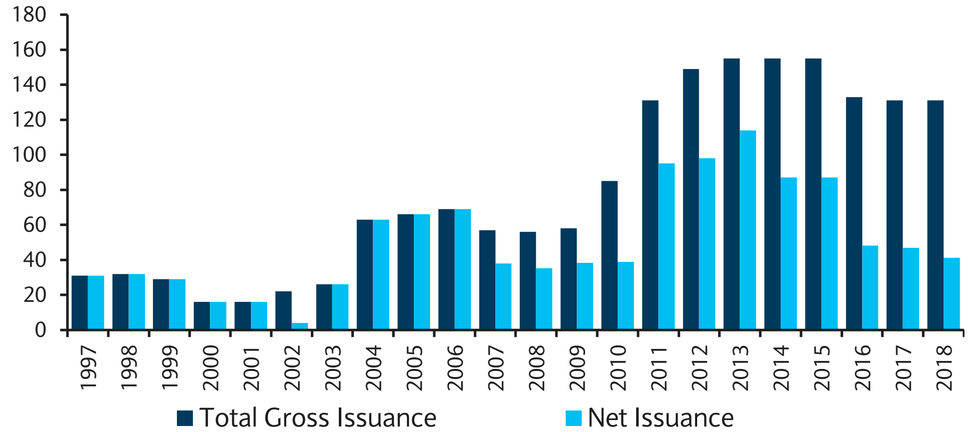
The 75% fall in oil starting in July 2014, combined with global disinflation pressures, caused many market participants to question whether central banks are willing or able to generate target inflation. Breakevens, both spot and longer forwards, fell sharply from mid-2014 to mid-2016 as inflation expectations fell and the inflation risk premium turned negative. The Fed's hawkish rhetoric over that period was a significant market headwind. Nonetheless, overall market liquidity relative to nominals seems not to have deteriorated; average daily trading volume has been $15-20bn/day since 2016, and relative asset swaps, a measure of the relative liquidity premium between TIPS and nominals, have generally tightened and been relatively stable. While breakevens have recovered from 2016 lows, they remain priced at levels consistent with the Fed's consistently undershooting its 2% PCE target. In part because inflation expectations have slipped, the Fed is exploring alternative inflation targeting frameworks; if they make a credible shift, it could be a positive catalyst for the market.

TIPS issuance summary

Figure 5 shows annual TIPS issuance since 1997. While supply in the first three years of the program was just above $30bn per year, it declined to only $16bn in 2000 and 2001. The reduction, however, was not a reflection on the TIPS program, but rather the effect of budget surpluses; all Treasury issuance was being reduced. With the return to deficits in 2002, issuance began to grow, and the $63bn issued in 2004 was equal to all TIPS issuance in the prior three years. TIPS issuance grew only modestly, by $6bn, from 2004 to 2005, but other Treasury issuance was being reduced, so the TIPS market grew on a relative basis (Figure 6).

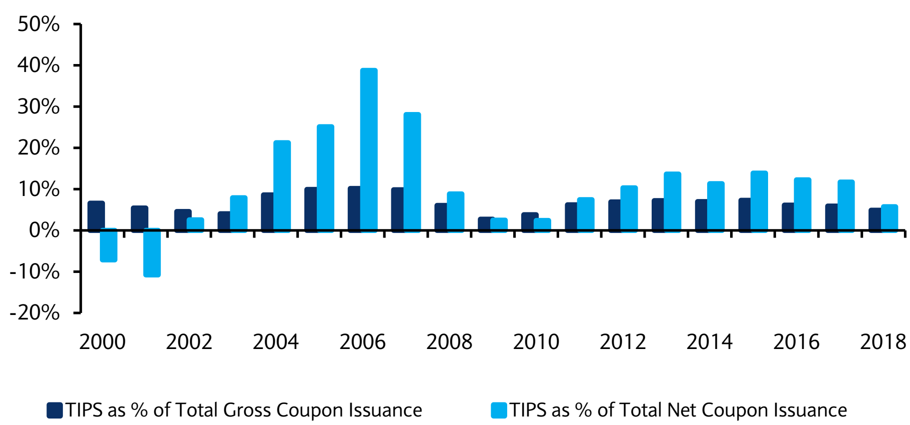
After picking up in 2006, TIPS issuance slowed in 2007 on an outright basis and relative to nominal coupon issuance as the Treasury became proactive in slowing the growth rate of the program as it matured. It held TIPS issuance steady at $56-58bn gross and $35-38bn net during 2007-09, even as it increased nominal issuance significantly and the percentage of Treasury debt represented by TIPS fell from a peak of 10.6% in late 2008 to less than 8% by the end of 2009. After recommitting to the asset class and aiming to improve the liquidity of the program, the Treasury increased gross TIPS issuance to $85bn in 2010, $131bn in 2011, and $149bn in 2012. It then slowed the pace of increase in 2013, when gross issuance was $155bn. This was kept steady in 2014 and 2015, before the Treasury guided the market to expect it to be reduced to $133bn in 2016. It cut TIPS auction sizes by $2bn, along with reduced nominal coupon auction issuance, mostly to make room for increased bill issuance. After TIPS as a percentage of net issuance fell in 2017 and 2018 as deficits rose, the Treasury announced in late 2018 that it would increase issuance to keep TIPS as a percentage of outstanding Treasuries constant. It also announced that it would add an October maturity 5y series for the first time.

FIGURE 5
Annual TIPS issuance ($bn)



Source: US Treasury, Barclays Research

FIGURE 6
TIPS issuance as a % of all Treasury note and bond issuance



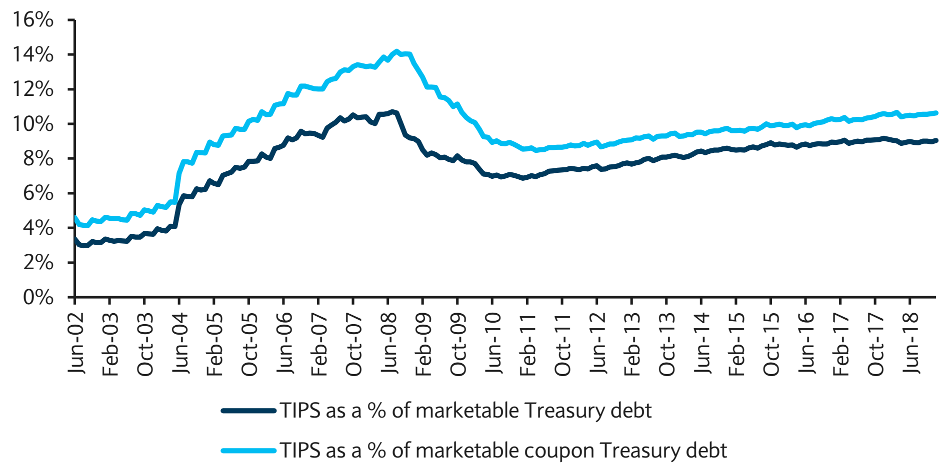
Source: US Treasury, Barclays Research

Because of the increases since 2009, TIPS as a percentage of outstanding Treasury debt has increased from 6.9% in February 2011 to 9% in December 2018, though this is still below its peak of 10.7% in July 2008 (Figure 7).

Increased issuance has driven an improvement in liquidity as well. In the initial years of market development, trading volumes tended to spike only around auction weeks, as they were seen as liquidity events in an otherwise low-volume product. While auction periods are still seen as liquidity events, this pattern has changed and trading volumes are more consistent, particularly now that there is a TIPS auction every month, whereas before 2010, the Treasury held TIPS auctions in, at most, four months of the year. While trading volume increased only slightly over 2000-02, when it averaged $1.87bn per day, it was $3.73bn in 2003, and average daily trading volume increased significantly in late 2004; it was $5.95bn in 2004 and took a sizable jump up to $8.77bn in 2005 (Figure 8). Trading volume then levelled off at $8-10bn/day until the financial crisis. From late 2008 to mid-2010, average daily trading volume declined to a trend near $4.5-5bn. This is because of the structural shift from hedge funds to real money investors, who typically take more of a buy-and-hold approach to investing, so tend to trade less. Volume has been increasing since mid-2010, likely because of increased issuance and market size, and has averaged just less than $12bn since the start of 2012. Average daily trading volume since early 2016 has trended at $15-20bn/day, though with considerable seasonal variability, as volumes have tended to be highest in the first few months of the year. However, the increased volume is just keeping up with growth in the amount of TIPS outstanding, leaving turnover roughly unchanged since 2009.

FIGURE 7

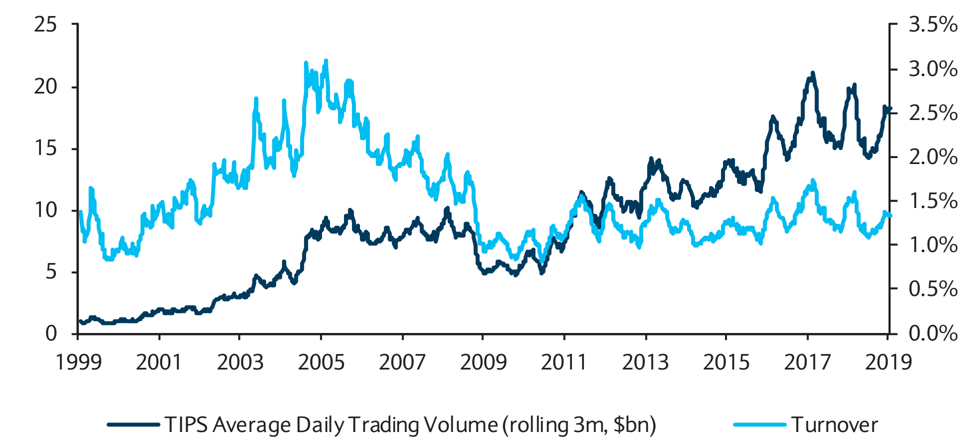
TIPS as a % of Treasury debt



Source: US Treasury, Barclays Research

FIGURE 8

TIPS market value and average daily volume ($bn)



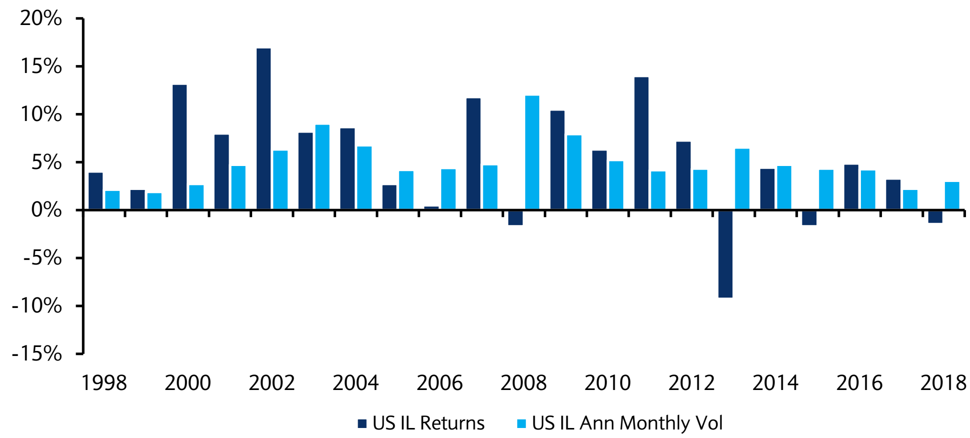
Source: Bloomberg, Federal Reserve, Barclays Research

Returns

Through March 2019, TIPS have had an annualized return since inception of 5.2%. This compares with the 5.4% annualized return on a basket of comparable maturity nominal Treasuries. The greatest annual return for TIPS was 17% in 2002, and the worst was -9.26% in 2013; the TIPS Index also had negative returns in 2008, 2015, and 2018. Relative to the nominal comparator index, the biggest underperformance was -18.4% in 2008, but that was followed by the largest outperformance, of 16.2%, in 2009.

FIGURE 9

TIPS historical performance and risk



Source: Barclays Research

TIPS structure

Along with most major inflation-linked bond markets, TIPS follow the Canadian model, in which the security pays a fixed coupon on the inflation-adjusted principal. The principal is adjusted on a daily basis using an index ratio that quantifies the rate of growth in inflation or deflation between the issue date and settlement date. The index is lagged three months from the settlement date; for example, for 1 April 2019, the CPI-U for January 2019 applies. We compute the index ratio as follows:

Index Ratio = Reference Index/Base CPI Index; where the Base CPI Index is the Reference Index at issue date and,

Reference Index = CPIm-3 + (t-1)/Dm x (CPIm-2 – CPIm-3)

where:

CPIm-2 = is the price index for month m-2

CPIm-3 = is the price index for month m-3

Dm = is the number of days in month m

m = is the month in which settlement takes place

t = is the day of the month on which settlement takes place.

For settlement amounts, real accrued interest is calculated as for ordinary Treasuries. The clean price, which is the trading price and does not include either the inflation or coupon accrual, and accrued are each multiplied by the index ratio to arrive at a cash settlement amount. For coupons paid, the (real) semi-annual coupon rate is multiplied by the index ratio, likewise for the par redemption amount (with the cash value subject to the par floor).

Floor

In addition, TIPS have an embedded floor such that at maturity, the investor gets the greater of par or the inflation-adjusted principal. Since the latter is the par amount times the index ratio (which is the ratio of the reference CPI to the base CPI), this is another way of saying that at maturity, the index ratio is floored at 1 as is applied to the principal. The pay-off on the principal amount at maturity can be written as:

$$Max\{Par, Par \times IndexRatio\}$$

The floor applies only to the principal amount at maturity: coupon payments can be and have been paid off an inflation-adjusted principal amount less than par. For example, the first coupon payment on the TIIJul16s was paid off an index ratio of 0.99858. The fact that there is not a floor on the coupon payments complicates the calculation profile of TIPS somewhat, but the deflation effect on coupons becomes significant only in severe deflation environments. The effect on the coupon can vary somewhat across issues, with different coupons in significant deflation.

It is important to remember that the “strike” on the floor is at par, or an index ratio of 1, not where the index ratio is at the time of purchase. For this reason, the floor of newer bonds tends to be more valuable because the index ratio is typically lower than seasoned TIPS. For example, for a trade that settles on April 4, 2019, the TIIApr23 Index ratio is 1.0138. This means that there has been 1.38% cumulative inflation accrued since issuance in April 2018, when the bond was issued. The floor would kick in if the index ratio fell below 1, so the inflation accrued since issuance would first need to be fully reversed out in a period of deflation. With about four years left, there needs to be about 0.35% annualized deflation to maturity for the floor to be at the money at maturity.

Before September 2008, the market put very little value on this embedded option. However, during the financial crisis, when breakevens out to the 9y turned negative and investors were increasingly risk averse, the value rose significantly: at one point, the real yield spread between TIIApr13s and TIIJul13s was 200bp, with most of this difference explained by the floor. The non-linear inflation market began quoting cumulative caps and floors around early 2009, and the value of the embedded option could then be priced separately from TIPS. However, over the past few years, there has been only very limited activity in the inflation volatility market.

Tax

On August 25, 1999, the Internal Revenue Service published final regulations covering the tax treatment of inflation-indexed instruments. Investors should consider the entire document, but a key paragraph is detailed below:

“The final regulations provide rules for the treatment of certain debt instruments that are indexed for inflation and deflation, including Treasury Inflation-Indexed Securities. The final regulations generally require holders and issuers of inflation-indexed debt instruments to account for interest and original issue discount (OID) using constant yield principles. In addition, the final regulations generally require holders and issuers of inflation-indexed debt instruments to account for inflation and deflation by making current adjustments to their OID accruals.”

Thus, the inflation escalation of principal in the US is taxable as income annually, even though the Treasury will be making the inflation payment at maturity. This creates a phantom inflation tax, which for non-tax-exempt investors such as insurance companies and individual investors may make ownership of TIPS unattractive. To ameliorate this problem, in 1998 the Treasury issued a Series I Savings Bond program targeted at individual investors. These bonds are tax exempt for 30 years.

Owing to this phantom tax issue, many retail or other taxable investors view nominal Treasuries and corporate inflation-linked notes as more tax efficient. While it is true that TIPS are disadvantaged from a cash flow perspective, they are not necessarily penalized on the expected after-tax total return versus nominal Treasuries. Other inflation-linked structures pay out the inflation on a monthly coupon, rather than accreting on the principal, so the investor is taxed on income actually received. However, as state taxes are typically paid on these bonds as well, the advantage is not as clear cut as many perceive.

Rules and regulations governing the tax treatment of TIPS can be found at the following link: *ftp://ftp.publicdebt.treas.gov/gsrintax.pdf*.

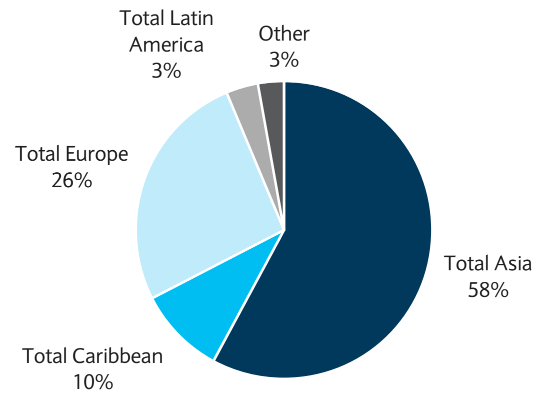
Major holders of US inflation-linked bonds

A broad range of investors has been involved in the TIPS market. The majority continues to own them as diversification from core positions, although this has been changing, and we continue to see demand from long-term structural accounts such as pension funds, insurance companies and, since 2008, foreign official institutions. Mutual funds were the heaviest early buyers of TIPS and remain the largest index tracking managers of the asset class, albeit with an increasing amount directly mandated from pension funds and endowments. Core and core plus-type total return funds and bond funds now commonly hold TIPS within their portfolios, while there is an increasing number of real return funds for which TIPS are the core asset. Endowments and lottery funds have also proved natural buyers. The insurance sector is notably less important than in Europe, mainly because inflation-linked life policies are much rarer, although inflation-linked structured issuance by insurance companies has become more common over the past two years. Real return balanced funds that own, for example, equities, commodities, and real estate with TIPS as their fixed income position had held significant structural positions in long maturity TIPS, but have generally been averse to holding long real yields below 1%.

One of the main reasons the Treasury reintroduced 5y TIPS issuance in 2004 was to encourage central bank buying. Foreign official institutions have become an increasingly important feature of the market, but until 2009 their position remained small compared with their nominal Treasury holdings. At the start of 2009, structural investments in TIPS from foreign central banks and sovereign wealth funds began because of diversification benefits and as a *de facto* currency hedge. We expect official institutions to move at least to market weight over time. The Treasury's TIC data showed that as of June 2011, foreign official institutions held $136bn in TIPS out of total Treasury holdings of $3.5trn. TIC data released in April 2018 show that as of June 2017, foreign investors owned $593bn TIPS, with $381bn of this held by foreign official institutions and 34% held by Asian investors (Figure 10). At nearly $200bn, China was reported to be the largest holder by country. The Fed included TIPS in its QE1, QE2, Operation Twist and QE3 programs and via these holds about 10% of the market in its SOMA portfolio. As of June 2017, the combined holdings of foreign and Fed accounts comprised 59% of the TIPS market. Using public data, we can attribute about 75% of the market to holdings by the Fed, foreign investors, mutual funds and ETFs (Figure 11).

FIGURE 10

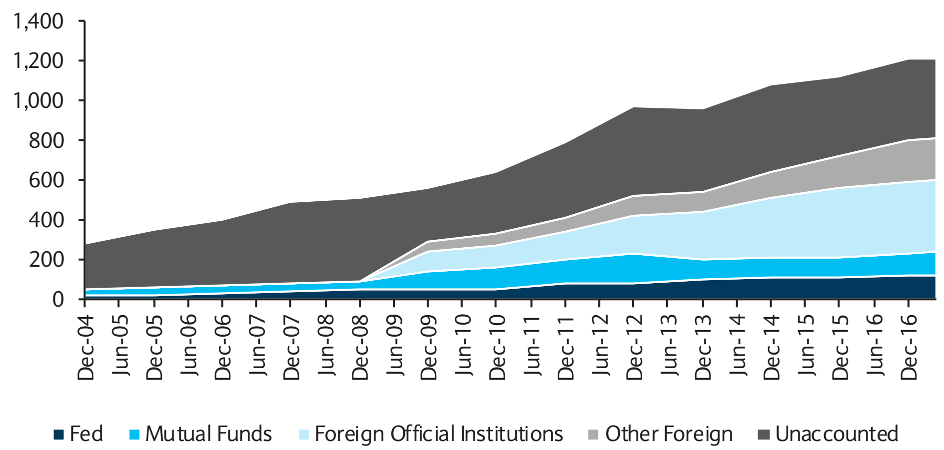
Regional distribution of foreign ownership of TIPS as of June 30 2017



Source: US Treasury, Barclays Research

FIGURE 11

Accounting for TIPS ownership ($bn)



Source: US Treasury, NYFRB, Bloomberg, Barclays Research

Pension reform could encourage more buying of TIPS by private defined-benefit pension schemes, but since most private funds do not have explicit cost-of-living adjustments (COLAs), allocations to TIPS would be mainly for diversification purposes. The absolute scale of private-defined benefit assets is considerably smaller than the more than $2trn state and local government sector, though. More importantly, state and local government pension scheme liabilities have more explicit price indexation than wage indexation and much more frequently have indexation commitments beyond the period when a member of the pension scheme is an active contributor. State and local government schemes are already the largest pension fund buyers of TIPS, and their liabilities mean the potential for increased buying is substantial. On the other hand, federal pension reform is unlikely to affect the state sector significantly, so the importance of the private defined-benefit sector may increase.

iSTRIPS

Over the years, the US Treasury has developed the inflation-indexed security market in a similar fashion to the nominal Treasury market. Hence, the development of a full yield curve has led to increased issuance, increased investor demand and a deep and liquid market.

Allowing TIPS notes and bonds to be stripped into zero coupon instruments is another step in this process. STRIPS is an acronym for Separate Trading of Registered Interest and Principal Securities. A TIPS security can be divided into its two components: coupon and principal. Each coupon cash flow, along with the principal payment, is made into a real zero-coupon instrument, or iSTRIP. All TIPS issues are now eligible for stripping, although to date, there has been only scarce interest in iSTRIPS. As of February 2019, there was about $9.4mn notional of TIPS held in stripped form, and most of this was concentrated in TIIApr29s. Most trades have been in lieu of structured products or derivatives. Coupon inflation strips should trade cheaper than the principal component because the latter carries the floor and is relatively more liquid.

The US Federal Register sets out basic conventions for the stripping and future settlement prices of zero-coupon inflation instruments. The complete formulas may be found at the following link for CFR 356.31 Appendix B:

http://www.access.gpo.gov/nara/cfr/waisidx_02/31cfr356_02.html.

Principal component

There is only one principal component (corpus) per TIPS issue. The par amount is the original face value of the bond to be stripped in $1,000 increments. The principal component retains one of the key attractions to TIPS. The embedded floor in TIPS applies only to the principal component, so holders of the principal at maturity receive the inflation-adjusted principal value or the par amount, whichever is greater.

FIGURE 12

Example of principal inflation strip (SIIP)

TIPS 1.625% 1/15/18
P = $1,000,000 par amount
Base CPI on issue date = 209.49645

Source: Barclays Research

If, on January 15, 2018, the reference CPI is equal to 248 (near where we expect it to be), an owner of the principal component will receive:

(Reference CPI at maturity/base CPI) * par value

(248/209.49645) * 1,000,000 = $1,183,790.94

If, however, the reference CPI at maturity of the bond were somehow less than the base CPI, resulting in an index ratio of less than 1.0, the inflation-adjusted principal would be less than par and the investor would, accordingly, receive the $1,000,000 face value.

The principal component trades at a discount to par when real yields are positive and a premium when they are negative. It will settle in the intervening period using the same methodology as above, substituting the current reference CPI into the equation. So, for example, on a settle date of September 13, 2016, the reference CPI was 240.88160. Therefore, if the January 2018 principal iSTRIP was priced at a real yield of -0.45% (real price of 100.604126), for that settle date the market value would be calculated as:

(240.88160/209.49645) * 1,000,000 * 1.00604126 = $1,156,756.30

Interest component

The US Treasury faced a hurdle in the initial formation of the strips program, as each TIPS issue having its own base CPI would have a different inflation accrual index. To make issues fungible with each other, the Treasury had to create a two-step process: remove the inflation indexation to allow for stripping and then re-adjust the zero coupons for their inflation accrual. The embedded deflation floor in the TIPS security stays with the principal component, making the coupon component a true real rate security; the development of the inflation derivative market allows buyers of coupon iSTRIPS to purchase inflation floors. Hence, a buyer of coupon iSTRIPS can effectively create "P" if necessary.

The interest component (coupon) from a particular TIPS issue is transferred at an adjusted value initially, which is established using the CPI reference value for its original issue (dated) date. The adjusted value represents the reset of the inflation accrual to 100, with an inflation adjustment made to an investor at maturity. In this way, coupons with the same maturity from different TIPS are now fungible and the coupon strip would be inflation adjusted at the same rate. All such components with the same maturity date have the same CUSIP number, regardless of the underlying security from which the interest payments were stripped.

The US Treasury, in the Federal Register, sets the stripped interest component and its adjusted payment valuation. It established that the adjusted valuation (AV) calculation is as follows:

FIGURE 13

Example of coupon inflation strip (SII) adjusted valuation

TIPS 1.625 % 1/15/18
C = quoted coupon
P = $1,000,000 par amount
CPI = 209.49645 base CPI on issue (dated) date
AV = adjusted value
AV = ((C/2) *P) *(100/CPI))
or ((0.01625/2) * 1000000) * (100/209.49645) = $3,878.347

Source: Barclays Research

In this example, with a $1,000,000 notional stripped, 3.88 of $1,000 bonds are created. Bundled with other issues, there could, in theory, be sufficient liquidity created to generate round lots of bonds. Prior to maturity, a buyer/seller of a coupon would settle a trade as follows:

Par x (Reference CPI U/100).

Using the example, assume that the January 2018 interest strip is purchased with a settlement date of September 13, 2016, and a reference CPI of 240.88160. If we assume the price is 100.604126 (real yield of -0.45%), the coupon would settle at:

Par x (Reference CPI-U/100) x market price or

$1,000,000 x (235.7077/100) x (1.0225) = $2,423,368.28

At maturity, the amount payable on a coupon strip is made via the following formula:

FIGURE 14

Amount payable on coupon inflation strip

AP = amount payable at maturity
RVCPI = reference value for CPI at maturity date
AP = AV *(RVCPI/100)

Source: Barclays Research

Following on our example for the principal strip, assume that in January 2018 the reference CPI (at maturity) is 248; final payment would thus be $1,000,000 * (248/100) = $2,480,000.00.

US inflation derivatives

US zero-coupon CPI swaps, the most traded US inflation derivative, have adopted an interpolated base index format, in the same way as the French CPIx market. This more closely aligns the swaps market methodology with the bond market, which also features an interpolated daily reference index. This serves to smooth out the discontinuities in swap breakevens at month-end that occurred while the market found its feet using the HICPx-style format. The index used is the CPI-U not seasonally adjusted index with a three-month lag, the same as that for TIPS. The Bloomberg ticker for the index is CPURNSA <Index>. Barclays's indicative CPI-U zero-coupon swap Bloomberg page is BCAP3.

While zero coupon-style swaps are the most active structure traded on the inter-broker market and with institutional accounts looking to get exposure to cumulative inflation, y/y structures are most commonly demanded by the US retail sector. A primary driver of US swap activity in 2004-07 was hedging related to inflation-linked MTN deals, although issuance in this sector has been extremely limited since 2008. Typically, these corporate deals pay y/y inflation on a monthly basis plus a fixed spread (with a floor usually set at zero on the sum of inflation plus the fixed coupon). Paying out the inflation uplift, rather than accreting the principal as with TIPS, is done primarily to provide higher current income and avoid the phantom income tax problem associated with TIPS. Options on CPI swaps, TIPS and breakevens, along with other non-linear inflation products, such as caps and floors, have traded in the US, but only in limited fashion thus far. Over the past several years, CPI swap activity has been driven more by institutional investors looking for an overlay hedge on their portfolios, particularly nominal fixed income ones, against a sharp rise in inflation.

Linking the cash TIPS and CPI swaps markets are asset swaps. Trading in these in the US has tended to occur as structural carry trades or on a tactical basis when valuations appear at the edge of a range. The general lack of payers in the inflation swap market thus far in the US means that CPI swap and bond breakevens are more loosely connected than, say, in the euro area. The gap between cash breakevens and CPI can be explained by the funding costs of a cash breakeven position, including expected repo differentials and balance sheet costs. As liquidity in the TIPS market has improved along with market growth and trading volumes, the relative liquidity premium between TIPS and nominals has come down and, thus, so have relative asset swaps.

CPI futures were introduced in the US in February 2004. However, the initial contract specifications did not prove useful, and it is no longer traded. While it is not likely soon, we do see some scope for reintroducing an inflation contract based on either monthly NSA CPI settings or monthly contracts on the y/y format, similar to the HICPx future in Europe, because it would be more useful for risk management and relative value trading.

The total rate of return swaps market took off in 2006. TRS provide an alternative to cash as a way to gain long or short exposure to cash instruments, particularly by investors looking to match index returns. Many use inflation-linked TRS to gain beta exposure to the asset class while generating alpha returns in some other product, though post-crisis shrinking of dealer balance sheets has limited growth in this segment of the market.

Trading in the inflation volatility market remains limited and has decreased significantly in recent years to nearly zero. Cumulative caps and floors have been used by real money investors to hedge tail inflation risk and some hedge funds and active managers to express structural views. Hedging of corporate inflation-linked notes also provides interest in y/y floors, though as mentioned above, issuance has been quite limited over the past several years. The inflation volatility market can also be used to value the par floor embedded in TIPS. If the economy recovers more, we would expect investors to look to use inflation caps to hedge the risk that the Fed will leave stimulative monetary policy in place too long. More detail on these structures can be found in the Inflation Derivatives Products section of the User's Guide.

INFLATION MARKETS

Euro area

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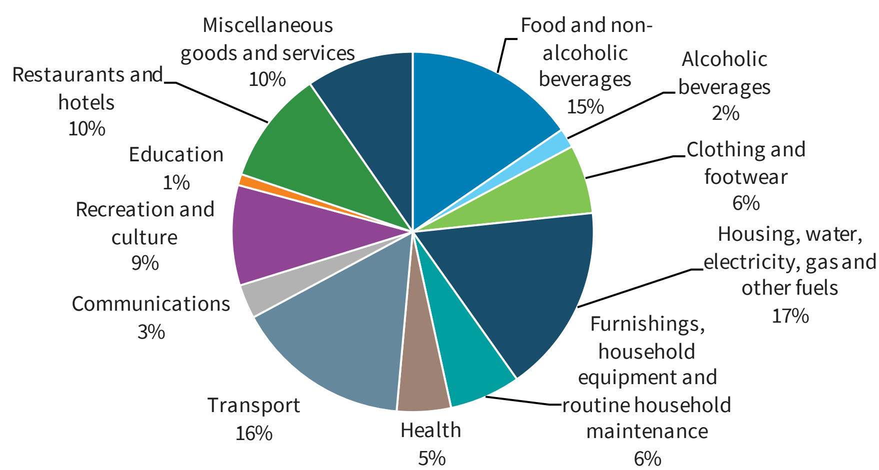
Since its initiation in 1998 until the financial turmoil of 2008-09, the European linker market continued to develop largely unchallenged. The market successfully navigated the global crisis, but the European debt concerns and the disinflationary trend posed significant challenges. The structure of the market has changed notably amid exacerbated volatility, but issuers have remained committed to their linker programmes. The inclusion of linkers within the ECB's QE programme has helped the market, and has likely encouraged and enabled issuers to maintain their commitment. Swaps remain a core element of the euro area inflation market, but the once dynamic volatility market has been dormant for the past few years.

Euro HICPx Index

The Euro Area Harmonised Index of consumer prices, all items excluding tobacco (referred to as HICPx), is currently the main inflation-linking index for the standard Canadian-style euro area government inflation-linked bonds, with around 86% of such tradable issues by face value tied to it as of end-January 2019. The HICPx is computed as a weighted average of the individual euro area countries' harmonised price indices. The weights are determined according to each country's share of consumption expenditure within the euro area as measured by the "household final monetary consumption expenditure" in national accounts data. Therefore, the country weights change over time, being reviewed each year and applied with the January data (ie, the January inflation figures published in February). Countries joining the European Monetary Union are also added to the index.

FIGURE 1
Breakdown of euro HICPx by major category in 2019



Source: Eurostat, Barclays Research

In 1996, the Eurostat statistical agency was charged with creating "common statistical standards for consumer price indices". The headline all-items HICP Index, also known as the MUICP or Monetary Union Index of Consumer Prices, is the main inflation reference for monetary policy for the European Central Bank (ECB). The ECB has a mandate to maintain price stability, which it defines as a level of MUICP inflation close to but below 2%. MUICP inflation swaps traded before the launch of the first French euro HICPx-linked bond, but after France had issued its first bond, HICPx became the most widely used inflation swap base, too. As most Italian domestic inflation liabilities also exclude tobacco, the Italian government used the same index for its first €i bond, confirming the benchmark status of euro HICPx for both bonds and swaps.

HICP indices, in common with most other CPI indices nowadays, are geometric chain-weighted Laspeyres indices. While there is annual chain indexation at the start of each year to reflect changes in consumption weights between and within countries, some euro countries prior to 2012, particularly Germany, had detailed re-weightings only every five years. The German resetting in February 2003 caused significant revisions to the inflation profile, but all bonds and swap contracts are based on unrevised index values. Following the German rebasing in February 2008, Eurostat decided to allow changes to affect the HICP series only from January 2008, which introduced a notable structural break in the package holiday sub-component of the series in 2008. A new methodology has been introduced to compile German package holidays from January 2019. It has, in addition, been used to revise Germany's package holiday series from January 2015. This latter change led to revisions in higher-level indices for Germany and the euro area, including the euro area HICPx series.

Final euro area inflation data are usually released around the middle of the following month, but a "flash" estimate of MUICP inflation is released around the end of the month in which data are collected. Individual countries also release preliminary estimates towards the end of the month. Also, individual country data are published in advance of the euro total, leaving only limited uncertainty in the final release of the latter. In fact, information from the preliminary data releases themselves are usually enough to significantly reduce the uncertainty ahead of the final prints. The final January inflation data are released very late in February as a result of extra calculations needed for annual re-weighting, which causes a complication for the bond market. When an inflation reference value is unknown for settlement, the official formula to calculate the index ratio is to extrapolate the last known y/y inflation rate to the latest index value. This is a poor approximation for January m/m inflation as the seasonal factor for this month is the most extreme negative of the year. As a result, in practice, the market no longer trades on the official convention at the end of February. There can, for instance be short settlement when the index ratio is unknown. If it is unknown only for a few hours on the release day, trading can be paused for a short while until the index is published. The rebasing of the HICPx Index at the end of February 2006 (base year 2005 = 100) did not materially affect valuations on bonds or swaps, for which the original reference HICP was rescaled accordingly. The latest rebasing exercise (base year 2015 = 100) was also a pure statistical exercise, with no apparent distortion in m/m or y/y rates. Since February 2006, the index is published to two decimal places rather than one. When the base year changes, a rebasing key is applied to the old discontinued unrevised series. This allows the new series to be compared with the old one without affecting any past inflation accrual. The methodological change to German package holidays and the rebasing of the German series to base year 2015 in 2019 led to diverging views among market participants about whether a scaling ratio needs to be applied to the old series.

All HICP data published by Eurostat are non-seasonally adjusted, but a seasonally adjusted MUICP series produced for the ECB monthly bulletin does provide information about the development of seasonal factors. In the years since the formation of the monetary union, there have been several changes to measurement by individual countries that have altered the seasonality of the aggregate index. A notable one was the inclusion of discounted sales prices in Italy and Spain from 2001, which slightly reduced average inflation but greatly increased m/m volatility. EC Regulation No 330/2009 came into force in January 2011, and imposed a different methodology for the treatment of seasonal products in the index. The consequence was a further increase in the amplitude of seasonality. The methodological changes by Destatis effective from January 2013 also introduced major changes in the seasonality of the package holiday and accommodation services components. The change from 2019 exacerbated the magnitude of the seasonal pattern of the series. Currently, the largest negative seasonals are in January and July, due mainly to sales periods, with the most positive seasonality in March.

There have been few major revisions to the composition of the euro HICPx in recent years. There is relatively little standardisation of quality adjustment measurement at present, but Eurostat has been focusing on gaining consistency. The use of hedonic pricing to adjust for changes in quality is likely to become more widespread as a result, which over the long term may produce a marginal downward bias in the index. More important is the consideration of housing, with owner-occupied housing (OOH) currently excluded from HICP indices. Housing rents make up around 6.5% of the HICPx in 2018, whereas national accounts data suggest that the weight of housing in consumption is around 15%. The ECB has highlighted the need to include owner-occupied housing, and Eurostat has been working for a decade on a project to address this, along with national statistics agencies. Eurostat's preferred methodology is a net acquisitions basis, which attempts to strip out the price of land from house prices given that land is seen as an investment rather than consumption. In effect, this will consider only new home prices (as sales of existing homes are merely transfers) and the cost of home improvements. While a decision on the inclusion of owner-occupied housing was originally intended to be made by 2006, it is still an ongoing project at the time of writing. Late 2018, the Commission's assessment was that the OOH price index could not, at that time, be produced according to HICP standards of frequency and timeliness. Its assessment was therefore that the OOH price index was not suitable for integration into the coverage of the HICP. Further methodological work required for the integration of the OOH price index into the HICP coverage will therefore be pursued.

French CPIx Index

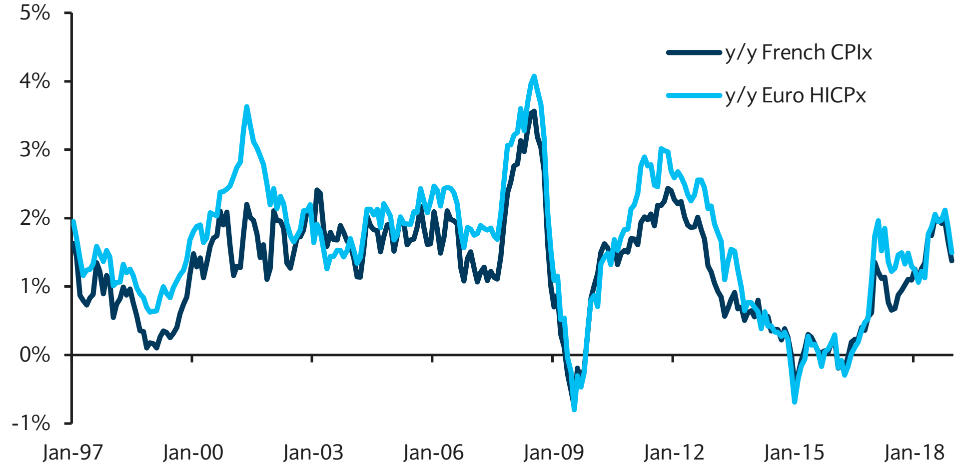
France first started issuing bonds linked to the French CPI excluding tobacco (CPIx), as indexation to tobacco prices had previously been banned in France. More substantive and difficult legislation would have been needed to change this, but it also meant that any inflation liabilities similarly had no link to tobacco. The bonds are linked to the non-seasonally adjusted CPIx series, but the process of euro area standardisation has led to some changes in measurement of French components.

The index is usually released around the middle of the month, just ahead of the euro area data. Until 2005, preliminary data were released early in the month with the final series published after the euro data, but Eurostat encouraged INSEE, the national statistics office in France, to publish earlier. From March 2005 to December 2015, there has been a single CPI released around mid-month, but monthly preliminary releases started again in January 2016. The unrevised index is used for bonds and swaps. If the series is rebased, all reference calculations are adjusted accordingly. From 2016, the base year for the released index was changed from base year 1998 = 100 to base year 2015 = 100.

The calculation methods for the French CPI and HICP are relatively similar. Both use geometric aggregation at the lowest strata sub-indices, and have the same methodology for quality adjustments. There has been no clear long-term bias between the two series. The difference is that HICP takes into account expenses net of rebates, while CPI uses a gross basis. This is particularly important for the healthcare component where rebates from the state are substantial in France. This leads to a much higher weight for healthcare in the CPI, but also leads to inconsistencies between the two series when healthcare reform affects the degree of public subsidy, for instance reducing the items on which they are available, which causes a jump in the HICP healthcare series without affecting the CPI.

FIGURE 2

French and European ex-tobacco inflation (based on unrevised series)



Source: Bloomberg, INSEE, Eurostat, Barclays Research

Development of the government market

The development of the market had been strong until the 2008-09 crisis. Subsequent years have been challenging, but issuance has risen again over the past few years, likely facilitated by the ECB's Asset Purchase Programme (APP). The euro area debt crisis and the disinflationary trend reduced structural interest in the asset class, but the market has evolved. For instance, bank treasuries now represent a significant proportion of demand, mainly in asset swap. Contrary to what could have been expected, issuers have remained committed to their linker programmes over the past few years, with even Spain entering the market in 2014. The fact that the ECB included linkers, contrary to general expectations, within its QE programme has helped the market, with purchases partially offsetting supply. That said, QE has also exacerbated relative value distortions, affecting liquidity in issues which are not frequently reopened.

France

France first announced its intention to issue inflation-linked bonds on 3 December 1997. The legislation to enable the launch of the new asset class was passed on 3 July 1998. On 15 September 1998, the OATi 3% Jul 2009 was syndicated, with the bond frequently re-opened by auction subsequently. Market participants were widely consulted on the main characteristics of the new bond, including the choice of inflation index to which it would be linked. It was decided that the bonds would adopt the Canadian methodology that was fast becoming the preferred global structure, but including a principal floor as the US had done. The timing of the first issue just ahead of the start of the euro area was not a coincidence. This monetary union was expected to intensify competition for financing in nominal bonds, and the hope was that France would gain a first-mover advantage by being the first euro area country to issue inflation-linked bonds.

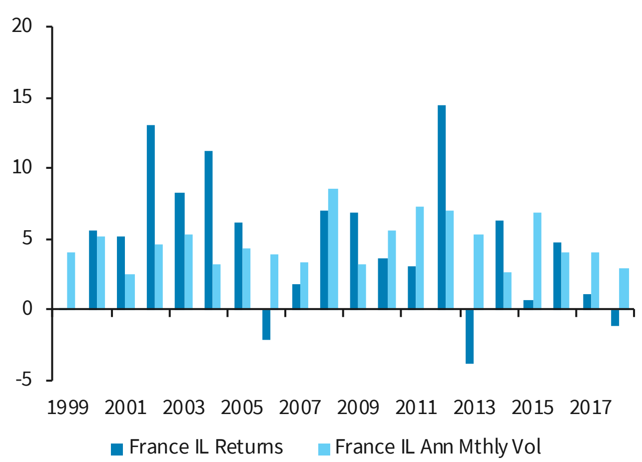
The inflation index was agreed as INSEE's official measure of French national CPI, excluding tobacco. There was considerable debate ahead of the initial launch of French inflation-linked bonds as to whether to link the first issue to French inflation or to that of the then-forthcoming euro area. The arguments for the domestic index included the likelihood that national inflation would be a better liability match for the government. However, international appeal would clearly be broader for a euro index. In 1998, the final decision most likely came down to practicalities. At the time, the disadvantages of Eurostat's European Harmonised Index of Consumer Prices for the EMU area were material as it was a relatively new, untested index with no track record. Full index coverage was not yet complete in some countries, which left an index in flux and an associated fear of revision risk.

A second linker, the OATi 3.4% Jul 2029, was launched a year later in September 1999, again linked to the French national CPI ex-tobacco. The same issuance route was followed, with an initial syndication and occasional re-openings. Growth in the outstanding market value of these two bonds was slow but steady. There was some disappointment that the instruments did not seem to be capturing the imagination of investors in euro area countries outside of France. In October 2001, France addressed this issue head on by launching the OAT€i 3% Jul 2012 linked to euro HICPx. This bond was also launched via syndication, but with its size boosted by some direct exchanges out of the OATi09. There were some fears ahead of this issue that the launch of a second inflation-linked product may harm the liquidity of existing OATi bonds, but in fact the move gave a new lease of life to the sector as a whole. Not only did turnover in the new issue quickly grow, but interest in the existing issues was heightened, too.

France responded to an increase in interest and demand in the sector with a significant pick-up in the pace of supply. The Agence France Trésor (AFT) has steadily increased linker issuance since the product was launched. It has issued new bonds almost every year while auctioning existing issues nearly every month. Auctions normally occur on the third Thursday of every month, excluding August and December, with at least one OATi and one OAT€i usually auctioned each month except when a new bond is launched. Prior to 2009, the AFT was committed to a minimum of 10% of its total bond issuance each year to be in inflation-linked bonds, but with the possibility of issuing significantly more if justified by demand. In more recent years, the commitment to a minimum of 10% of total bond issuance was changed to "around"/"approximately" 10%, likely as a response to more volatile market conditions and to increase flexibility in the programme. Issuance in 2009 was only €12bn, half its peak in 2004 despite increased funding needs. The strategy to reduce issuance in late 2008 and over 2009 was combined with a pragmatic approach, which consisted of tapping specific issues that were in demand. For instance, in October 2008, when fears about deflation were intense, only OATis were issued, given that there was still demand for French inflation due to Livret A hedging.

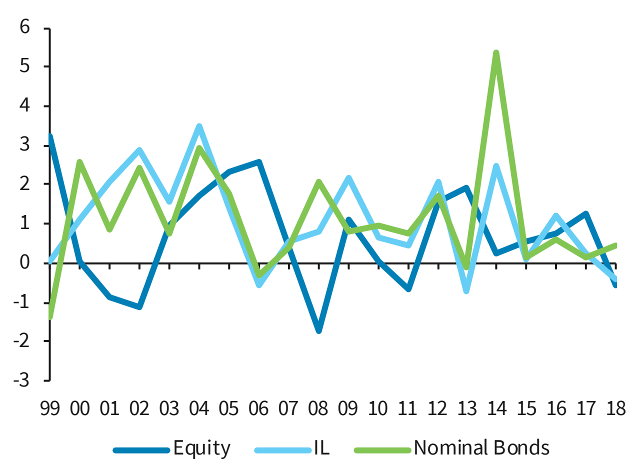
The AFT has steadily built up curves in both OATis and OAT€is. The OAT€i Jul 2032 was launched via syndication in 2002, including some exchanges out of the OATi29. The OATi Jul 2013 was the first issue to be launched via auction in 2003. At the start of 2004, the OAT€i20 was syndicated, but the OATi11 and OAT€i15 were launched via auction later in the year, as was the OATi17 in September 2005. In April 2006, the first BTAN linked to euro HICPx, the BTAN€i10, was launched via auction but with a T+3 settlement date for the

FIGURE 3
French linkers – historical performance and risk



Source: Bloomberg, Barclays Research

FIGURE 4
Return/risk French IL versus nominals and equities



Source: Bloomberg, Barclays Research

BTAN€i (at the time nominal BTANs settled T+1) to be consistent with other inflation-linked bonds. The OAT€i40 in March 2007 and OATi23 in February 2008 were both syndicated. The launch of the OAT€i22 in the summer of 2010 was done amid a specific emphasis on the value of the par deflation floor in the bond, an emphasis which later led to strong demand for the bond in asset swap. In January 2011, the BTANi 2016, the first FRCPIx linked BTAN was launched, while the AFT syndicated the OAT€i27 the following month, plugging the gap in the 15y sector of its curve. The OAT€i18 auctioned in April 2012 was similarly a response to the need to fill the gap between the 2015 and 2020 maturities. Later that year, in October, the OATi21 was launched via auction. In February 2013, the AFT added a new point in the 10y sector (ie, the OAT€i24). In June 2014, the OAT€i30 was launched via syndication. In February 2015, France innovated by issuing an OATi maturing on 1 March 2025, opening a new category alongside July-maturing issues. The 1 March maturity means it coincides with the December FRCPIx fixing which is used in the formulaic resetting of the Livret A rate. There was innovation in maturity month again in March 2016 with the launch of the OAT€i 1 March 2021. The OAT€i July 2047 was issued by syndication in September 2016. In February 2017, the OATi28 was auctioned. Late-March 2018, the OAT€i36 was launched by syndication. The timing of that bond was a surprise given that regular linker auctions had already been conducted earlier in that month and also because the week was expected to see reduced presence from market participants ahead of the long Easter weekend. The OAT€i March 2029 was launched via auction in March 2019.

The intensification of the European debt crisis has had a notable effect on the French linker market. Apart from the fact that general conditions for issuance became more challenging, French issues suffered from linker investors being typically more risk-averse than nominal ones. Volatility in spreads thus exacerbated a significant cheapening versus nominals when French spreads were at their widest. However, ultra-cheap relative valuations triggered significant interest, mainly from domestic investors who were willing to reap the extra value offered by linkers. For that reason, the crisis did not lead the AFT to signal any reduction in its commitment to the linker programme. Having linkers referencing two indices gives France flexibility to tailor monthly issuance to demand, such that it has been, by far, the most consistent among linker issuers in the euro area. Over the past couple of years, France has been the main driver of the increase in DV01 risk from euro area linker issuance, thanks in particular to regular issuance in the long-dated bonds.

Italy

Italy announced its intention to issue its first inflation-linked BTP on 5 September 2003 and syndicated a €7bn 5y bond within five days. The speed of the ground-breaking transaction took many in the market by surprise, but the issue was quickly accepted, enabling a syndicated reopening in October to bring the bond to over €10bn. The BTP€i 1.65% Sep 2008 followed an almost identical model to French OAT€i bonds, except that it paid semi-annual coupons like conventional BTP bonds. The bond was initially priced using an interpolated spread to the nominal BTP curve, but a maturity matched conventional bond was auctioned the week after the launch, enabling straightforward trading of the breakeven inflation spread. The choice of maturity was determined by heavy domestic retail demand for inflation-linked notes, particularly swapped 5y MTN notes with inflation-linked coupons, which were relatively difficult for issuers to hedge without a 5y point on the OAT€i curve. Italy hoped to capture both swap-hedging demand and to appeal directly to individuals who had been buying the structured notes. More than 220 investors bought the initial syndication, with the majority placed in Italy. Much of the remainder went to the UK and US, a combination of derivative houses and long established, international inflation-linked investors, with relatively little going to other euro area countries. The first re-opening syndication in November 2003 redressed this imbalance, with almost 40% being allocated to French investors. Further syndicated supply of the issue in 2004 brought its face value up to €13.4bn. The majority of this bond quickly became held versus inflation swaps, much of which was locked away to maturity.

Having started issuance with a relatively opportunistic 5y maturity, the next new bond was a 10y, the BTP€i 2.15% September 2014. The bond was initially syndicated in February 2004 for €5bn and subsequently built up via syndications and then auctions to a notional size of €14.5bn, in line with the target size indicated at launch. The BTP€i 2.35% 2035 was syndicated in October 2004 for €4bn and was subsequently re-opened by syndication and then auction. The BTP€i10 was syndicated in January 2005 as the second 5y issue, being built up by auctions subsequently as was now standard. In June 2006, the 10y BTP€i 2.1% September 2017 was sold via syndication. The BTP€i 2012 was the first Italian linker to be launched via auction in March 2007, but the Tesoro reverted to the syndication method in June to launch the BTP€i 2023, its first 15y linker. In addition, Italy issued private placements of two ultra long-dated euro HICPx linkers maturing in September 2057 and September 2062, which, alongside similar issuance from Greece, sparked two-way interest in ultra-long euro HICPx swaps. Italy has subsequently privately placed shorter maturities, but the size remains small compared with the BTP€i market. In May 2008, the 10y BTP€i 2019 was launched via syndication.

In 2005, Italy overtook France as the country with the largest stock of bonds linked to euro HICPx. Similarly to France, Italy reduced its inflation-linked issuance significantly from the third quarter of 2008 and over 2009, as a response to reduced demand, with the scheduled auction of October 2008 cancelled and smaller sizes for other reopening. After a year of notably reduced issuance, supply subsequently picked up, with the BTP€i41 syndicated in October 2009, followed by the BTP€i21 in April 2010. The BTP€i16 was launched via auction in Jan 2011 and the BTP€i26 via syndication in June 2011. However, just after this bond was launched, the condition of the Italian bond market worsened notably, with spreads to Germany widening sharply. The response of the authorities included adding Italian (and Spanish) bond purchases to the ECB securities markets programme in August 2011. However, these purchases did not include BTP€is, significantly distorting breakeven valuations. Furthermore, with much focus at that time on credit ratings downgrades of peripheral countries and future eligibility of their bonds to remain in bond indices, BTP€is saw significant selling pressure from investors. While there was a similar trend in nominal BTPs, it was somewhat more pronounced in BTP€is. This was because the threshold for inclusion in Barclays' main inflation-linked bond indices was higher than for nominal bond indices, which implied that BTP€is were closer to being excluded from those indices. Many investors acted in anticipation of this removal, some choosing to switch to benchmarks excluding BTP€is, while others actively underweighted BTP€is versus benchmark. Without the ECB to absorb the flow in linkers, real yields were pushed sharply higher and the high in nominal spreads in late November 2011 coincided with breakevens troughing at negative levels out to 10y. BTP€is eventually were excluded from Barclays' main linker indices at the end of July 2012 following Moody's downgrade of Italy; however, the fact that many investors had already adjusted their portfolios meant that the market impact of selling flows at month-end was limited. Furthermore, ECB President Draghi delivered his "Whatever it takes" speech late July 2012; the general positive tone on peripheral spreads that the ECB instilled in markets likely cushioned the impact of the index exclusion on BTP€i valuations.

Despite extreme market conditions, Italy indicated its intention to continue with the monthly issuance of BTP€is; indeed it even conducted a reopening at the most extreme point of the market stresses in November 2011. As in late 2008, the Treasury attempted to maintain market functionality by conducting both buybacks and switch auctions out of BTP€is. Nonetheless, the guidelines for 2012 public debt management indicated that the share of BTP€is in Italian debt would likely fall given the redemption of the BTP€i12 (a €10.3bn notional issue), which implied intentions for notably less supply than previously.

Indeed, 2012 saw no new BTP€is, although this is very likely partially explained by the success of the BTP Italia programme that year. The Tesoro maintained its commitment to the BTP€i segment though, with the new BTP€i18 auctioned in January 2013. In March 2014, despite a challenging context for European inflation markets as a result of a very low inflation backdrop, Italy offered a new BTP€i24 via syndication. In November 2014, it was announced that the minimum credit rating for the Barclays World Government Inflation-Linked (WGILB) and Euro Government Inflation-Linked (EGILB) Indices would be lowered and, subsequently, Italy (alongside Spain) would qualify for inclusion in the flagship WGILB and EGILB Indices, effective 31 March 2015. In October 2015, the BTP€i32 was launched by syndication. In May 2016, Italy issued the BTP€i 15 May 2022 via syndication, offering a new point of supply on the seasonality curve. The Tesoro stuck to that new maturity month with the syndicated launch of the BTP€i28 in March 2017. In March 2018, the BTP€i May 2023 was offered via auction.

BTP€i auctions are typically held towards the end of the month, normally on the same day as the auction of the CTZ. Auctions are not held in months when new issues are launched via syndication. August and December typically see no issuance in BTP€is, with November's also sometimes cancelled.

As with a conventional BTP, a BTP€i pays its coupon every six months, but its yield is quoted on an annual basis. Calculations work in exactly the same way, with inflation accrual calculated on a daily interpolated basis between the inflation data from three and two months previously. Italy likely chose the same index as France mainly for market convenience, as it is the index most widely used in inflation swaps and MTN bonds as well as OAT€is, although domestic Italian indexation has usually excluded tobacco too.

In March 2012, Italy introduced a new inflation-linked product, designed to appeal to domestic retail investors. BTP Italia references the Italian FOI inflation excluding tobacco, in a structured form so that cash flows are not back ended. The FOI, "Famiglie di Operai e Impiegati" is a CPI index derived only from the consumption basket of households of workers, with FOIx (Bloomberg code ITCPIUNR) the most commonly referenced series for Italian indexation. The initial BTP Italia 2.45% March 2016 was brought for almost €7.3bn following a four-day offering window through which both individuals and institutions could apply to buy bonds at par. The coupon of the issue was only fixed after the window had closed, but a guaranteed minimum real coupon of 2.25% was announced before the opening of the issuance window. The Italian Treasury indicated at the start of the programme that it expected to bring three to four new BTP Italia bonds a year in the future. The Treasury stated that only around 3% of the initial issue was sold to international institutions. BTP Italia are traded only on the MOT retail platform and given the relatively complex cash flow formula, discussed below, the bonds trade on a price basis, with the real yield an unsafe metric given the nature of the deflation floor.

The second BTP Italia launched in June 2012 gathered only €1.74bn but the third bond, the BTP Italia October 2016 was launched with an impressive €18.02bn size. The apparent cheapness of the bond versus the BTP€i16, coupled with the fact that it was launched close to a nominal BTP redemption, likely helped to drive the huge issuance size. Additionally, significant participation by institutional investors was apparent, with foreign ones not negligible either. In 2013, two other BTP Italia bonds were issued, the April 2017 for €17.06bn and the November 2017 for €22.27bn. In both cases in 2013, the Tesoro closed the issuance window on the third day, having reserved the right to do so ex-ante. That said, it appeared that the early closure of the issuance window did little to prevent the BTP Italia issuance books from growing to sizes that were probably more than was desired or expected by the issuer. In particular, it appeared that a significant chunk of the buying came from institutional investors. The Tesoro changed the issuance mechanism for the bond launched in April 2014, which was a six-year bond (maturing in April 2020) while previous issues were 4y. The first three days of the issuance window were reserved for retail investors (with an option of early closure on the second day), with the fourth day dedicated to institutional investors. The bond's total size reached €20.56bn, of which €10.50bn was placed on the fourth day, ie, the day reserved for institutional investors. From then, the Tesoro introduced a rationing mechanism to limit excessive institutional allocations. The October 2020 was issued in October 2014 for €7.5bn, with 100% of the €2.9bn institutional demand fulfilled. In 2015, only one issue was offered; an 8y maturity bond (maturing April 2023) launched in April, with the size reaching €9.4bn and with a 74% allocation coefficient applied to institutional demand. From 2016 to 2018, the Tesoro has offered two BTP Italia issues per year. The allocation ratio applied to institutional demand was a low as 31% for the Nov 2023 bond issued in November 2017, but there was full allotment for the two issues offered in 2018.

The indexation structure of the BTP Italia is not straightforward. The coupon rate is applied to a principal, which is revalued and reset in each six-month period, but with a floor mechanism and a dependence on previous levels reached by the index. Also, unlike a BTP€i, inflation accretion on the revalued principal is paid out semi-annually alongside the coupon, ie, like a "pay-go" structure. The principal is then reset at par semi-annually.

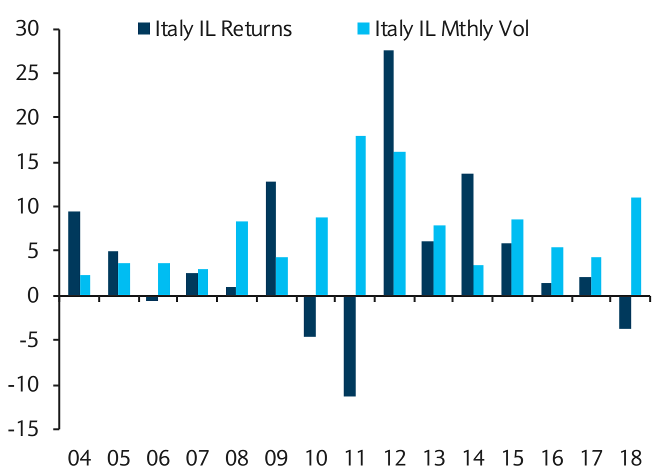
The floor mechanism embedded in the BTP Italia is therefore significantly more complex than y/y or zero-coupon inflation options that are traded in the broker market on euro HICPx. A rigorous pricing for the BTP Italia's embedded optionality would need to take into account the path-dependence of cash flows. Given that the market is not particularly active even for simple y/y or zero coupon structures on FOIx, there is unlikely to be consensus on the value of new issues' embedded optionality. That said, it is apparent that there has been asset swap activity around some BTP Italia issuance, which would not be surprising given the active part played by institutional investors in its primary market.

Germany

The intention to issue euro HICPx-linked bonds was announced by German finance ministry officials in November 2004, but it was not until March 2006 that the initial bond was launched. The inaugural inflation-linked bond meant that all G7 countries were issuers of inflation-linked bonds. The 10y DBR€i 1.5% April 2016 was issued via syndication with an initial size of €5.5bn, including €0.5bn retained to boost liquidity in secondary market trading, and was priced against the nominal Bund January 2016. The German Finanzagetur indicated its intention to tap the bond up to three times to a volume of €10-15bn. The bond was re-opened in September 2006 via syndication for €3.5bn, including €500mn retained. Germany switched

FIGURE 5

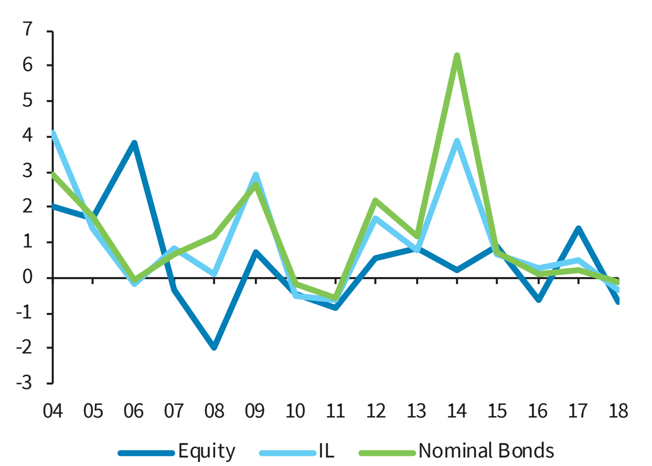
Italian linkers – historical performance and risk



Source: Bloomberg, Barclays Research

FIGURE 6

Return/risk Italian IL versus nominals and equities



Source: Bloomberg, Barclays Research

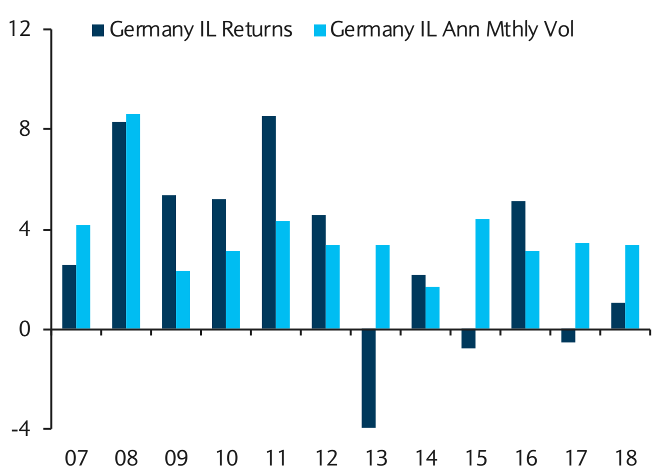
to an auction procedure for the second tap of the DBR€i16 in April 2007 for €2bn and has subsequently auctioned all its linker issuance. The second euro HICPx German linker, the OBL€i 2.25% April 2013, was issued in October 2007 for €4bn. The DBR€i 2020, which came in June 2009, was the first euro linker launched after the episode of extreme deflation-led fall in breakevens during the second half of 2008. This reaffirmed Germany's commitment to the inflation market, given that the development of the German real €i curve had been slow compared with what was broadly expected when the programme was launched in 2006. The OBL€i18 was launched in April 2011 and the DBR€i23 in March 2012, but the pace of issuance remained moderate. From 2013, there has been a stated commitment to monthly issuance (except in August and December), a development in terms of transparency for market participants. For 2014, that transparency was strengthened with the Finanzagentur specifying that such auctions of the Inflation-linked Federal Securities generally take place on the second Tuesday of a month. In April 2014, a DBR€i30 was launched. The longest linkers issued by Germany up to then had been 10y benchmarks, so a 16y bond was an innovation. That said, according to comments relayed by Bloomberg on 1 April 2014, the German Finanzagentur's spokesman said that the 2030 bond is an "extended 10-year" benchmark and is neither the start of a new 15y segment nor indicative of plans for a 30y issue. The DBR€i 2026 was issued via auction in March 2015. In June 2015, the long-awaited 30y DBR€i was launched with a 15 April 2046 maturity, via a syndicated deal. At the time of writing, no new linker has been offered since the DBR€i46's launch.

Over recent years, transparency has increased with the communication of a monthly linker issuance schedule for the year. The Finanzagentur now also gives itself the option of issuing two lines at its monthly supply. That said, a key concern for inflation market participants has been the very low level of issuance and the fact that no new bond has been offered in several years. Total notional in 2015 was €12bn, but for 2016-2018, annual issuance was only €6.5bn.

The focus during the launch of the first German linker was on seasonality pricing. Before the launch of the DBR€i16, bonds linked to the euro HICPx had maturities of 25 July (French and Greek linkers) and 15 September (Italian linkers). The fact that the DBR€i16 would redeem on 15 April 2016 meant that it would accrue less positive inflation seasonality compared with a BTP€i and much less versus an equivalent OAT€i. Although the bond was being priced against the nominal Bund January 2016, the market was also focused on estimating fair value versus the OAT€i15, and estimating the difference in the seasonality component of the two bonds was key in determining this fair value. This difference becomes increasingly important in basis point terms as bonds roll shorter on the curve.

FIGURE 7

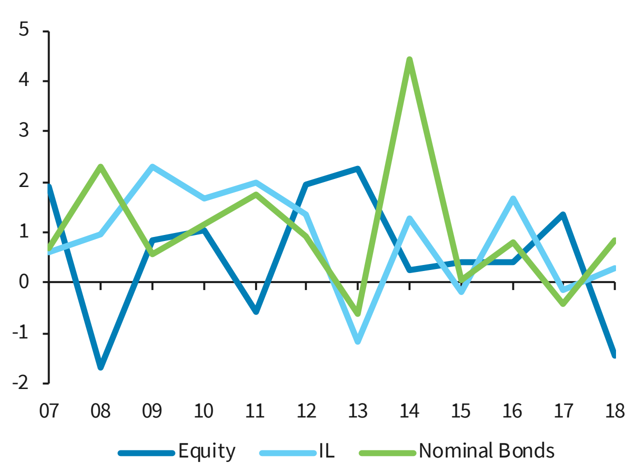
German linkers – historical performance and risk



Source: Bloomberg, Barclays Research

FIGURE 8

Return/risk German IL versus nominals and equities



Source: Bloomberg, Barclays Research

Greece

Before it entered the euro area, Greece had issued bonds linked to domestic CPI in small size, in a Canadian format, but the last of these redeemed in 2007. Greece became the second sovereign to issue a euro HICPx benchmark, the GGB€i 2.9% Jul 2025 in March 2003 via syndication. It was subsequently increased via syndications, before a GGB€i 2.3% July 2030 was launched in March 2007. A few weeks before this, Greece issued a 50y bond linked to euro HICPx via private placement. In 2012, Greek linkers were subject to the same binding bond exchange as nominal Greek government bonds, with the final inflation accretion of the issues fixed on 24 February, the date that the exchange notice was issued.

Spain

The latest newcomer to the European government inflation-linked bond market to date is Spain with the SPGB€i November 2024 issued via syndication in May 2014 for €5bn. From the start, the Tesoro indicated a strong commitment to the linker programme and has been swift to build a curve despite challenging conditions for inflation-linked market in general. The SPGB€i19 was issued in October 2014, followed by the SPGB€i30 in March 2015, both via syndication. In May 2016, the SPGB€i21 was the first Spanish linker to be launched via auction. The SPGB€i27 was offered via syndication in April 2017, the SPGB€i23 via auction in June 2018 and the SPGB€i33 via syndication in September 2018. While Spain remains a small issuer compared to France or Italy, issuance has been regular and consistent with a strong commitment to the programme.

Euro inflation-linked STRIPS

In June 2007, the Agence France Trésor (AFT) made it possible to strip all French inflation-linked issues. The Italian Treasury followed suit in January 2008, making it possible to strip all BTP€is. Each linker under the stripping process can be decomposed into a series of coupon payments and a principal repayment, whereby each individual component is traded as a zero-coupon instrument. Coupon payments of a bond with CACs are not fungible with those of a bond without CACs. In other words, coupon payments with the same maturity and linked to the same index are fungible and have a single ISIN, provided that all their underlying bonds have the same status in terms of CACs. Given that coupons from two different bonds will have two different base reference inflation indices, an adjustment is needed. In order to achieve fungibility for coupon iSTRIPS, there is an adjustment that transforms the base reference inflation index value for each coupon strip to 100.

For French government issues, each linker has one principal component, identified by its own ISIN. Conventions for the principal component are exactly the same as for the underlying issue except that there is a floor on the principal. Hence an investor receives at least the face value of the position at maturity. If inflation has occurred since the underlying bond was issued, the investor receives the face value multiplied by the index ratio, ie, the reference inflation index at maturity divided by the initial reference inflation index value for the underlying bond. While the value of the par floor option on its own is usually very small, the guarantee of nominal principal repayment may be worth notably more for investors who are unable to buy bonds without floors.

The coupon-stripping process for BTP€is, initiated as from 2008, holds an additional complexity compared with French bonds. Investors can actually request that the principal be split into a nominal component and a floored inflation uplift component. This introduces a major innovation to the principle of iSTRIPS, given that this three-component stripping model does not exist in any other inflation-linked bond market.

Inflation strips provide increased flexibility to hedge inflation-linked liabilities. Demand may come from insurance and pension sectors in countries with inflation-linked liabilities but with difficultly accessing inflation swaps, for example.

Regulation, accounting and taxation

Compared with the UK, regulatory and accounting factors have been less important in the development of the European linker market. The evolution of the framework allowing investors to hold inflation-linked bonds has been a determinant. For example, prior to 2002 in France, insurance companies could not report principal accrual as earnings as it was unrealised. The revision of this rule in 2002 opened the linker market to a deep investor base, with the French insurance sector now structurally a major participant in the market. Some German investors were restricted from holding inflation-linked bonds prior to 2004, and one factor that delayed Germany from issuing in 2005 was ensuring that accounting and regulatory restrictions from investing in government issues were removed or addressed.

The pressure for life insurers and pension funds to address liabilities with the introduction of IAS19 has been similar to that in the UK, but far fewer liabilities are explicitly inflation-linked in the euro area and of these, most are linked to indices that are very different from euro HICPx. Pension reform in Europe may crystallise more demand to hedge long-dated, inflation-linked liabilities but beyond demand from pension schemes that were previously unfunded, to date this has not happened. The Netherlands, the euro country with the largest private defined benefit pension assets, currently has a regime where indexation is conditional, ie, only paid out when nominal solvency levels are sufficiently high, to unconditional. Inflation hedging demand there has overall been limited over the past few years as solvency ratios have, on average, been at low levels despite some improvement in 2018. Nevertheless, it appears there has been inflation receiving from some entities with ratios high enough for full or partial indexation. Currently, one main challenge for Dutch pension funds is uncertainty regarding future regulation, which hinders hedging appetite to some extent.

The development of the FRCPIx inflation-linked bond and swap markets has been largely driven by the decision to partially link the remuneration rate on Livret A savings accounts (called Livret Bleu when distributed by the Credit Mutuel network) to the FRCPIx inflation rate. The decision, taken in 2004, was meant to depoliticise the rate-setting decision. The original formula determined the rate as half the y/y FRCPIx rate plus half the 3mth Euribor rate plus 25bp, rounded to the nearest 25bp, and was used in the twice-yearly revision of the rate. The Livret A rate is used to determine the remuneration rate on various other savings accounts and in 2004, around €270bn of instant access account deposits became, de facto, linked to French inflation. Funds collected on Livret A and Livret Bleu savings accounts have traditionally been centralised at the DFE (Direction des Fonds d'Epargne), an agency administered by the state-owned financial institution, CDC, which finances social housing schemes at lending rates that depend on the Livret A rate.

From an ALM perspective, there is therefore an automatic hedge for funds centralised at the DFE and used to finance social housing. However, hedging of the exposure to French CPIx inflation is needed from commercial banks which distribute savings accounts linked to the Livret A rate, either through OATi bonds or FRCPIx swaps. The reform of the Livret A, undertaken in 2008 and effective from the start of 2009, had important implications with regards to the latter. From 1 January 2009, the distribution rights for the Livret A were extended to the whole banking network in France (as opposed to only La Banque Postale, the Crédit Mutuel and the Caisse d'Epargne in the past). This led to a surge in total Livret A and Bleu outstandings, including an increase of more than €17bn in January 2009 alone. Probably more important in terms of potential demand was the fact that the centralisation rules with the DFE changed. Under the new regulation, commercial banks were allowed under some conditions to keep Livret A funds on their balance sheets. The expected and realised increase in Livret A outstandings therefore implied a substantial increase in hedging demand and the impact on the French inflation market was obvious.

Nevertheless, the change in the rate-setting formula, and especially inconsistency in setting the rate according to the formula, has weakened the formulaic link between French inflation and the Livret A. In 2008, an element of non-linearity was added to the formula: it referenced the maximum of y/y FRCPIx +0.25% and half the sum of y/y FRCPIx and the average of 3M Euribor and Eonia. The addition of Eonia lowered the weight of 3M Euribor in the formula. The aim there was to reduce the volatility in the rate from Euribor fixings in the context of the 2007 financial turmoil. At the start of 2009, a condition was added such that the magnitude of change in the Livret A rate between the two consecutive fixings cannot be more than 1.5%, a non-linear condition that makes hedging less appealing. Furthermore, since 2009, the government can change the rate between the usual February and August fixing dates if changes in money market rates or inflation are viewed as significant. The rate given by the formula has been overruled frequently since the beginning of 2008. This means that the once-strong formulaic link, the basis of hedges and justification of those hedges from an accounting perspective, was broken. In our view, Livret A-related hedging demand has structurally decreased as a result of inconsistencies in the rate-setting decisions. In particular, there is less value in undertaking precise hedges involving swaps tailored to the formula (Livet A swaps) for instance, but broad hedges involving some element of inflation protection are still carried out. Indeed, despite formula overrulings, the Livret A payoff is still perceived to have a link to French inflation over the long term and simpler hedges involving standard FRCPIx swaps or even FRCPIx-linked bonds are to a greater extent preferred. To some extent, hedging in euro HICPx swaps or bonds is not uncommon either, when they are sufficiently economically cheap to their FRCPI equivalents.

The ceiling for Livret A deposits was increased in October 2012 and again in January 2013, which led to further sharp increases in outstandings. In September 2012, attention turned to a report commissioned by the French government. The “Duquesne Report” recommended a new Livret A formula in which the inflation rate carries a significantly higher weight than before. It also recommended the Livret A remuneration rate be determined only by the mathematical formula – ie, with no possibility of it being overruled. The report recommended that the remuneration rate is calculated as the sum of y/y inflation and 10% of the economic growth rate when the latter is positive.

At the time of writing, there is significant uncertainty regarding the future Livret A landscape. The remuneration rate is currently frozen at 0.75% until January 2020. A new formula is meant to kick-in after that. It should reference the average of the six-month averages of y/y inflation rates and Eonia rates, floored at 0.50%. However, there has been push-back against the new formula by several consumer protection associations. In addition, some market participants have expressed the view that the formula would be very challenging to hedge. The centralisation rules with the DFE also changed in 2018, with overcentralized funds to be gradually transferred back to banks.

The uplift of euro inflation-linked bonds is generally taxable. This is one of the main reasons for the existence of the structured inflation market, on which taxes are paid only on coupons as they are paid. OATis and OAT€i bonds are taxed similarly to other French government bonds, ie, the inflation accrual is taxable for domestics, while there is no withholding tax payable for international investors. Retail investors can pay all withholding tax at maturity or sale. Institutional investors pay tax both on interest received and annually on inflation as it accrues. BTP€i bonds follow the same tax rules as conventional BTPs. This means that domestic entities are taxed on inflation uplift as well as on real returns. International investors are exempt from paying withholding tax as long as they are within countries that Italy does not define as tax havens, and they send in the necessary initial documents that are on the Treasury website.

Euro non-government inflation-linked bonds

Two distinct strands of non-government bonds have been issued in the euro market with cash flows linked to inflation. There has been issuance of bonds in a similar accreting Canadian-style format in line with that issued by governments. There has also been considerable issuance of structured notes whose cash flows are linked to inflation. The accreting style issuance has been directed at similar institutional investors to those buying government linkers and has generally not involved accompanying derivative transactions. Most structured note issuance has been to individual investors, and the inflation exposure of these notes has largely been hedged using inflation swaps.

Government-style bonds

Agencies, quasi-agencies and regions have mostly issued inflation-linked bonds in a government-style format. The largest non-government issuer has been the Caisse d'Amortissement de la Dette Sociale (CADES). This sovereign agency was created in 1996 as a vehicle to consolidate and service the debts of the French social security funds. Its revenue comes from a ring-fenced tax on income called CRDS, making it a natural issuer/payer of French inflation. Historically, these issues have been built up via multiple syndications and in practice have traded similarly to OATis, albeit with notably lower liquidity, helping to define the curve when there were relatively few government issues.

Other non-sovereign issuance has come from Réseau Ferré de France (RFF), the owner of French railway infrastructure, whose 2023 HICPx-linked bond has reached €2bn face value, having initially been syndicated for €800mn in February 2003. Caisse Nationale des Autoroutes (CNA), which grants loans to toll road companies, issued a €600mn 2016 French CPIx-linked bond in 2001. The Italian agency, Infrastrutture (ISPA), which had inflation-linked revenues from some projects such as high-speed railways which it funds, issued a €750mn 2019 bond in February 2004. This issue, which was subsequently redefined as Italian sovereign credit, was the first benchmark inflation-accreting bond to be linked to FOIx inflation. The first major true corporate inflation-accreting bond came from Veolia Environnement in June 2005, a euro HICPx-linked 2015 bond initially for €600mn. As the owner of a range of utilities in France and across Europe, Veolia ought to be well suited to using the inflation-linked market as part of its funding strategy. Terna SpA became the first Italian listed company to issue a bond linked to the Italian FOIx in October 2007. The €500mn issue matures in September 2023 and was priced against the BTP€i September 2023, which carries the same maturity date. Given its revenues derive from regulated activities, Terna is a natural payer of inflation. In August 2008, France Telecom issued a 2018 bond linked to euro HICPx.

Inflation structured notes

While there was issuance in inflation structured notes even before the first OAT€i was issued in 2001, notably an inflation-protected equity-linked note issued by the Italian Post Office, it was in 2003 that the market really took off. There was over €18bn of inflation structured note issuance in 2003, with almost all of it sold into Italy. As with other structured products sold mainly to individuals, the popularity of this kind of product faded, particularly as falling real yields made it increasingly difficult to structure sufficiently appealing cash flows. Total 2004 issuance was around €10bn, while there was less than €3bn issued in 2005. Issuance picked up slightly in 2006 with around €7bn in issuance but issuance in subsequent years has been somewhat less, other than in 2009. The widely dispersed nature of this issuance means that while there are several issues of over €500mn, liquidity is very limited. In 2003, most issuance was 5y, but as yields fell and the type of demand changed, issuance moved longer, with 10-15y supply becoming as common as 5y.

Most issuance in 2003 was of bonds paying an annual coupon at the rate of inflation plus a fixed percentage but with a fixed principal. Coupons were usually floored at the fixed rate, although in 2004 higher floors became more common. Coupons were often backward-looking, eg, paying inflation from the previous year and high fixed coupons early in the life of the bond were commonly offered as enticements. As distribution of this type of bond became more widespread, there was increased interest from corporates as well as individuals, but fees were such that most institutional investors were deterred. With the slight revival of issuance in 2006, products with coupon payments linked to inflation (mostly euro HICPx) with leverage became more popular. These notes often carried a fixed attractive coupon at the beginning and a cap and/or floor on the subsequent floating payments. 2006 also saw several structures with coupons linked to the differential between euro and French ex-tobacco inflation. The issuance of such products thrived on what was perceived as an anomaly on the forward breakeven differentials in the swap market. Indeed, forward French inflation breakevens were higher than on the euro HICPx curve because of Livret A-related demand. These notes proved popular as French inflation was expected to be lower than European inflation over the medium term. 2007 saw the appearance of inflation range accruals, where pay-offs are dependent upon the length of time that inflation remains within a specified range. The development of these products marked a stepping stone as they helped increase liquidity in the market for inflation caps and floors, but with realised inflation breaking above the top of the ranges specified by the end of 2007, holders of the notes suffered poor performance and demand for them waned. In 2008, notes paying a coupon linked to a multiple of the y/y inflation rate were widespread, with activity driven by demand from retail investors given the high inflation environment. The structuring of attractive pay-offs was also relatively easy as a result of expensive credit/funding for financials.

Most structured inflation notes have been issued by financials, although opportunistic swapped issuers including EIB and KfW have also been involved. Greater retail scepticism over bank names has limited the scope for issuance since the Lehman bankruptcy. This exacerbated a trend towards more institutionally focused structured issuance. The fees involved in this kind of note are often lower due to smaller distribution fees, providing access to investors who are unable to take direct advantage of the development of the inflation swap market. Even so, a significant increase in issuance likely requires a combination of higher real yields and fear of inflation. In 2011, the heaviest demand for structured notes was evident in Germany, but this fell away as euro sovereign fears increased. Overall, inflation-linked structured note issuance has been limited in recent years, partially due to lower funding rates for financials.

An area where at times there appears to be much scope for development is in domestic inflation bases. Issuance has been relatively significant on occasion, for instance in 2006 there was significant issuance in structures linked to Spanish inflation. Demand for German inflation linked notes was apparent when German CPI swaps were cheaper than euro HICPx in 2009, but has not been a significant feature in more recent issuance. In smaller countries it is hard to see how a structured note market can develop in any size without structural paying of inflation in swaps, or government issuance of bonds with a local inflation reference.

Inflation swaps and other derivatives

Euro HICPx

The benchmark format for euro HICPx quotes is the zero-coupon structure, with a standard lag of three months, meaning that the base inflation index for the swap is the value of the HICPx three months before settlement. Towards the end of the month, swaps on the next base month also begin to trade. There will be a discontinuity in the quoted "breakeven" at the time of the roll from one month to the next, reflecting typical seasonality between months. Barclays displays live prices for the currently trading base month on Bloomberg page BISW. Standard swaps used to trade with a T+2 settlement, but since the market moved towards clearing, the standard settlement convention has changed. They now typically settle on the 15th day of the month in which they are initiated, even if the trade date is after the 15th; that is, some trades back-settle. Activity at the front end used to be very limited, and the inflation futures were never active enough to provide significant transparency or to cater for hedging needs. However, this changed from 2012-13 given a very active resets market; the 1y point, in notional terms, is now probably as liquid at the longer benchmark points.

Euro HICPx swap broker volumes began to pick up substantially from late-2002, driven by a rise in the need to hedge retail products and structured MTNs. In 2003, it accelerated further, aided by the issuance of BTP€i08, the most suitable hedge for most of these exposures. Typical monthly broker volumes moved from €500mn in mid-2002, to €5bn by mid-2004, a level that was maintained in 2005 even though structured issuance fell notably. Liquidity in the market has been increasing since, with typical monthly broker volumes rising to €15bn in 2007. Total volume traded surged in 2008 in the interbank market but mainly because of the Lehman collapse. Direct interest in trading inflation swaps, from proprietary desks and hedge funds for instance, meant volumes did not suffer even when issuance hedging flow slowed down, while liability hedging has been continuing. Liquidity in swaps suffered notably less than in euro linkers during the sovereign spread turmoil of Q4 2011, though activity in early 2012 was driven by significant forced swap unwinds due to Greek restructuring, which left previous asset swap exposures orphaned.

Government linker asset swaps often represent a significant proportion of volumes in the euro area inflation swap markets. The relatively high level of activity in asset swaps often helped align swap and bond breakevens more closely than in other markets. The private placements of ultra long-dated linkers by Italy and Greece in 2007 raised the prospect of the euro inflation curve stretching out to the 50y maturity as in the UK, but the depth of demand at such extreme liabilities remains limited. During the financial turmoil from 2007, many speculative participants or natural investors in linker asset swaps were no longer very active, which led to a wide distortion between swap and bond valuations in 2009. The cheapness of linker asset swaps then attracted demand, mainly from bank treasuries, but with a notably narrower investor base than before the crisis. This investor base narrowed notably further as euro sovereign woes increased, with very little interest in asset swaps in France or Italy beyond domestic banks and insurers, albeit demand was encouraged by 3y LTRO related liquidity. Activity from bank treasuries now represents a significant proportion of linker asset swap activity and with linkers included in the ECB's QE programme, it has not been uncommon to see inflation trade at flat levels versus bond breakevens.

Activity in inflation caps and floors on euro HICPx was boosted in 2007 by the issuance of inflation-range accrual notes. Given that these rely on inflation remaining within a specified range, this means that dealers selling them were actually long inflation volatility and they have tried to offset their risks by selling inflation caps and floors in the market. The increased trading activity on inflation options provided a clearer picture of the implied inflation volatility. Hefty issuance in leveraged notes over 2008 also encouraged hedging activity in the cap/floor market, which led to a significant rise in implied volatility. The presence of embedded floors in previously issued notes and increased volatility in realised inflation led to a sharp repricing of the cap/floor vol surface in 2008-09. The link between the vol and the swaps market was very tight towards the end of 2008, when increasing deflation fears pushed short-dated swaps lower, leading to a downward spiral of valuations at the short end of the curve as dealers sought to delta-hedge their short floor positions. The pick-up in asset swap activity after Q1 2009 was accompanied by much better definition in the market for zero-coupon floors, a process which appeared to help the recovery in the y/y vol market, with dealers becoming more comfortable in comparing their long zero-coupon floor positions to their structural short in y/y inflation. Until around 2014/2015, there was healthy activity in the vol market, with hedge funds particularly active. Nevertheless, activity has been drastically lower in the past few years. While asset swapping does sometimes create some activity in low-strike floors, the market is generally much less well defined than before.

French CPIx

The default format for French CPIx zero-coupon swaps historically used different lagging conventions to euro HICPx, as it was based on the same interpolated daily reference value as used for OATis, rather than the stepwise format used. This avoided the discontinuity of the HICPx method and aligns swap methodology more closely with bond methodology. On the other hand, it discouraged short-term tactical trading within the same monthly inflation base (as in HICPx swaps) and made it more difficult to compare market movements within a given month, as it can impose a drift on the level of breakevens. However, with the advent of clearing, standard FRCPIx swaps now share the same interpolation and settlement conventions as standard euro HICPs swaps.

The French CPIx market is the oldest major euro area inflation market, first trading in 1998, just ahead of the launch of the first OATi and before the HICP market that began almost as soon as the euro currency was created in 1999. The earlier development of the OATi bond market and short-dated issuance by French agency CADES allowed the French CPI swaps to initially have better liquidity than HICPx. Some domestic real money investors started using swaps to match cash flows as the market developed. However, it was not until trading of the basis against euro HICPx began, with broker screens becoming readily visible, that the market gained any depth. Compared with the size of the underlying bond market, however, outright paying flows are more common than in euro HICPx, while liability hedging is significantly broader than just Livret A-related flows.

The decision to link the Livret A French public sector savings rate to inflation from August 2004 greatly heightened activity levels in French CPIx. With banks being restricted on the amount of bonds they could hold versus their liabilities, the flow became increasingly skewed towards using derivatives as a solution. A variety of swap types have been used to hedge liabilities, including zero coupon across the curve, tailored maturity inflation swaps matching the inflation element of reset on the Livret A rate and Livret A swaps covering the nominal as well as the inflation element of the reset. In aggregate, there has been a tendency for hedging activity to decrease as real yields fall but also to move longer on the curve, with relatively little apparent sensitivity to breakeven levels. Bank hedging demand at times has led to more significant deviations between OATi asset swaps and those of nominal OATs than in the €i market. There is a significant percentage of OATis that are held in asset swap form until maturity as a result of the Livret A hedging pressure, but there is also two-way asset swap interest.

In 2006, the richness of French CPI swaps triggered substantial issuance in structured notes paying euro versus French inflation, usually with a leverage factor. These notes were actually hedged in the corresponding swap markets, correcting the squeeze created by Livret A-related hedging. FRCPIx again richened significantly versus euro HICPx swaps toward the end of 2008/beginning of 2009, given the extension of Livret A distribution rights to the whole banking network in France. However, the fact that the formula was changed in 2008, and then over-ruled most of the time in 2008 and 2009, implies that French inflation is no longer a good hedge for Livret A-related liabilities, at least from a pure formulaic perspective.

Other euro area inflation markets

While an underlying government bond market and developments on the regulatory front (Livret A) helped create liquidity in the FRCPIx swap market, activity on other euro area domestic inflation swap markets has been muted. Italian and Spanish inflation swap markets have been the most active 'other' countries, with live prices even available from some dealers, but activity in these indices has been relatively muted since 2008 and bid-offer spreads on screens are very wide. Other inflation bases are usually quoted as a spread against the more liquid euro HICPx basis, with the pricing dependent on the expected evolution of each index relative to the euro area. From a general perspective, activity on these swap markets could gain momentum if there is growing demand to hedge explicit liabilities linked to domestic inflation, especially if increased divergence in inflation rates implies that euro HICPx may not prove an appropriate hedge against domestic indices. Generally, given the difficulty to hedge positions in those domestic indices and therefore large bid-offer spreads, trading is often possible only if specific payer and receiver interests can be directly matched by dealers.

German CPI

Explicit indexation to German CPI had been illegal prior to 2003, but the German government's intention to issue inflation-linked bonds, even though this was euro HICPx, spurred a market to develop. Prices are available from Barclays on Bloomberg page BISW27. Until 2009, the higher real yield that a German inflation basis offers compared with one linked to euro inflation created some interest to retail and corporate investors. This prompted limited structured note issuance, which tended to narrow the spread, and from mid-2010 onwards, German inflation has traded richer than euro HICPx. Until now, supply in German inflation has come primarily from property securitisation and rental leases. The tendency towards utility privatisation may produce paying flows, particularly if there is indexation embedded in the formulae for renewable energy projects. Banks may have some willingness to pay German inflation through swaps because of its weight in the euro HICPx, such that the basis risk involved is less of an issue than for other domestic inflation indices.

Pension liabilities in Germany were traditionally backed by company assets, meaning that implicit or even explicit inflation risks tend to be ignored. The trend towards funded schemes in Germany implies that embedded domestic inflation risks in liabilities are likely to be addressed on a larger scale. However, the extent to which this can effectively create substantial demand for German CPI is debateable. Liabilities rarely reference national headline CPI but can be based on various other indices, and where the basis risk of the relevant index versus German CPI is high, hedging needs may as well be met using the euro HICPx swaps market. Furthermore, even in cases where the relevant index is the German CPI, pension funds may prefer to hedge euro HICPx swaps, given relative liquidity and with the basis risk versus European inflation perceived to be low.

Italian FOIx CPI

Traditionally the Italian FOI inflation (ex-tobacco) market is the most active inflation swaps market without a substantive underlying government bond market to hedge against. This was initially driven by substantial retail note issuance in Italy on this basis, but the market slowed from 2005 with less structured issuance. The FOIx market is quoted with the same conventions as euro HICPx, including lagged basis month. Prices are available from Barclays on Bloomberg page BISW28. Most retail issuance has now redeemed and the swap market was quiet in the years prior to the launch of the initial BTP Italia. The market for Italian-linked retail notes started in 2002, when there were small issues in both FOIx and the alternative NIC basis (Bloomberg code ITCPNIC). The FOIx measure became the most widely used because it is more widely referenced in Italian inflation-linked liabilities. While retail notes were predominantly sold to individuals, there was some demand from corporates to hedge TFR exposure, which was 1.5% plus 75% of FOI ex tobacco inflation.

Prior to the mid-2011 sovereign spread widening, most investors with Italian inflation exposures seemed content to hedge with euro inflation, given that the level of prices in Italy converged with the euro area average in the first 10 years of the single currency. It is notable that the turmoil in late 2011 saw domestic Italian expectations rise sharply, to their highest level since euro notes and coins were introduced 10 years previously. We suspect this reflected fears of a return to a domestic currency, a concern which likely underpinned demand for the BTP Italia product.

Spanish CPI

The market for Spanish CPI developed in 2004 with some limited swapped structured note issuance. Structured note issuance, however, rose strongly in 2006. These notes typically had 10y and 15y maturities, and the hedging of these triggered strong demand and richening in Spanish CPI swaps as the Street was left short. The rise in demand coincided with a period when actual inflation was high due to the real estate boom, thereby accentuating the richening versus euro HICPx swaps. Demand for Spanish CPI was mainly from the insurance and retail sectors, while natural supply came from residential property leases and property securitisation. Spread levels to euro HICP swaps decreased in 2007, from the very rich levels observed in 2006, helped in part by speculative selling from some, who viewed the spreads as unsustainable, and a narrowing of realised inflation spreads.

The first half of 2008 saw renewed activity in Spanish CPI swaps due to structured note issuance. The interesting feature of structured note activity in Spain during 2008 was that the underlying was commonly the domestic index, in contrast to demand in other countries. This led to renewed relative richening in sub 10y Spanish CPI swaps, while the long end lagged versus euro probably due to infrastructure-related paying flows.

Dutch CPI

The Netherlands is the euro area country with the largest potential demand for long-end domestic inflation protection. Given the size of Dutch defined benefit pension schemes, demand for Netherlands CPI ought to be considerable. However, because of the conditional indexation of liabilities to inflation, there has been no regulatory pressure to address inflation risks as there was in the UK. Indexation is usually to either sector-specific or general wage inflation rather than Dutch CPI and, in the absence of large natural inflation payers, most pension funds have accepted that they cannot match their liabilities. Some funds in the past have been willing to pay a significant premium to source specific inflation though, inducing payers mainly from the infrastructure and property firms. This is a market of one-way flow, with all inflation receiving by pension funds locked to maturity. Barring the unlikely event of the Dutch state issuing domestic CPI-linked notes, not much is likely to change. Dutch pension funds tended to address the conditional indexation on an ad-hoc basis when funding ratios are high enough. Given the liquidity of the euro HICPx market and the absence of any other suitable alternative, pension funds tend to take the basis risk created by long exposures to euro inflation; however there was significant unwinding due to Greek related euro HICPx strength in early 2012, which coincided with low solvency ratios. While the short-term basis risk between Dutch CPI and euro HICPx is significant, so too is the basis risk between wages and Dutch CPI.

Belgian Health Index CPI

In Belgium, the relevant index against which almost all inflation liabilities are based is the Health Index measure, which excludes alcohol, tobacco and fuel oils (Bloomberg code BECPHLTH). As with other smaller markets, local government, infrastructure and property developments may bring the most likely payers of Belgian inflation. Until now, supply has come mainly from rental leases paying Belgian Health inflation, but also Belgian CPI and HICP.

Irish CPI

Ireland has a longer history of inflation paying than anywhere else in the euro area. Supply historically came mainly from housing associations and Public Private Partnership (PPP) deals in swap form. Pension fund liability needs are more explicit than in most other euro countries, with significant indexation in an LPI format, floored at 0% each year and capped at 4%. This, coupled with the longer history of the market, has often resulted in relatively complex structures. As of April 2019, the National Treasury Management Agency (NTMA) has issued two inflation-linked bonds linked to Irish HICP, via private placement under its EMTN programme.

The rest

Of the remaining countries in the euro area, Portugal has had a higher degree of potential payers than elsewhere, while pension funds have mostly chosen the more liquid euro HICPx options rather than addressing their liabilities directly, producing a relatively balanced market. By contrast, in Finland, even though there is interest to receive domestic inflation from pension funds, the lack of Finnish CPI payers restricts the development of a market. Austria has seen little activity due to limited explicit liabilities linked to Austrian CPI, even though the government has previously issued swapped structured HICPx notes. The latest entrants from the east European block have relatively undeveloped private pension systems. Thus, we would be surprised if domestic inflation markets emerged there.

INFLATION MARKETS

United Kingdom

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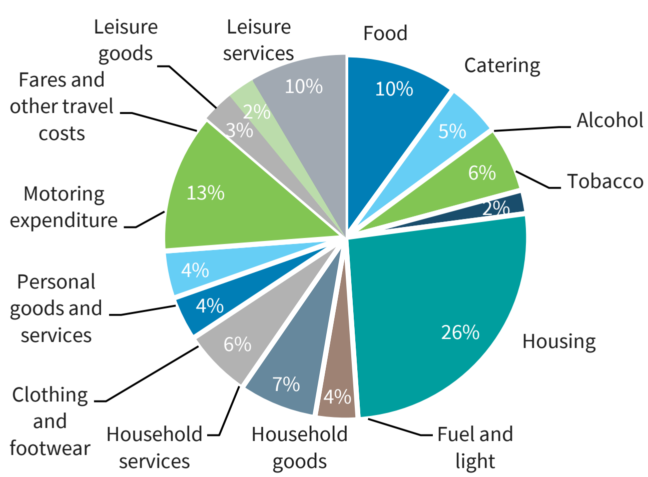
The UK Treasury has been issuing gilts whose principal value is linked to the Retail Prices Index (RPI) since March 1981. At the end of 2018, the gilt linker market value was £675bn, representing just under 30% of UK government bond debt – a fairly large proportion relative to other comparable markets. This reflects the embedded inflation indexation in many UK defined benefit pension liabilities, which has long provided a natural demand base for the asset class. However, the linkers proportion of the debt stock is likely to reduce as the government has become concerned about the level of exposure to inflation in its liabilities. Following legislative changes in 2010, many liabilities reference a mixture of RPI and CPI exposure. The UK inflation market is currently almost exclusively RPI-based but there has been increased activity in CPI derivatives and corporate linkers. We expect issuance to ultimately move away from RPI to either CPI or CPIH but this is likely to be a lengthy, considered and managed process.

The Retail Prices Index

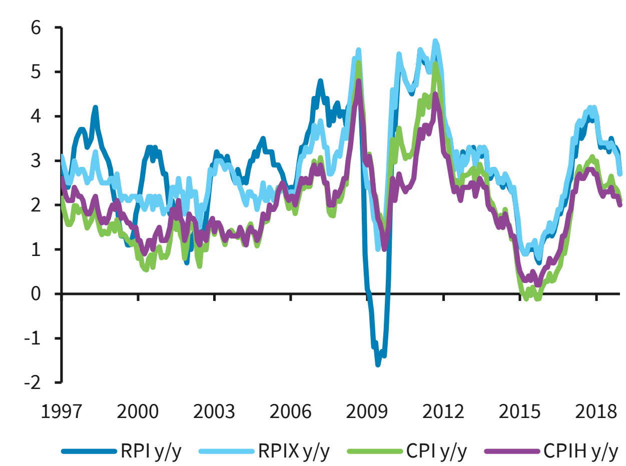
The Retail Prices Index (RPI) has been used as a measure of UK inflation since 1947 and was the main measure of headline inflation for over 50 years, although it was never formally adopted as a targeted inflation series for monetary policy. Since December 2003, the Bank of England's Monetary Policy Committee has had an inflation target based on CPI. UK CPI was developed as a harmonised index of consumer prices, using Eurostat's HICP principles, but the name was changed from HICP to CPI in June 2003, when it was announced that the inflation target would be changed. Previously, the inflation measure targeted by monetary policy was the RPI excluding mortgage interest payments, RPIX. Raw data for the RPI are collected in the middle of each month, with the new index published on a Tuesday in the middle of the following month. Weights are recalculated annually, with re-weighting calculated for the January data. The ONS now produces a measure of CPI including house prices on a rental equivalence basis called CPIH. The ONS now treats CPIH as its main measure of UK inflation, but it has struggled to gain wider acceptance. It initially suffered from a lack of confidence owing to methodological issues, which the ONS has worked hard to resolve. Nevertheless, RPI and CPI remain the most widely referenced indices.

FIGURE 1
Breakdown of RPI by major category (2019 weights)



Source: ONS, Barclays Research

FIGURE 2
UK RPI, RPIX , CPI and CPIH inflation



Source: ONS

In contrast to most consumer price indices collected internationally – including the UK CPI – the RPI is predominantly constructed with arithmetic (Carli), rather than geometric, aggregation. As this aggregation is based on the average of relative prices rather than a ratio of averages, it produces an upward bias compared with a geometric aggregation. This statistical bias, often referred to as the formula effect, has been worth almost 1pp in recent years. Methodological changes to the treatment of seasonal prices have been responsible for greater inflation dispersion in the clothing and footwear component in RPI, which has largely been responsible for the increased impact of the formula effect from 2010. Historically, the bias had consistently been worth close to 50bp, which was the basis for the Bank of England's inflation target adjustment from 2.5% RPIX to 2.0% CPI, with tolerance bands remaining at 1% on either side of the target. If inflation is outside these bands, the Governor of the Bank of England is required to write a letter to the Chancellor of the Exchequer each quarter accounting for this deviation, outlining when the committee expects inflation to return to target and what steps are being taken to anchor inflation. Even though monetary policy is now focused on CPI inflation, gilt linkers are likely to remain indexed to RPI inflation for the foreseeable future, after the government decided against issuing CPI-linked gilts following consultation in 2011. However, we expect the case for non-RPI linked gilts to be eventually revisited following the 2019 House of Lords Economic Affairs Committee Report into RPI.

The RPI measure was the source of some controversy, and even market panic, from Q2 12 until Q1 13. The now-disbanded Consumer Prices Advisory Committee (CPAC) had been deliberating means of managing the RPI formula effect, and ultimately held a consultation on how best to proceed. Participants in the UK inflation market had feared that the formula effect would be substantially or wholly eliminated, resulting in lower inflation accrual over the maturity horizon of their linker holdings. Indeed, the CPAC recommended excluding the Carli measure of aggregation from the RPI since it has been internationally discredited given the upward bias it imparts into inflation indices, which gives rise to the formula effect.

On 10 January 2013, the National Statistician announced that no changes would be made to the aggregation formulae in RPI, effectively preserving the formula effect. Additionally, it was noted that revisions to RPI should be limited to just routine updates of the inflation basket and methodology. RPI has been stripped of its 'National Statistic' designation and is now classified as an 'Official Statistic'. This has almost no consequence for the inflation markets because the ONS is obliged to continue producing RPI. There have been recommendations, such as in the Johnson Review of Consumer Price Statistics, to denigrate RPI, but most feedback-gathering exercises the ONS undertakes tend to see market participants reiterate the importance of RPI and committing resources to it. The issue of RPI has come to the fore again following the House of Lords Economic Affairs Committee Inquiry into RPI, which reported in January 2019. This was highly critical of the Statistics Authority and ONS stance on RPI (that it should not be updated) and recommended that the UK choose a main inflation measure over the next five years and ultimately start issuing non-RPI linked gilts. The Inquiry is only advisory in nature and the formal government response was still to come at the time of writing.

Decomposing the RPI/CPI basis

The RPI/CPI basis (or wedge, as it is sometimes called) is of interest for two reasons. First, information from inflation-linked bond and derivative markets is of interest to policymakers as a gauge of market expectations regarding the credibility of inflation-targeting regimes. By the same token, inflation targets are often viewed by market participants as a reasonable assumption of medium-term breakeven fair value. In the UK, the inflation target is 2% CPI, so an RPI/CPI basis assumption is needed to assess the fundamental fair value of breakevens on a CPI basis. Second, those hedging CPI liabilities with RPI products require a framework for the RPI/CPI basis to provide a realistic gauge of the likely hedging error.

The Office for National Statistics provides a breakdown of the RPI/CPI basis, divided into the following components:

- **Formula effect:** the magnitude of the upward bias to RPI relative to CPI stemming from the different aggregation formulae used in the two indices. RPI relies heavily on Carli (arithmetic) aggregation, whereas CPI is largely a Jevons (geometric index). A Carli-based average is always higher than a Jevons average. Clothing and Footwear is the primary source of the formula effect, which is proportional to the extent of dispersion within its individual subcomponents.

- **Mortgage interest payments (MIPs, not in CPI):** historically the most volatile component of the basis, given its sensitivity to interest rates, and based on a 23-year average house price, and the average effective mortgage rate (AER). Prior to 2010, the calculation referenced the standard variable rate (SVR); so, in future rate cycles, MIPS will be less volatile than previously.

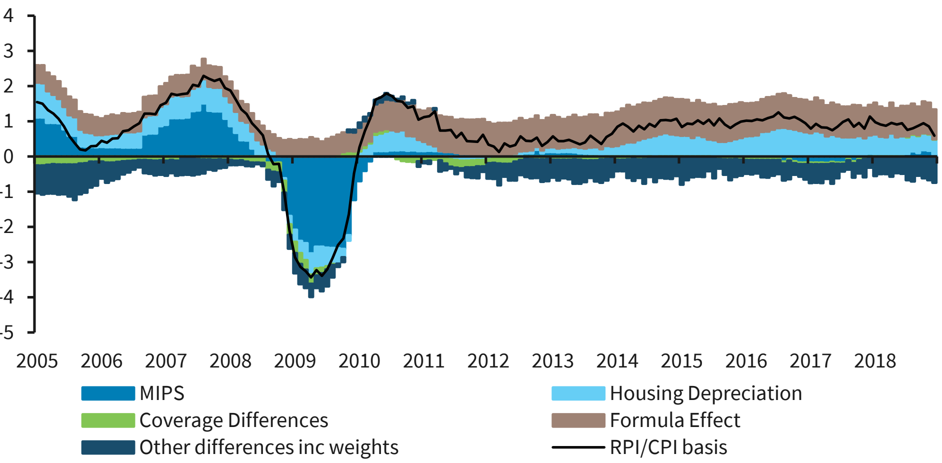
- **Housing depreciation (not in CPI):** an exponentially smoothed house price series. It can be modelled using third party house price indices (eg, Nationwide, Halifax) including an appropriate lag structure.

- **Differences in coverage between RPI and CPI:** some items, such as stockbroker fees and overseas tuition fees, are not included in RPI but are in CPI. Historically, other components fell into this bracket, but the proportion of these is diminishing.

- **Other differences including weights:** this is the most idiosyncratic component of the RPI/CPI basis because it encapsulates the spread between the two indices as a result of the different weightings of volatile components such as food, petrol, air fares, etc. Insurance costs (particularly motoring) have also been an important driver recently. We forecast this component using a model based on selected volatile components of CPI. This component has been responsible for much of the narrowness of the RPI/CPI basis in the past few years.

We expect the RPI-CPI basis to average 1.0pp over the long run assuming the calculation of RPI is unchanged, but interest rate and housing cycles are likely to cause significant (more than 0.5pp) variance around this central projection in either direction.

FIGURE 3
RPI/CPI basis breakdown



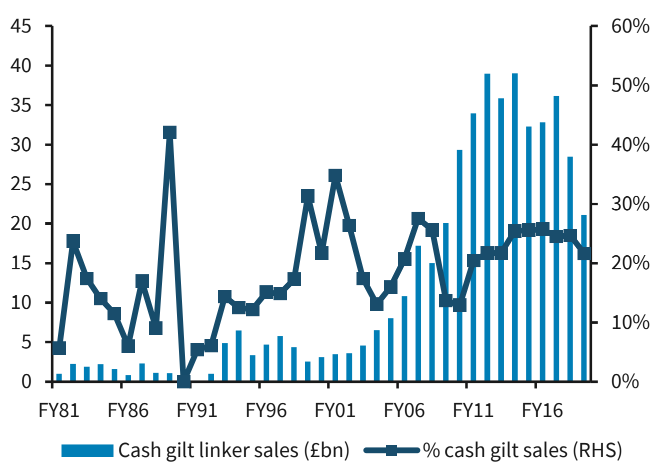
Source: ONS, Barclays Research

Development of the UK inflation market

The first index-linked gilt, the 2% Sep 1996, was auctioned by the UK Treasury on 27 March 1981 for £1bn. An ongoing commitment from both the Treasury and the investor base saw market capitalisation grow to £675bn by December 2018, almost 30% of the total outstanding value of the gilt market, with 52 bonds issued of which 30 are outstanding as of January 2019 on a real yield curve that stretches out to 2068. "Old-style" 8m lag linkers are no longer issued or tapped, while Canadian model 3m lag bonds are actively supplied with November, March and August maturities. Originally, all 3m lag gilt linkers were issued with November redemption dates; the IL50, launched in 2009 was the first to carry a March maturity and the IL48, launched in November 2017, was the first August redeeming bond.

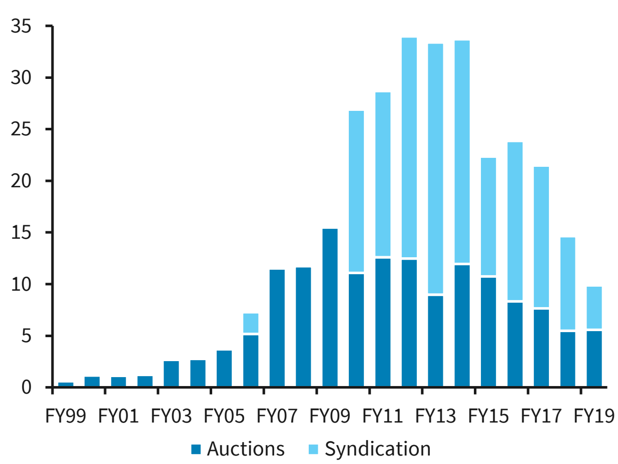
The creation of a linker market was formally recommended by the "Committee to Review the Functioning of Financial Institutions (1977-80)" (known as the Wilson Committee, after its Chair Sir Harold Wilson). However, indexation of debt was not a new idea in the UK – the UK Government's National Savings department had been issuing inflation-linked savings certificates for retail investors since 1975, while Keynes recommended the move as early as

FIGURE 4
Linker issuance chart



Source: UK DMO, Barclays Research

FIGURE 5
30y equivalent gilt linker issuance (£bn)



Source: UK DMO, Barclays Research

1924. In the 10 years prior to the launch of the first linker, annual RPI inflation moved between 6% and 26%, prompting strong demand for inflation protection, but pension funds were allowed to buy the new asset class for the first year only. Issuance of indexed debt contributed to the credibility of the government's anti-inflationary rhetoric by diminishing the incentive to debase the real value of the outstanding debt, but as inflation fell the programme proved a windfall for government finances. Early breakevens were about 9%, an expected inflation accrual cost considerably higher than was realised; within two years of the inception of the market, the RPI dropped below 5%. It generally stayed below 5% with the exception of the boom and oil price shock at the end of the 1980s, but rose above this level during the sharp rise in energy prices in 2008. After a period of negative inflation as the MPC lowered the Bank Rate to a record low of 0.5%, the RPI touched a local high of 5.6% y/y in September 2011, fuelled by increases in consumer energy prices and hikes in VAT to shore up the UK public finances.

Other than a bond issued in 1983 that was convertible into nominal debt, the 2% 1999, dubbed "Maggie Mays" (a reference to the then Prime Minister Margaret Thatcher – 'Maggie may or may not convert the issue'), all gilt linkers issued prior to 2005 had the same idiosyncratic format that has not been copied in other countries. Since September 2005, starting with the first syndication by the UK government of the 2055 linker, a new curve has been built up of Canadian-style bonds. By 2007, all new issuance was in Canadian-style bonds, with six issues with maturities of 2017 and longer having been launched by the end of that year. This rapid issuance of new bonds contrasts with the 2035 old-style linker, which was the only bond launched between 1992 and 2005.

The prospectuses of linkers issued before the 2035 bond contained "comfort language", giving some protection against adverse RPI measurement changes. That is, in the event of changes to the coverage or to calculation of the RPI, which the Bank of England (acting as "index trustee") deems both "fundamental" and "materially detrimental", investors would be given the right to sell bonds back to the government at indexed par (ie. adjusted for inflation). That, however, is of limited comfort at present because all stocks under this protection are trading well above indexed par. This clause has also been copied by some corporate issues, where the reference gilt is old-style. There was considerable concern in late 2012 about the potential effect of such clauses on both gilt and corporate linkers, and we believe the related possible ramifications are one reason the aggregation of RPI was not altered. For the 2035 and new Canadian-style bonds issued by the Debt Management Office (DMO), the choice of linking index is at the Chancellor's discretion, with the proviso that there is consultation with a body with "recognised expertise in the construction of price indices". This choice will be "conclusive and binding".

Government funding plans are laid out annually in a "Gilt Remit" within the Treasury's "Debt and Reserves Management Report". This is usually released just ahead of the beginning of the new fiscal year in April. Under the old UK fiscal timetable, this coincided typically with the Budget, but this has now moved to the Autumn and been replaced by a "Spring Statement" that accompanies the OBR Economic and Fiscal outlook. The remit contains an estimate of the total size of linker sales, by cash value, to be carried out in the new fiscal year. Planned auction dates for the year are released at this time, and there is often guidance as to how plans might be altered in the event of changes to the health of public finances. Formal remit revisions can happen at any time, but are usually performed around key fiscal events. Auction stocks are announced quarterly, although they are subject to remit revisions, with size details announced on the Tuesday in the week before an auction.

Prior to 2009, the vast majority of linker issuance since November 1998 was via auction. Linker auctions are single-price – ie. all successful bidders pay the same price, in contrast to nominal gilt auctions, which use a multiple price mechanism. Since 2009, there has been an additional 10% of stock for each auction that may be sold to successful bidders at the clearing price in a post-auction facility. The DMO also sells linkers via tenders (previously called mini-tenders), which are auctions of about half the size of regular auctions that are announced at shorter notice and for which there is no post-auction allotment. Tenders are a relatively small element of total issuance, and are seen as a safety valve or as a vehicle for opportunistic issuance in small size. Institutional buying at auctions must come via index-linked gilt-edged market makers (IL GEMMs). In the past, only some nominal market makers were IL GEMMs, but it is now common for most GEMMs to trade linkers. These banks are also the route through which the DMO can conduct syndications, switch auctions, taps and other market activities. IL GEMMs can also access the DMO's standing repo facility (10bp below the Bank of England's Policy Rate), though with a few exceptions, it is rare for the linker repo to stray far from general collateral rates for long.

Syndicated issuance of gilt linkers was first used in September 2005 for the launch of the 2055 linker, due to the extreme extension of the curve and the innovation of the new bond format. Syndicated gilt linker issuance was not used again until 2009, when the DMO noted in its response to the consultation on the supplementary methods for distributing gilts in March 2009, that it would use syndicated issuance alongside the auction programme in FY 09/10 to issue larger volumes of gilt linkers and long nominals than it judged would be possible via auction. While initially used sparingly for supplementary issuance, syndications have become an important feature of the UK gilt remit. Particularly for linkers, syndications are able to provide sufficient liquidity to draw deep demand for particular bonds, which would not be feasible at a regular auction. From FY13/14, the DMO focused on holding fewer but larger syndications than in preceding fiscal years, with an aim of increasing the size of these to facilitate deep demand for long conventionals and linkers to best meet the needs of those hedging sizeable liabilities. Recent issuance has struck a balance between syndicated and auction issuance to suit market trends and investor preferences.

While there has been some non-government issuance of sterling inflation-linked bonds since the mid-1980s and RPI swaps have traded since the early 1990s, until the early 2000s gilt linkers were by far the dominant feature of the UK market. In 2000, when the Minimum Funding Requirement (MFR) encouraged pension funds to favour gilts, asset swaps were sufficiently attractive for significant supranational swapped supply. This helped to kick start what was until then a niche RPI swaps market. As equity markets declined in the following two years, the life insurance industry began to focus on the potentially more accurate liability-matching benefits of using inflation derivatives rather than bonds. In particular, the PS16/04 regulation hastened the use of inflation swaps by the insurance sector. Initially, they covered their life policy RPI exposure before focusing on immunising bought-out and in-house pension portfolios. It was not until 2004 that pension-specific, rather than insurance, business became the main driver of the UK swaps market; however, having been spurred on by heavy swap activity around the time of the IL55 launch in September 2005, it quickly grew to dominate end-user demand.

In the mid-2000s, inflation derivatives became the main source of inflation liability hedging; however, the significant increase in gilt linker supply from 2009 saw focus revert to inflation-linked bonds. Even with the government's increased issuance, the market remains far too small to address the liabilities completely. Fundamentally, there remain notably more RPI-linked liabilities in the UK than available assets. The Pension Protection Fund (PPF) survey of 7,800 pension schemes showed estimated private sector pension liabilities to be £1,603.2bn as of December 2018. The PPF liability measure is more conservative than most schemes report in their accounts with measurement based on nominal and inflation-linked gilt curves. However, there are few new inflation liabilities effectively accruing in the private sector, given scheme closures and most remaining exposures being capped at 2.5%.

FIGURE 6

The changing face of pension indexation legislation

Measure announced	Effective	Change(s)
Social Security Act 1986	6 April 1988	Guaranteed minimum pensions for contracted-out service required to have 3% LPI.
Pensions Act 1995	6 April 1997	Statutory indexation introduced, capped at 5% RPI.
Pensions Act 2004	6 April 2005	Minimum RPI cap reduced to 2.5%.
8 July 2010	January 2011	CPI used for uprating most benefits and public sector as well as for revaluation order under Pensions Act 1993.
16 June 2011		Government response to impact of using CPI as measure of price increases on private sector pensions schemes rules out overriding scheme rules stipulating specific RPI accrual.
Budget 2014		Requirement for defined contribution pensioners to purchase annuity removed.

Source: HM Government, Barclays Research

As recently as 2003, insurers and pension funds owned over 90% of all gilt linkers, but their share of the total market has fallen steadily since as the size of the market has increased. Demand from insurers stems mostly from life insurers who are matching real annuity obligations and, increasingly, pension fund obligations that have been bought out (ie, the risk of pension funds has been transferred to the insurer). When a scheme is bought out, the purchaser tries to immunise as much risk as possible, typically with a much higher asset allocation into inflation than before the liabilities are transferred. Buy-out demand was probably the largest single source of end-user demand in the linker market in 2008, whereas in 2009 a more important driver appeared to be the significant number of very large pension schemes that were closing further accruals to existing members. When schemes close, they often also choose to de-risk, particularly if closure also involves a cash injection from its sponsor, as the uncertainty of their future liabilities is reduced considerably without active members.

UK linkers faced a demand shock in July 2010 following a surprise announcement that the government intended to switch the reference inflation measure for statutory pension indexation from RPI to CPI. This left significant uncertainty regarding the nature of existing liabilities, as there was concern that all RPI-based liabilities might be transformed to CPI, rather than just those indexed to the 'statutory minimum'. Following a Department of Work and Pensions (DWP) consultation on the matter, the government announced in its response to the consultation in June 2011 that it would not offer overrides to schemes explicitly referencing RPI indexation, thus removing the layer of uncertainty. A DWP survey of defined benefit schemes, published in 2011, estimated that 72% of schemes referenced RPI explicitly for indexation purposes, but that for revaluation 61% referenced CPI. This means that the majority of schemes will pay out benefits uprated by RPI subject to any caps or floors upon retirement of individuals, but that most benefits will accrue indexed to CPI prior to retirement upon leaving service. This presents something of a conundrum for some schemes in hedging their liabilities, but without a viable CPI inflation market, hedging will likely take place with RPI instruments for now. The government announced it would not issue CPI linkers in fiscal year 2012-13, due in part to the uncertainty about the status of CPI with regard to changes such as the inclusion of owner-occupied housing, but it may reconsider potential issuance in the future.

Traditionally, most linkers have been held versus an index benchmark rather than directly matching liabilities, but the percentage of the market held this way has fallen steadily as investors have increasingly moved to liability-driven investment (LDI) strategies, even in bond portfolios. Over-5y indices are more widely used than all linker indices; it is no coincidence that the yield on the FTSE over-5y gilt linker index used to be the reference for minimum funding requirement (MFR) liability measurement. Thus, when a bond drops below five years, there can be significant dislocation to the market, with the bond seeing forced selling, but bonds remaining in the index are likely to be supported due to an extension of index duration.

Pension regulation encourages recognition of the nature of pension liabilities and has been a major factor behind increased inflation-linked demand since the 1990s. However, unlike the MFR, regulation in recent years has surprisingly not prescribed how pension funds should address their exposures. There is no longer a generally accepted discount curve dominating all others. This is likely to have encouraged the use of swaps, which are likely to be closer than gilt linkers to the FRS17/IAS19 accounting definition. Buy-outs are typically priced off a gilt linker curve, with insurers tending to have more regulatory flexibility if their base investment is in gilt linkers rather than swaps. Neither the Pensions Regulator nor the Pension Protection Fund actively push schemes backed by strong sponsors towards lower-risk or liability-driven solutions. The Pensions Regulator has pushed for pension schemes to be safeguarded when firms are taken over by lower-rated or foreign entities, which has led to significant capital injections into pension funds, but a scheme's trustees decide whether to use this injected money to immunise risks. The Pension Protection Fund does oversee risk reduction by schemes that are in assessment for being taken over by the Fund, but it is not prescriptive beyond this universe, even though its Section 179 liability estimate is referenced off the gilt linker curve. When schemes are significantly in deficit and scheme sponsors are cash rich, this can encourage cash injections to shore up scheme funding. This is typically followed by de-risking activity, which can encourage price-insensitive demand for linkers.

Mechanics of UK linkers

While new issuance is in Canadian-style linkers and most of the stock of UK linkers is now in new-style issues, there are still many old-style bonds. The new-style issues have a virtually identical framework to US TIPS, with the exception that they have no deflation floor (ie. they can be redeemed below par if RPI falls over the lifetime of the bond), consistent with old-style linkers. The mechanics of new-style linkers are addressed earlier in this guide, but calculations for old-style linkers are more complex and are set out below.

Instead of trading in real space, with a real price and with settlement amounts adjusted to reflect the inflation experienced over the life of the bond, old-style linkers trade in clean price cash terms (not real), with the traded price including inflation that has occurred. An example of the difference in price evolution between the old-style 2.5% IL Jul '24 and the new-style 0.125% IL Mar '24 is shown in Figure 7. In a positive inflation environment, the clean price of the old-style linker tends to drift higher; linkers first issued in the 1980s now trade with prices above £300 in some cases. Since the price of an old-style linker already includes accrued inflation, no index ratio is used to create the settlement price, unlike for new-style linkers, and accrued interest is calculated on the cash value of the coupon and paid on an actual/actual basis.

FIGURE 7

Example of difference in pricing styles between old-style and new-style linkers

Linker	Clean price	Index ratio	Accrued interest	Dirty price
UKTI 0.125% Mar '24 (new-style)	111.77	1.17388	0.04	131.25
UKTI 2.5% Jul '24 (old-style)	362.20	N/A	0.12	362.32

Note: As of the close on 22 January 2019, settling 23 January 2019. Source: Barclays Research

To trade in nominal space, it is necessary to know the inflated value of the next coupon so that accrued interest can be calculated. As a result, the inflation indexation for the coupon of an old-style linker is done with an eight-month lag (a coupon's cash value will need to be known six months before it is due, and it takes some time to gather and publish the price information for the final month). Accrued interest is then calculated in the usual way for gilts but using the known inflated value.

For example, the eight-month lag means that the principal value of the UKTI 2.5% July 2016, issued in January 1983 and redeeming in July 2016 will be uplifted by the ratio of the RPI for November 2015 versus May 1982. So, investors "gain" the inflation for the eight months prior to the bond's issue, but "lose" the inflation for eight months prior to the bond's maturity. This term mismatch is not especially large in a benign inflation era, but history shows that, at times, the effect has been large on the realised return.

Using this methodology, the cash value of semi-annual coupons for old-style linkers are calculated as follows:

Coupon paid = $$\left(\frac{C}{2}\right)\left(\frac{RPI_{m-8}}{RPI_{i-8}}\right)$$

Where: *C* is the quoted annual coupon

RPIt is the RPI for month t

m is the payment month

i is issue month

Similarly, the cash value of the redemption amount is:

Redemption value = $$100\left(\frac{RPI_{r-8}}{RPI_{i-8}}\right)$$

Where: *r* is the redemption month.

Therefore, to calculate the settlement amount for an old-style linker, we simply add the accrued interest to the clean price (which already includes uplifted inflation).

A few extra stages are required to find the real yield corresponding to the quoted nominal price of the old-style linker. To calculate the real yield for a linker with a nominal pricing convention, a model for the future value of the nominal cash flows is required. These are defined by future RPI prints; as such, the future nominal cash flows are unknown as future inflation is inherently uncertain. For analysis of Canadian-style linkers, this is irrelevant because they are quoted at a real price, which is translated into a real yield by using the same calculations as for a nominal bond. The price is then uplifted for inflation already accrued at settlement. For old-style linkers, the convention is to apply a fixed inflation assumption to determine the future nominal value of the bond cash flows. It is then relatively straightforward to calculate the money yield, or nominal yield of the bond.

To arrive at the nominal yield or "money yield", it is assumed that the RPI grows at a fixed rate beyond the most recently published RPI print. By convention, this assumption has been 3% per annum since the mid-1990s (prior to this, it was 5% and, originally, 10%).

Therefore, an unknown RPI for month *t* is given by:

$$RPI_t = RPI_{t-1}(1+f)^{\frac{1}{12}}$$

Where *f* is the RPI assumption (in this case, 3%).

Using this RPI assumption, the coupon payments and redemption value of an old-style linker are then mapped out according to the assumed future path of RPI this creates. From these cash flows, the internal rate of return, or "money yield", is then calculated for any given dirty price in the same way as the internal rate of return for a nominal bond.

DMO's Real Yield Formula

The DMO's "*Formulae for calculating gilt prices from yields*", 16 March 2005 update, gives a closed solution real yield formula. It also highlights the detail of Canadian-style linker calculations. The yield formula, expressed algebraically, is daunting, while a practical spreadsheet calculation is less so.

The real yield formula covers traditional bonds with two or more cash flows left (when there is only one coupon remaining, the bond has known nominal value and, hence, is best valued using a money market yield). The term "quasi-coupon date" is the theoretical cash flow date determined by the redemption date; weekends and holidays may mean true payment dates differ.

We have reproduced formulae and trimmed and altered the wording of explanatory notes. Readers should refer to the above official publication to see complete details.

$$P = \left[d_1 + d_2(uw) + \frac{acw^2}{2(1-w)}(1-w^{n-1}) \right] (uw)^{\frac{r}{s}} + 100au^{\frac{r}{s}} w^{\frac{r}{s}+n}, \text{ for } \quad n \geq 1$$

Where:

P = The "dirty" price (ie, including accrued) per £100 face.

d_1 = Cash flow due on the next quasi-coupon date per £100 face.

d_2 = Cash flow due on the next but one quasi-coupon date per £100 face.

c = (Real) coupon per £100 face.

r = Number of days from settlement date to next quasi-coupon date.

s = Number of days in coupon run containing settlement date.

g = Semi-annual real yield.

$$w = \frac{1}{1+\frac{g}{2}}$$

f = Assumed inflation rate (3% is the current convention).

$$u = \left(\frac{1}{1+f}\right)^{\frac{1}{2}} = \left(\frac{1}{1.03}\right)^{\frac{1}{2}}$$

n = Number of coupon periods from next quasi-coupon date to redemption.

$RPIB$ = The Base RPI for the bond – ie, for the month eight months prior to issue date.

$RPIL$ = Latest published RPI.

k = Number of months from the month whose RPI determines the next coupon to the month of the latest RPI.

$$a = \frac{RPIL}{RPIB} u^{\frac{2k}{12}}$$

Once the "money yield" is found, the inflation assumption is then removed to give the "real yield" by using the following calculation, which is the convention:

$$\left(1+\frac{g}{2}\right)^2 = \frac{\left(1+\frac{y}{2}\right)^2}{(1+f)}$$

Where g is the real yield, y is the money yield and f is the RPI assumption.

Old-style linkers in practical terms

Beyond liquidity issues, the greatest source of confusion for old-styles comes from the different inflation carry model from new-style linkers. New-style, Canadian model linkers accrete inflation daily with the standard 3m interpolated lag. However, for old-style linkers, each time an RPI inflation print is released, it replaces one month of the 3% inflation assumption with the actual value. As can be seen in the box above, the pricing formula for old-style linkers references the latest known RPI print. Given that old-style linkers are priced in nominal terms, the linker market tends to anticipate imminent RPI prints and adjust accordingly; typically, the consensus forecast for the forthcoming RPI print is used as a reference. Accordingly, if RPI prints in line with consensus, then, all else equal, the price of the linker is unlikely to change. However, the pricing model for old-style bonds means that the real yield will mechanically adjust depending on the degree to which the m/m realised inflation print differs from the 3% annual (0.247% m/m) assumed inflation schedule.

In the formula above, the 'a' term is proportional to the latest known RPI, and the 'u' term inversely proportional to the real yield. Thus, if m/m inflation is firmer than 0.247%, then the real yield mechanically moves higher, making the bond appear cheaper. This is counterintuitive at first given that one might expect real yields to richen on 'high' inflation prints as a consequence of greater demand for inflation protection. If inflation prints higher than consensus, real yields often rise less than the mechanical adjustment motivates – ie. the bond richens in price, thus mitigating the optical yield effect. An alternative interpretation of the apparent cheapening on a firmer m/m inflation print than implied by the inflation assumption is that this is equivalent to inflation carry. Thus, the instantaneous forward yield is higher than the previous spot yield, and positive carry is accrued. On an inflation print less than 0.247% m/m, a negative mechanical adjustment is applied to the yield such that it falls. In our experience, the mechanical adjustment causes more confusion than it ought and is simply a consequence of the arcane format of the real yield model. Figure 8 presents an example of mechanical adjustment.

FIGURE 8

Sample mechanical real yield adjustments on old-style linkers for an RPI print

Projected RPI (December 2018)			Real yield adjustment on 16 January 2019 (bp)			
Index value	**m/m**	**y/y**	**IL20**	**IL24**	**IL30**	**IL35**
285.1	0.18%	2.52%	-5.6	-1.3	-0.7	-0.5
285.2	0.21%	2.55%	-2.8	-0.7	-0.3	-0.2
285.3	0.25%	2.59%	-0.1	0.0	0.0	0.0
285.4	0.28%	2.62%	2.7	0.7	0.3	0.2
285.5	0.32%	2.66%	5.5	1.3	0.7	0.5
285.6	0.35%	2.70%	8.3	2.0	1.0	0.7
285.7	0.39%	2.73%	11.1	2.6	1.4	1.0
285.8	0.42%	2.77%	13.9	3.3	1.7	1.2
285.9	0.46%	2.80%	16.7	3.9	2.1	1.4
286.0	0.49%	2.84%	19.5	4.6	2.4	1.7
286.1	0.53%	2.88%	22.2	5.2	2.8	1.9

Note: Example uses projection for December 2018 RPI print, which printed 285.6. Source: Barclays Research

In this example, December RPI printed 285.6, or 0.35% m/m, higher than the 0.247% m/m inflation assumption embedded in the pricing formula. Hence, real yields on old-style linkers mechanically adjusted upwards immediately after the RPI release by the amount of the difference between the actual data and the assumption. As Figure 8 shows, this equated to a mechanical cheapening of the IL20 real yield by 8.3bp. Because indexation is a price effect, the yield adjustment applied is inversely proportional to the modified duration of the bond and is thus greatest for shorter-dated linkers. As old-style linkers become short in maturity, the monthly adjustment obfuscates the information content of 8m lag linker real yields and breakevens and value is better assessed in an alternate way. It is fairly straightforward to evaluate the implied total return for a short linker for any given percentage change in the RPI over the remainder of the bond's indexed life at the current price, which can then be compared with either a short-dated gilt or other swap-based rate to assess value.

We recommend a z-spread asset swap comparison for micro valuations of old- and new-style gilt linkers because this measures the inflation elements versus a consistent curve. A more straightforward, but less complete, method is to compare the yield of traditional linkers with that of new-style linkers forward to the end of their known carry period because this leaves the same known inflation data in the pricing of both bonds. While this is an appropriate, simple method to compare moves in real yields and breakeven, the distortions due to the embedded 3% assumption in 8m lag linkers do not make the spreads between bonds using this approach representative, especially at shorter maturities.

Corporate UK linkers

At the end of 2013, the market value of non-government bonds in the Barclays Sterling Linker Index was almost £32bn. However, non-government inflation-linked issuance has been very limited in recent years following the reclassification of Network Rail as a public sector body on 1 September 2014, which previously was the main issuer of such paper. This contrasts sharply with 2005-07, which saw almost as much corporate inflation-linked bond issuance as in gilt linkers. However, most new corporate linkers were not bought by bond investors and, hence, were not eligible for inclusion in the Barclays Sterling Inflation-Linked Index. By the end of 2007, there were about £20bn of corporate inflation-linked bonds that had been monoline-wrapped to transform them into AAA issues based on utility, Private Finance Initiative (PFI) and infrastructure projects. Of those issued between 2005 and 2007, the vast majority had been absorbed by asset swap investors, particularly covered bond investors, who provided for the inflation swap needs of pension funds by translating these into real rate swap paying flow. However, as AAA insurers themselves lost their ratings, this demand effectively ended.

Network Rail was an important issuer of RPI-linked bonds and was the largest single source of non-government supply from 2007-2014. Network Rail had been unusual in conducting much of its real rate funding on a programmatic basis, launching benchmark issues at 20y, 30y and 40y in 2007 but further issuance under the Network Rail name seems highly unlikely following its reclassification as a public sector body. Most other issuance has been very small scale in recent years (usually <100mn) and predominantly 'reverse inquiry' or for project finance. Examples of bonds can be found related to student accommodation, solar panels as well as utility and infrastructure issuance (eg. Heathrow Airport). Social housing rents are now CPI-indexed, so this presents a source of CPI-linked supply. Additionally, proposed redefinition of utilities indexation in the long run could also result in some supply of CPI(H) exposure to the market.

Realistically, inflation-linked issuance is logical for corporates if the breakeven rate achieved is high enough to represent cost-effective funding versus nominals. Yet, despite the improvements in the credit markets, the overhang of old monoline wrapped supply may limit the scope for corporate linker supply from utilities. The largest single utility issuer in corporate linkers is National Grid Plc, which has electricity and gas prices linked to RPI. With the overhang of positioning limiting potential issuance to institutional investors, National Grid Plc sold a 10y bond in October 2011 focused specifically on retail investors, albeit in a standard Canadian-style format, with its size eventually exceeding £280mn, the largest non-government-related issue since 2007.

PFI-related deals were another source of non-gilt issuance. PFI deals involve a private company building infrastructure and being paid an income stream until the asset comes under the ownership of the relevant authority. Most hospital-related projects involve RPI-linked cash flows that will be paid to the financier once the hospital is operational, making them ideally suited to funding via inflation-linked issuance. Thus, this kind of issuer has been numerous, although other large PFI projects have also involved partial inflation-linked financing. Almost all of these issues were wrapped with credit guarantees to enable AAA ratings, and, as with utility supply, most ended up with asset-swap investors. Due to specific accounting restrictions, PFIs almost always issue bonds rather than paying swaps. In duration terms, PFI financing has been a less important factor than utilities in recent years since most, particularly hospital, bonds are amortising either immediately or after a number of years in which the building project is expected to be complete and the offsetting of cash flows begins. Hence, while many utility linkers have durations above 30, it was rare for those of PFI bonds to be much longer than 15 years.

UK inflation derivatives

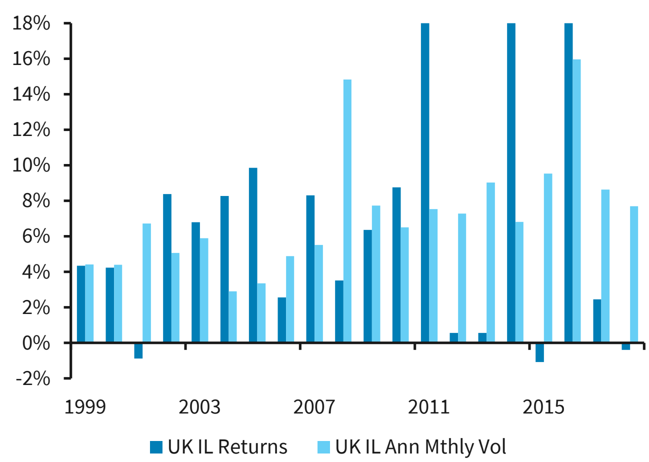
While RPI swaps have been traded since at least 1994, prior to 2005 the derivatives market was fairly niche compared to the euro area, comprising a limited subset of active participants looking to match pension demand and corporate supply. Often the market served to help facilitate reasonably large, but infrequent, long-end flows. UK inflation swaps saw notably more inflation duration traded than any other market between late 2005 and early 2008, as the launch of the IL55 in September 2005 and resultant tactical asset-swap activity provided sufficient momentum for the market to become self-sustaining. However, liquidity in UK inflation swaps fell dramatically in 2008, and distortions between inflation swaps and gilt linkers became extreme as swaps were driven richer than bonds by position unwinds and an absence of inflation swap supply. Previously, the frequent asset swapping of new non-government inflation-linked paper had provided an environment in which gilt linkers did not always trade at a discount in asset swap to nominal gilts. Once leveraged investors ceased supplying non-government inflation-linked flows via asset swaps of wrapped corporate inflation-linked issuance while pension demand for swaps continued, the market gradually became unbalanced.

The absence of asset swap paying flow led to significant distortions between inflation bonds and swaps, with gilt linker asset swaps becoming much cheaper than nominals in Q4 08 and long forward real rates pushing into negative territory. Many of these distortions corrected significantly, and the inflation swap and gilt linker markets still interact via asset swap activity, now concentrated in gilt linkers. The level of linker asset swaps fell in 2009 from the extremes reached in Q4 08 as pension funds and life insurers who had already immunised inflation and duration were significant buyers of gilt linkers on asset swap. This flow accelerated as relative z-spreads gapped wider versus nominal gilt asset swaps in March 2009 on the announcement of BoE gilt purchases. Hence, despite quantitative easing deliberately not focusing on linkers to avoid falling real yields, causing problems for the pensions sector, linker yields were actually affected significantly. This has also been the case in the round of QE conducted by the BoE from October 2011, during which real yields turned negative at every maturity across the curve.

While the underlying liquidity of the inflation swap market recovered significantly in 2009, it is was no longer consistently superior to inflation-linked bonds for many years after. The introduction of clearing helped encourage a broader range of tactical participants. While the most common format of inflation swap in the UK market remains zero-coupon RPI swaps, real-rate RPI swaps can also trade directly, both zero coupon and in a par-swap format, providing a consistent comparison with nominal swaps. The standard initial lag for almost all swap transactions other than asset swaps is a two-month calendar lag. While domestic pension funds provide the main source of demand for RPI swaps, they are also traded by a variety of other leveraged and real-money investors. Forward trading in inflation and real-rate swaps is present, even at long maturities, and to some extent, this aids liquidity and helps reduce relative value distortions across the curve. It is also possible, albeit rare, to see trading in forward swaps versus other markets. Dealers also offer screens for CPI swaps and exposure does trade, but the market is unlikely to achieve critical mass until the UK Government issues non-RPI linked bonds.

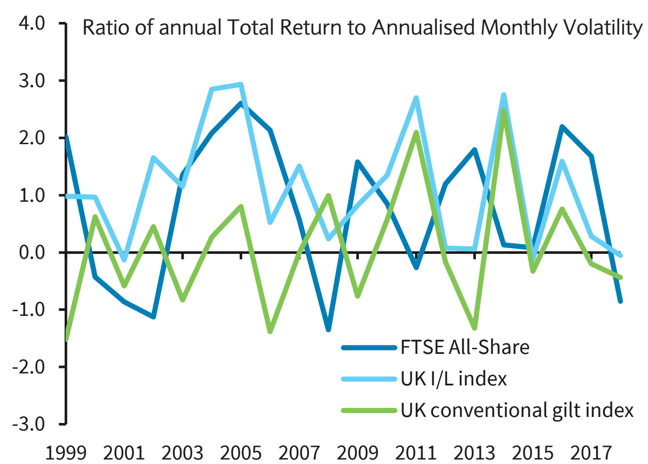
Inflation vol markets have been notably less active in the UK than in the US and Europe. A lack of deflation floors in gilt linkers means that zero coupon floors are not readily supplied to the market via asset swap activity, unlike in US and euro inflation markets. Activity in UK inflation options is predominantly in Limited Price Indexation (LPI) swaps, though activity in y/y floors has picked up in recent years, particularly to hedge bank products. LPI historically has been the dominant form of pension inflation indexation, which entails paying RPI inflation but with a cap and a floor. LPI[0,5] is the most common structure traded as the largest number of pension liabilities have this exposure. Prior to the switch of statutory minimum indexation to CPI, LPI[0,2.5] was the legal minimum indexation, but as RPI has tended to be higher than 2.5% y/y, there has been little incentive for schemes to hedge this exposure. To date, there has been no activity in CPI-based limited price indexation (LCPI), and nor is there likely to be without an active CPI swap market, but given the legislative change, LCPI[0,2.5] liabilities are now widespread.

FIGURE 9
UK linkers: historical returns and volatility



Source: Bloomberg, Barclays Research

FIGURE 10
Volatility adjusted UK asset returns



Source: Bloomberg, Barclays Research

INFLATION MARKETS

Japan

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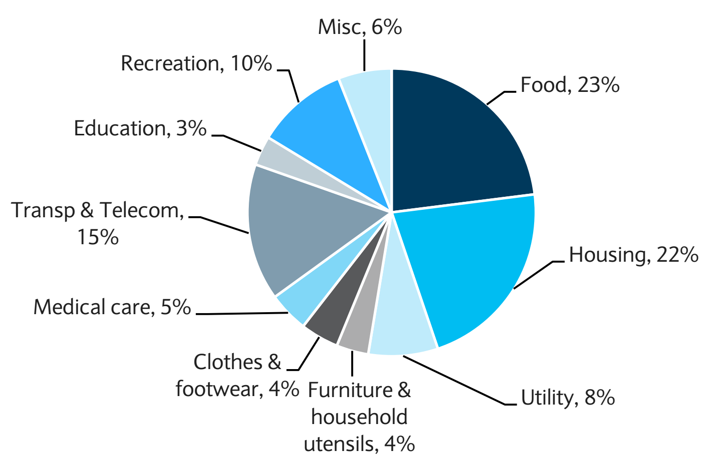
Issuance of JGBi, which was suspended in 2008 amid the GFC, resumed in 2013 with the launch of a new "floored" product. While this new JGBi initially drew firm investor demand, supported by a pick-up in inflation, breakevens have been capped around 60bp since 2016 due to a lack of progress on achieving inflation of 2%, despite large-scale GPIF investments, BoJ buying operations, and MoF buybacks.

The Japanese CPI: Technical overview

Inflation-linked Japanese government bonds, the few corporate linkers issued so far, and JPY inflation swaps all reference the non-seasonally adjusted consumer price index excluding perishable food items, such as fresh fish, vegetables, and fruits (Bloomberg ticker: JCPNJGBI <Index>). Perishables are excluded due to their very high volatility, but energy prices are included. The index is commonly referred to as the "core CPI" and is released monthly by the Ministry of Internal Affairs and Communications (MIC) Statistics Bureau. The nationwide index covering the previous month is released at 8:30am on Friday of the week including the 19th of each month; a preliminary mid-month index for Tokyo is released at 8:30am on Friday of the week including the 26th of each month.

The CPI indices currently cover over 580 items that account for at least 1/10,000 of the total consumption expenditure of Japanese households (including imputed rent in goods and services). The prices of items used in calculating the consumer price index are, in principle, the retail prices for each item in the various municipalities nationwide, according to retail price data. Japan's CPI broadly conforms to the international standards regarding consumer price indices set by the International Labour Organization (ILO). The basic 10 categories have been standardized globally, but there are differences in their respective weights by country. The breakdown of the Japanese core CPI is shown in Figure 1.

FIGURE 1
Major items in the Japanese core CPI (2015-base index)



Source: Ministry of Internal Affairs and Communications (MIC), Barclays Research

The Japanese CPI is calculated based on the Laspeyres method, which compares the prices of goods and services according to their weights at the time of the base year (currently 2015) with the y/y change in those figures. Under the Laspeyres price index, the weight (quantity) of various goods and services is fixed at the base year. Accordingly, goods that have undergone steep price drops in recent years, such as IT goods, do not reflect any increases in real volume accompanying such price drops (for the calculation of the price index for such items, the MIC uses the Hedonic adjustment method based on the correlation between the price of products and their performance derived from available sales data).

Goods undergoing price increases, on the other hand, tend to be overestimated in the calculation because there is an increasing effect due to the fixed weightings. As a result, the Laspeyres method tends to show an upward bias, which increases the further one moves away from the base year. To address this issue, from January 2007, the MIC began to release CPI numbers based on the chain-weighted calculation method as a supplement to the fixed-weight CPI, where weights are adjusted each year to reflect changes in spending patterns.

Meanwhile, base revisions to the index are conducted once every five years for years ending in "5" and "0". The last such adjustment took place on August 2016, when the CPI data were rebased to the year 2015 (ie, the July 2016 nationwide CPI adopted the year 2015 as a base, and 2015-based data were made available retroactively from January 2015). At this last rebasing, the overall effect on the CPI was estimated to be nearly zero, and hence the effect on JGBi was also limited. Further details on the Japanese CPI in English are available from the MIC Statistics Bureau[1].

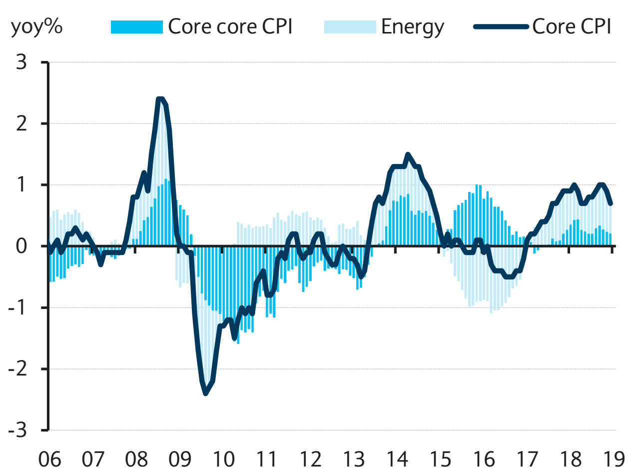
In terms of monetary policy, the BoJ is conducting quantitative and qualitative monetary easing (QQE) with a CPI price stability target of 2%. Japan's core CPI excluding VAT impact has reaccelerated to around +1% after temporarily turning negative in late 2016 due to sharp declines in oil prices. On the other hand, the core core CPI, which excludes energy prices in addition to perishables, has been depressed since late 2016, indicating a lack of sustained inflationary pressure (Figure 2).

Seasonality in CPI

Seasonality of the Japan CPI is shown in Figure 3. Prices tend to fall early in the year due to New Year's sales. After bottoming around February, they turn up and peak during the summer holiday season, when travel, leisure and other service prices rise sharply and summer bonus payments support consumption. Then, from fall to winter, they tend to decline slightly, led by service prices, while goods prices tend to stay relatively firm.

FIGURE 2

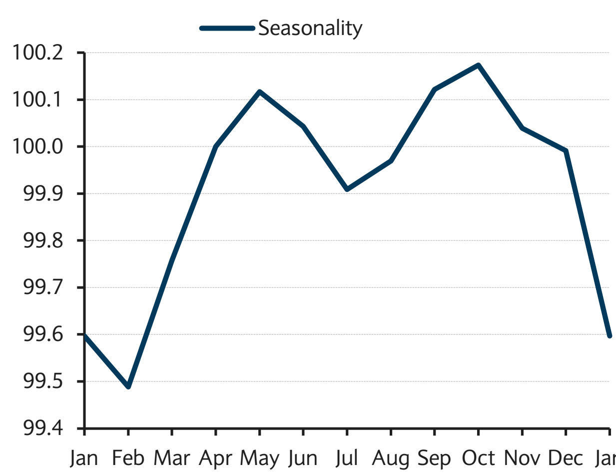
Japan's core and core core CPI



Source: MIC, Barclays Research

FIGURE 3

Japan core CPI seasonality



Source: MIC, Barclays Research

[1] See *http://www.stat.go.jp/english/data/cpi/index.htm*

Inflation-linked government bonds

JGBi issuance and JGBi market

Discussions about the possible issuance of inflation-linked government bonds in Japan kicked off in September 2002. Some market participants also voiced concern about issuing such instruments in deflationary times (spot inflation had ranged between -0.7% y/y and -0.9% y/y throughout 2002), but as deflationary pressures eased and borrowing needs remained high, a year and half later, in March 2004, Japan issued its first inflation-indexed government bond (JGBi1), with a 10y maturity and a small pilot size of JPY100bn. The bond came in at a low 15.5bp BEI (spot inflation was -0.1% y/y at the time), but shortly thereafter, market perceptions turned favourable and breakevens subsequently rallied to a high of 94bp during the same year (Figure 4).

Between 2004 and the global financial shock in 2008, the market evolved rapidly in terms of size and depth. By August 2008, the MoF had issued a total of 16 bonds, and the market size had reached almost JPY10trn (about USD96bn, or nearly 1.4% of total JGBs outstanding at the time), placing Japan ahead of other inflation-issuing countries with longer experience with the product, such as Australia and Sweden.

As the global financial shock reached its climax during September-October 2008 and JGBi BEIs sank to unprecedented levels, and the MoF cancelled two JGBi auctions planned for October 2008 and February 2009. Issuance was suspended from then until 2013, when it was resumed with a new floored product, as noted below.

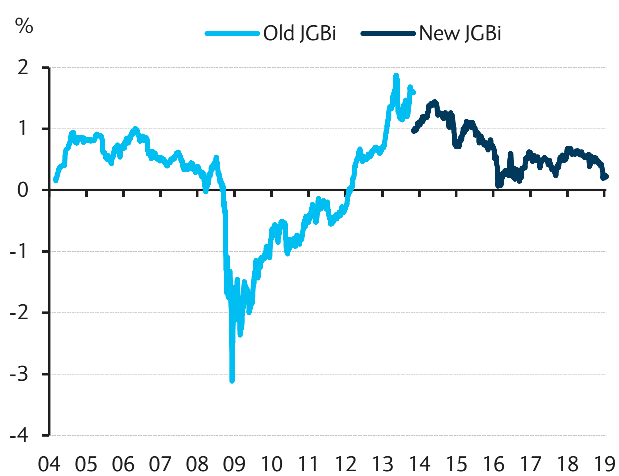
Resumption of JGBi issuance as a new floored product

After a five-year suspension from 2008, JGBi issuance resumed in October 2013 with the launch of a new product incorporating a deflation floor on the principal. In FY13, the MoF started by issuing JPY300bn each in October 2013 and January 2014. The outstanding amount of new JGBi has steadily grown since then as old JGBi were redeemed through 2016 (Figure 5). Under FY19 plans, the MoF is scheduled to issue JPY400bn each in April, August, and October 2019 and in February 2020, unchanged from the previous fiscal year.

JGBi are issued via Dutch-style price-competitive auctions (0.05 yen bidding scale). New issues are auctioned in April and re-openings are held for the rest of the auctions. The coupons, announced in the morning on auction days, are determined based on market

FIGURE 4

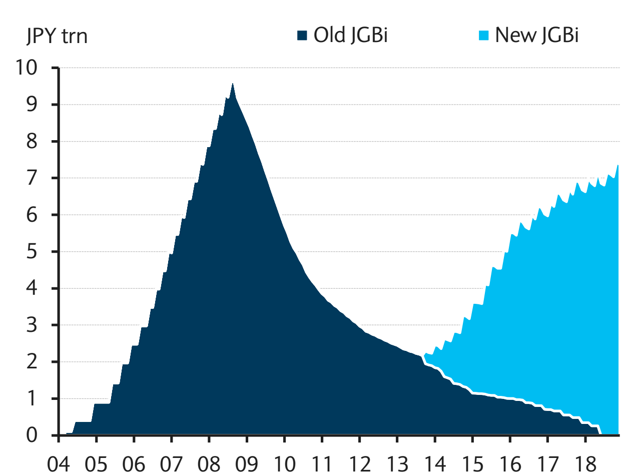
History of on-the-run JGBi BEI (March 2004-current)



Source: Barclays Research

FIGURE 5

Outstanding amount of JGBi



Source: MoF, BoJ, Barclays Research

yields with a floor of 0.1%. New issues have carried a coupon of 0.1% given persistently negative real yields. The JGBi auctions conducted since the resumption of issuance went smoothly at first, supported by strengthening inflation, but demand began to fade from 2015 as inflationary pressures gradually waned along with declining oil prices.

Differences between old and new JGBi specifications are summarized in Figure 6.

FIGURE 6
JGBi product specifications

	Old	New
Maturity	10 years	
Type of issue	Coupon-bearing bonds	
Coupon frequency	Semiannual	
Issuance method	Public offering	Public offering
Auction method	Yield-competitive auction for reopen/ Dutch-style auction for new issues	Dutch-style price-competitive auction
Reference Index	Japan nationwide CPI ex-fresh food (Japan Core CPI)	
Reference Index digit	3rd digit	5th digit from JGBi21
Reference Index frequency	Monthly	
Reference Index seasonality adjustment	No seasonal adjustment	
Indexation lag	3 months	
Indexation style	Canadian Model (linear interpolation to the 10th of the month)	
Floor	No floor	With floor
Transfer restriction	Corporates cannot hold JGBi	

Source: MoF

MoF buyback and BoJ purchase

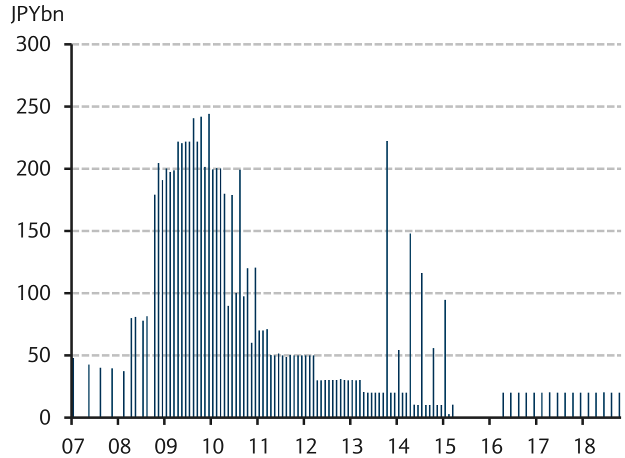
JGBi became eligible for MoF buyback operations in January 2007. Until April 2008, the MoF held five buybacks, on each occasion retiring a modest JPY40-50bn worth of linkers. From April 2008, the Ministry stepped up its JGBi buybacks to JPY80bn in response to the sudden decline in linker prices around March (the on-the-run 10y linker's BEI briefly touched -2bp, when deleveraging by investors distorted many asset prices.

Subsequently, after BEI dropped sharply due to the 2008 financial crisis, MoF increased the size and frequency of buybacks. The precise buyback amounts have been determined on a quarterly basis, with the choice between linkers, floating-rate JGBs, or fixed-coupon JGBs made following MoF meeting with the primary dealers; since October 2008, the weight has been placed on linkers, rather than floating-rate or regular JGBs. In March 2016, buybacks of floating-rate JGBs ended, while buybacks of JGBi, which were suspended in March 2015, resumed from April 2016 with the MoF buying the new JGBi in amounts of JPY20bn every two months (Figure 7).

Since the launch of the new JGBi in 2013, the MoF has bought back old JGBi through the traditional method in months when there are no new auctions and conducted switch auctions for the old and new JGBi when there are new auctions. In March 2015, the buying of old JGBi through switch auctions came to an end. From April 2016, MoF resumed buybacks of new JGBi. BoJ buying operations continue to be conducted as usual with new issues eligible for purchase.

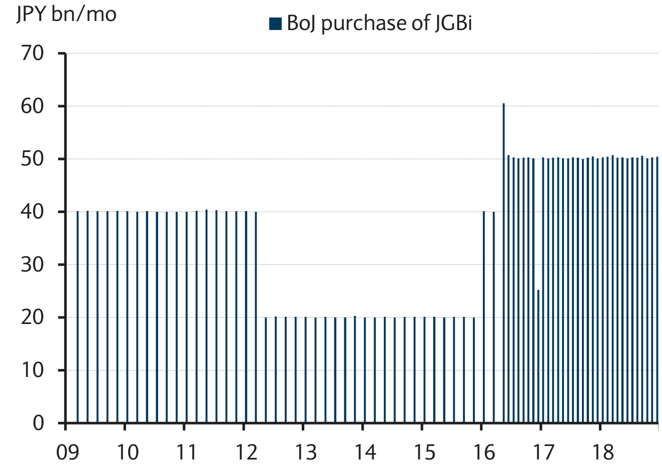
In addition to MoF buybacks, JGBi also became eligible for BoJ outright purchase (*rinban*) operations from the end of 2008. As of January 2019, the BoJ buys JPY50bn/month (or makes two purchases of JPY25bn each per month) of JGBi from dealers in an auction format

FIGURE 7
MoF's monthly JGBi buyback amount



Source: MoF, Barclays Research

FIGURE 8
BoJ's monthly JGBi purchase amount



Source: BoJ, Barclays Research

(Figure 8). At the end of 2018, the BoJ's total JGBi holdings amounted to JPY1.80trn. The BoJ purchases and MoF buybacks absorbs about a quarter of the outstanding issuance, as shown in Figure 9.

GPIF participation

As part of public pension reforms under the Abe administration, the GPIF began to buy JGBi in FY14, at the pace of JPY400bn per annum, which appears insufficient to hedge inflation risk given its enormous portfolio size of over JPY150trn. We expect the GPIF to continue its massive buying of JGBi although the market impact of their purchases, which largely occur at auctions on corresponding issuance and are limited in secondary market, is likely small.

While the floored new JGBi face less risk of a market crash seen during GFC for the un-floored old JGBi, a lack of growth in size and breadth of structural demand from domestic real money accounts has been the persistent problem behind JGBi market illiquidity, for both old and new JGBi. A lack of secondary market liquidity has been commonly cited by market participants at the MoF's investor meetings as the key reason behind their request for continued MoF buyback.

FIGURE 9
JGBi balance by issue

(JPY bn)	Maturity	Coupon	Issuance	MoF buybacks	BoJ holdings	MoF+BoJ	Mkt Outstanding*	
JGBi17	9/10/23	0.1	646.7	22.0	234.5	256.5	390.2	60.3%
JGBi18	3/10/24	0.1	821.7	19.6	159.2	178.8	642.9	78.2%
JGBi19	9/10/24	0.1	1,091.8	8.7	114.3	123.0	968.8	88.7%
JGBi20	3/10/25	0.1	2,139.4	59.0	326.0	385.0	1,754.4	82.0%
JGBi21	3/10/26	0.1	1,727.2	92.6	332.7	425.3	1,301.9	75.4%
JGBi22	3/10/27	0.1	1,760.4	83.3	510.0	593.3	1,167.1	66.3%
JGBi23	3/10/28	0.1	1,300.9	35.8	123.0	158.8	1,142.1	87.8%
Total			**9,488.1**	**321.0**	**1,799.7**	**2,120.7**	**7,367.4**	**77.6%**

Note: as of 31 December 2018. Source: MoF, BoJ, Barclays Research

Consumption tax hike and offsetting measures

The consumption tax (VAT) rate is scheduled to be hiked to 10% from 8% in October 2019, after PM Abe delayed its timing in June 2016 from its earlier schedule of April 2017. The risk of another delay cannot be completely discounted depending on the state of Japan's political economy.

While we estimate that the VAT hike would boost core CPI inflation by 1.7pp, assuming a pass-through rate of 83.5%, various offsetting measures are set to amplify the noise in CPI data around this tax hike. Such measures include exemptions from the hike for certain daily necessities (-0.3pp), free education policies at the preschool/higher education levels (-0.6pp), and cuts to mobile phone fees at the request of the government (-0.2pp). Excluding the impact of both the VAT hike and other special factors, we think the core CPI is likely to trend around +0.5-1.0% in 2019.

Indexation features and calculations

The JGBi inflation indexation mechanism follows the Canadian style adopted by most developed inflation markets. That is, within a given month, the rate of inflation accrual is constant at the rate of month-on-month inflation between the inflation index three and two months previously.

However, there is one notable difference: JGBi inflation accrual is based on the tenth of the month (rather than the first), due to the relatively late release of inflation data each month, which would otherwise cause uncertainty at the end of some months. JGBi principal and coupons accrue based on the ratio of the Daily Reference CPI (DRI) value to the Base Reference Index (base CPI) at issuance (this number obviously does not change throughout the life of the bond, although rebasing the CPI every five years requires additional adjustments to link the old and new indices). This ratio is referred to as the "CPI ratio," or "inflation ratio."

The official calculation formula for the daily reference CPI and the CPI ratio is illustrated below.

First, the daily reference CPI (DRI) for day N in month M is:

1. If N = 10, the reference CPI is the index three months previously, ie, CPIM-3
2. If N > 10, the reference CPI is:

$$\mathbf{DRI} = \mathbf{CPI}_{M\text{-}3} + (\mathbf{CPI}_{M\text{-}2} - \mathbf{CPI}_{M\text{-}3}) \times \frac{\textbf{(N-10)}}{\textbf{No. of days from 11th of month M to 10th of month M+1}}$$

3. If N<10, the reference CPI is:

$$\mathbf{DRI} = \mathbf{CPI}_{M\text{-}4} + (\mathbf{CPI}_{M\text{-}3} - \mathbf{CPI}_{M\text{-}4}) \times \frac{\textbf{No. of days from 11th of month M-1 to N}}{\textbf{No. of days from 11th of month M-1 to 10th of month M}}$$

Next, the CPI ratio for any given day N is calculated as DRIN/Base CPI

An important feature of JGBi was that due to rounding conventions, inflation accrual did not develop smoothly across the month. As mentioned above, the ratio of the reference CPI on settlement to the base CPI on which the settlement price was based was rounded to only three decimal places until JGBi20 (the CPI itself is published to one decimal place, unlike other countries such as the US), in contrast to other markets where it is usually rounded to five decimal places. Because of this, carry on a 10y JGBi jumped almost 1bp when the rounded index ratio changed by 0.001, a situation not seen in other inflation markets. The number of these "carry jumps" exhibited by linkers' CPI ratio in any given month obviously depended on the magnitude of the month-on-month change in the CPI. However, starting with JGBi21, the CPI ratio was disclosed to five decimal places, as in many other countries, and the above feature disappeared.

JGBi are traded in real price terms (ie, without incorporating inflation adjustment). In the broker market, linker prices move in five-sen increments, and daily closes are also rounded to the nearest five sen. While this is not a strict rule, it is an appropriate degree of accuracy, given the approximately 10-sen jumps in nominal price terms that occur with inflation accretion. Settlement and day-count conventions applied to the nominal market are also used for JGBi (T+1 for all JGBs from 1 May 2018, ACT/365). The simple bond calculation between price and yield is used; therefore, real yields are determined by the rate that equates the traded price with the sum of the bond's cash flows discounted to present value.

Accounting and tax treatment

JGBi can be held under the "available-for-sale" category; gains or losses do not have to be immediately reflected in the income statement. Furthermore, at the end of October 2008, the Accounting Standards Board of Japan (ASBJ) allowed domestic investors to book their holdings of illiquid instruments, including floating-rate JGBs and JGBi, at theoretical value, rather than market levels. To date, many domestic investors, including large banks, have used this accounting rule for floating-rate notes, but the absence of a benchmark forward CPI curve made the theoretical valuation of inflation-linked JGBs problematic from an accounting perspective. The National Tax Agency formally clarified at the end of 2005 that JGBi interest and the gains or losses on principal would be exempt from withholding taxes if they are held by "entities entrusted to manage corporate pensions approved under the tax systems in the UK and the US, provided the bonds are held in book entry form."

Corporate and derivative markets

The corporate market in Japanese inflation-linked bonds has been limited. The only issuer of note of straight inflation accreting bonds was the Japan Finance Corporation for Municipal Enterprises (JFM), which in 2005 was able to issue JPY40bn of 10y bonds at yields well through those of matched-maturity JGBi (coupons were 0.47% on the first bond and 0.45% on the second, versus prevailing government bond real yields of 65-75bp) because it featured a deflation floor. The EIB also issued a JPY50bn accreting bond as an opportunistic swapped funding in 2004, also maturity matched to a JGBi. This bond offered a par floor that made it attractive to real money investors, despite having an aggressive principal cap at 110%, equivalent to 96bp per annum, which greatly limited upside at a time when JGBi breakevens were 85bp.

In Japan, the typical inflation derivative transaction has been the zero-coupon inflation swap. Inflation swaps are traded by investors who prefer derivatives to cash and also by dealers who hedge inflation structured products.

Since 2007, JGBi began to be traded in asset swaps, as spreads have been tighter versus Libor relative to nominal asset swap spreads of similar maturities. Prior to 2008, long-dated JGBi asset swaps were quoted at Libor-4bp to Libor-8bp, mid-market, about 12bp cheaper relative to nominal asset swaps. As has been the case in other inflation-linked bond markets, the major asset price disruptions in 2008 left JGBi exceptionally cheap on an asset swap basis, with the long end of the JGBi curve at times indicated at Libor+80bp. However, as the market's cheapness corrected gradually throughout 2009, asset swap margins normalized as well, hovering around Libor+16bp to Libor+28bp across most issues by early 2010. Old JGBi asset swaps traded extremely rich relative to new JGBi due to the rapid decline in the balance of outstanding issues as a result of switch auctions since 2013.

INFLATION MARKETS

Canada

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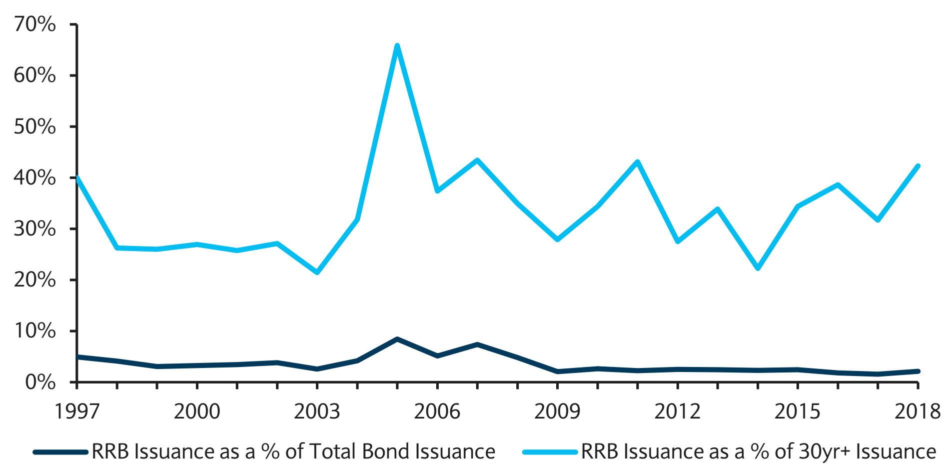
Canada first issued linkers in 1991, and its securities have been the model for most sovereign issues that have followed. As of March 2019, the market value had grown to CAD80bn, double the value from 10 years ago. Ownership remains concentrated among local participants.

Real return bonds (RRBs) were first issued by the Canadian government in December 1991, and there are currently eight issues outstanding with a weighted modified duration of 15.1 years. The initial issue, the 4.25% 2021, was a 30-year maturity and is now the shortest RRB on the curve. The Treasury had been issuing new bonds at four-year intervals: ie, the 4.25% 2026 issued in 1995, the 4% 2031 in 1999, the 3.0% 2036 in 2003 and the 2.0% 2041 in 2007. This pattern meant the initial maturity was extended by one year with each new issue. However, this pattern ended when it issued the 1.5% 2044 in May 2010 and followed with the 1.25% 2047 in 2013. The Treasury holds four RRB auctions per year, which have totalled CAD2.2bn each of the past 12 years. As of December 2018, with an adjusted principle amount of CAD62bn, RRBs made up 8.8% of total marketable Canadian government debt, 10.8% of Canadian government coupon debt and 32% of Canadian government debt with maturities longer than 10 years. In 2018, RRBs made up 2.1% of all Canadian government coupon issuance, and 42% of issuance in the long end, down from peaks of 8.4% and 66%, respectively, in 2005 (Figure 1).

FIGURE 1

RRB issuance as a percentage of Canadian government coupon issuance



Source: Bank of Canada

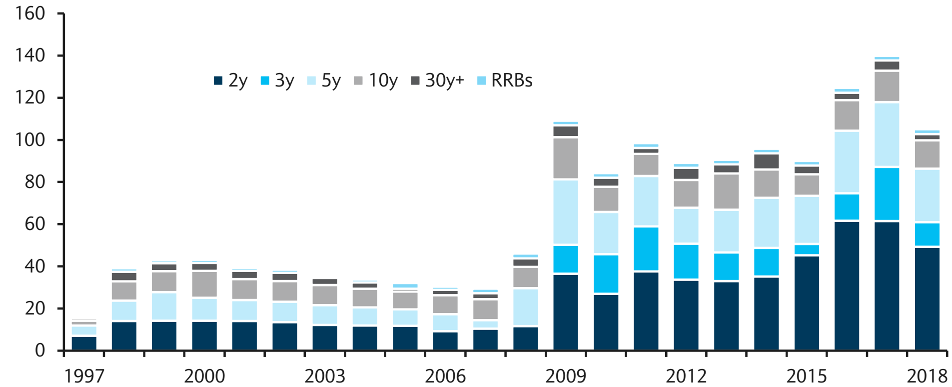
Given its maturity profile and size, the Canadian inflation-linked bond market has been largely the domain of pension funds. However, from time to time, international investors have taken advantage of real yield differentials versus other more heavily traded international markets such as the UK and US, and RRB issuance can have a valuation effect on the long end of other markets, particularly around auction time.

Because of the tendency for pension fund investing to be buy-and-hold, secondary market liquidity can be difficult to obtain. A large portion of RRBs outstanding are held as an offset to future pension liabilities, reducing the available float. Therefore, bid/offer spreads tend to be relatively wide versus much more liquid markets such as the US. Despite liquidity issues, RRBs tend to trade at general collateral levels in the repo market due to the willingness of the funds that own the bonds to lend them.

The Bank of Canada (BOC) acts on behalf of the Department of Finance to manage the financing program. The BOC currently operates under a quarterly funding schedule with one 30-year RRB auction about every three months. RRB issuance has been relatively constant despite an increase in total borrowing needs since 2008 (Figure 2). We expect the quarterly issuance to continue, as the government appears committed to using the program as a cost-effective way to diversify its investor base. At present, the BOC alternates between CAD400 and CAD700mn auction sizes in RRBs each quarter, up from CAD300-400mn before 2007.

FIGURE 2

Distribution of Canadian government coupon issuance



Source: Bank of Canada

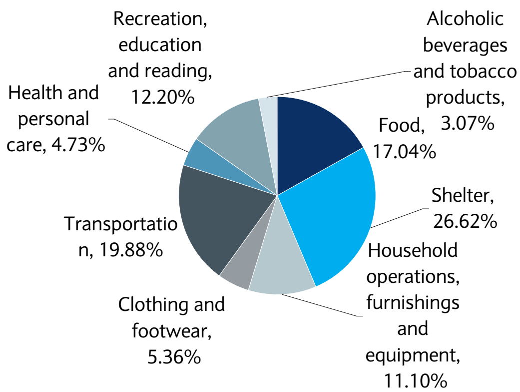
The linking index

Canadian RRBs are indexed against the Not-Seasonally-Adjusted All-Items Consumer Price Index. It includes all Canadian families and individuals living in urban or rural private households. Information on consumer expenditures is gathered through the Survey of Household Spending and the Food Expenditure Survey, which uses random samples of Canadian households. The index measures price changes using the cost of a fixed basket of commodities through time. The basket consists of about 600 goods and services including transportation, clothing, housing, food and recreation. The CPI index reflects pure price movements only because the basket includes goods and services of identical or equivalent quantity and quality over time.

The index is weighted to reflect typical spending patterns. The weights are determined based on family expenditure surveys conducted periodically. The current weights are based on the 2017 survey. As Figure 3 and Figure 4 show, the index comprises eight major components. The component with the highest weight is the shelter component, which includes owner-occupied and rented accommodation. The CPI includes only consumer items and excludes personal income taxes, consumer savings and investments. The index uses geometric means at the first-stage aggregation of collected price data, making quality adjustments where possible. The fixed basket price index is an arithmetic average of price relatives for all single commodities contained in the basket. The index attempts to capture innovations in final prices, which include any changes in the Goods and Services Tax, as well as provincial retail sales taxes.

FIGURE 3

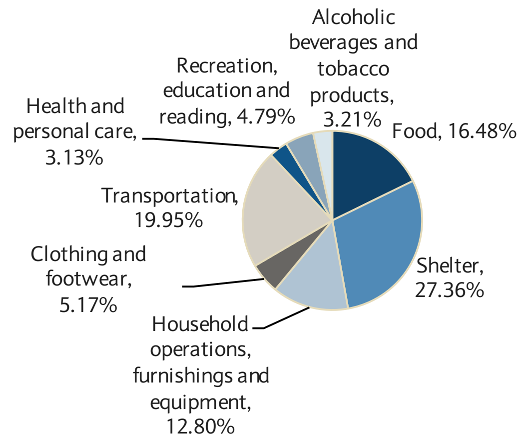
2007 CPI weights – 2005 basket at April 2007 prices



Source: Statistics Canada

FIGURE 4

2019 CPI weights – 2017 basket at December 2018 prices



Source: Statistics Canada

The Canadian model

The Canadian Treasury was an innovator, pioneering a simplified approach to the indexation of inflation for real return bonds. The change in the indexation process introduced with the first RRB was dramatic, with the inflation lag reduced to three months, from the eight months previously used by the UK. This enabled a more contemporaneous measure of inflation and allowed the market to trade in real space without an embedded inflation assumption. The crucial change in structure was the use of an index ratio to inflate principal and coupon for a given settlement date. This change eliminated the effect of real yields' changing when the inflation index is published. Old-style UK real yields vary each time there is an inflation release different from this assumption.

This new methodology became known as the "Canadian model" and has been generally followed by all subsequent major issuers, including all newly issued UK inflation-linked gilts. The change in methodology allowed for simpler valuation and has assisted in the relative value analysis of the product versus conventional bonds, as well as cross-currency real yields. The concepts of forward real yields and forward breakevens have become determining factors in the relative valuation of international markets that have adopted this calculation method.

Calculation methodology

A reference CPI value is calculated for every day based upon the CPI values for three months and two months prior to the month containing the settlement date. The reference CPI for the first of each month is the index value of three months previous. The reference CPI for any day during the month is calculated by linear interpolation. Unlike some other countries that issue based on the Canadian model, RRBs do not have a par floor on the inflation adjusted principal.

Reference CPI for day '*d*':

$$\frac{(d-1)}{m}(CPI_{t-2} - CPI_{t-3}) + CPI_{t-3}$$

d = day of the month (eg, the 1st implies *d*=1)

m = number of days in that month

The indexation factor is the reference CPI for the settlement date divided by the reference CPI for the base date. Coupons are accrued on an actual/actual basis and paid semi-annually. The gross settlement price is calculated as follows:

$$(p+c)\left(\frac{CPI_t}{CPI_{base}}\right)$$

p = clean price of the bond

c = real accrued

CPI_t = Reference CPI at time t

CPI_{base} = Base CPI

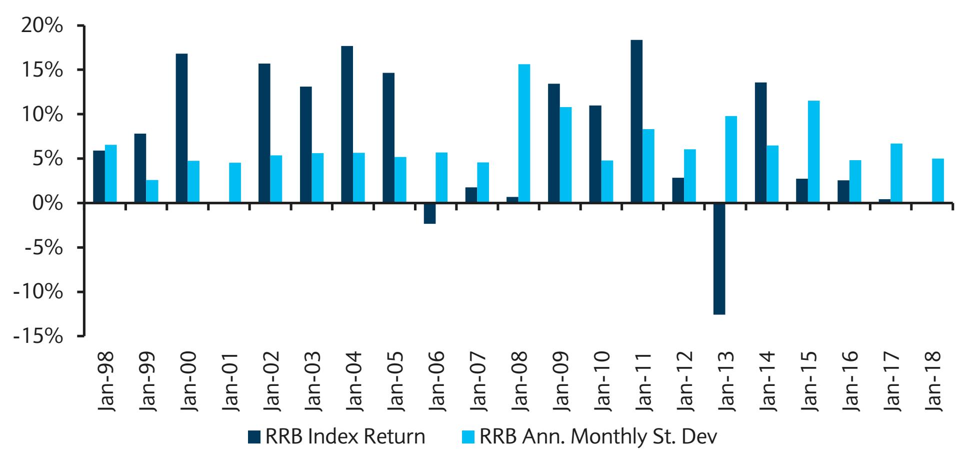
Real return bonds are taxable for residents but are not subject to withholding tax for non-residents. For residents, RRBs' income received and accrued is taxed in a given year, while the inflation accretion on the principal is also taxed. Capital gains are not taxed until realised. For non-residents, the Canadian Treasury is not ordinarily required to withhold tax from interest or principal paid on RRBs. However, the Treasury's website provides more detail on these conditions: *http://www.fin.gc.ca/invest/taxtreat-eng.asp*.

Non-government issuance and derivatives

Non-government issuance has been slow to develop in Canada. Swapped bank issuance picked up in 2008 but nearly came to a halt in 2009. The amount of corporate issuance as of the end of 2018 was negligible, totalling CAD1.2bn across four firms, and no issue was more than CAD250mn. There were several larger inflation-linked bonds issued by provinces, namely Quebec and Ontario, with the same maturity and structure as the Canadian linkers, but the last of those was in 2008.

FIGURE 5

Historical performance and risk



Source: Barclays Research

Demand for a Canadian inflation derivatives market continues to grow from pension funds, which already hold most of the outstanding Canadian linkers, seeking exposure through receiving inflation in swaps. Many Canadian investors have considered going to the US or other more liquid inflation-linked markets as a proxy for Canadian inflation because of the lack of an inflation swap market in Canada and depth of the RRB market.

INFLATION MARKETS

Sweden

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The Swedish government has been issuing linkers since 1994. While the SNDO strives to maintain a well-defined curve, the growth of the market is limited by low borrowing requirements. The local investor base has been historically dominant in the market. There is a small non-government linker market, and the inflation swaps market remains very small.

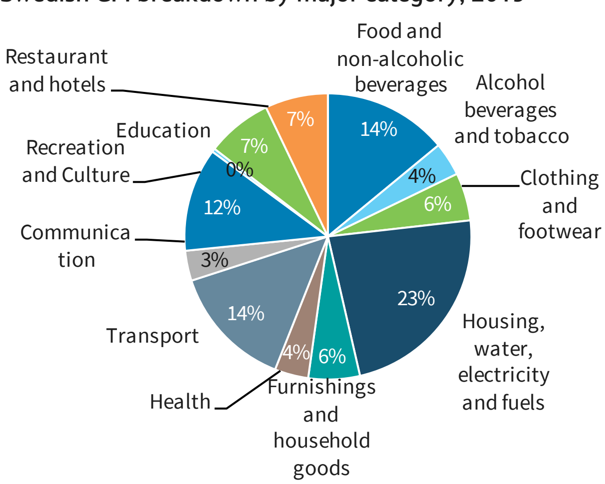
The Swedish Consumer Price Index (CPI)

Swedish inflation-linked bonds are linked to the Swedish CPI (domestically referred to as the KPI or Konsumentprisindex), a weighted chain index with annual links (referred to as a Walsh-Laspeyres type index) compiled monthly and a useful proxy for the consumption patterns of the entire country. The index is based on the Cost-of-living Index (COLI) economic theory, ie, a constant utility index. The full chain CPI is calculated with index reference (base) period 1980. The index has been published by Statistics Sweden to two decimal places since January 2006, in order to be consistent with the previous compilation of the official inflation rate. The weights and samples are revised each year and are introduced from the January index. The weights for the main and some sub-groups are based on the Swedish national account statistics and the index uses regular prices paid by the public.

Price collection is carried out for the 15th of every month or during the week that contains the 15th. The composition of the index for 2019 is shown in Figure 1. The fixed CPI index numbers used for legal purposes and inflation-linked bonds are not revised. However, on several occasions since 1980 there have been revisions in the official inflation rate, which is calculated based on a so-called shadow index; however, at each current month, the fixed index and shadow index show the same index number.

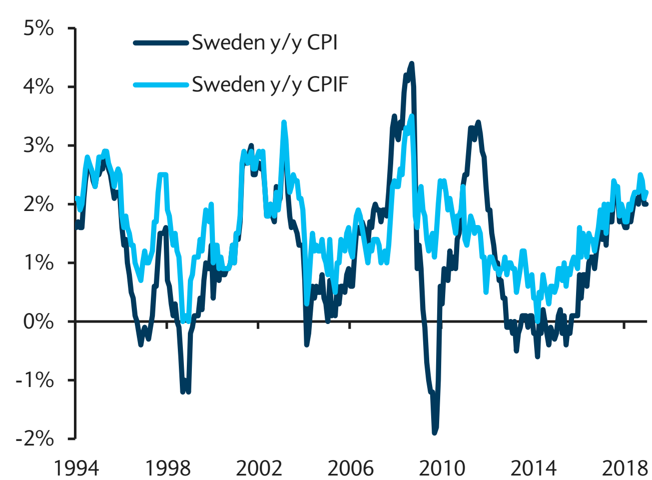
Since September 2017, the Riksbank's target variable for monetary policy is the CPIF (consumer price index with a fixed interest rate). The target is that the annual change in the CPIF shall be 2%, with a variation band that stretches between 1% and 3%. Previously, the target variable was the CPI, although, from an operational point of view, the monetary policy was already often based on CPIF. In periods of highly volatile energy prices, the CPIF excluding energy can also be used for guidance (see Figure 2). To cover parts of housing

FIGURE 1
Swedish CPI breakdown by major category, 2019



Source: Statistiska Centralbyran/Haver Analytics, Barclays Research

FIGURE 2
Swedish inflation – CPI and CPIF



Source: Statistics Sweden, Barclays Research costs, the CPI contains the sub-group 'mortgage interest cost', which is a calculated cost of owner-occupied houses with one part tracking the capital amount and one part tracking the average mortgage interest rate that households face (ie, the product of the two indices is the capital cost of a mortgage). The latter sub-index is compiled as an average of different durations on interest rates, but also moving averages for long-duration mortgage rates. As interest rates are part of the CPI, any given rate change by the Riksbank is followed by the same directional movement in the CPI index. To see through this counterintuitive movement, the underlying CPIF has normally been the preferred index of the Riksbank, even prior to September 2017. The difference between the CPI and CPIF is that the latter does not contain the second part of the 'mortgage interest cost' sub-group, ie, changes in interest rates. While the inflation rate differs in the short term when interest rates change, in a steady state, the CPIF and the CPI by definition show the same inflation rate. Official Swedish statistics also include the release of HICP, providing a consistent comparison with other European countries, with some differences compared with the domestic basket.

In addition to typical seasonality considerations, the volatility in Swedish CPI is further exaggerated by the fact that a large proportion of Swedish electricity is generated by hydroelectric power, with a significant minority of households opting for floating electricity price contracts. Therefore, headline CPI is highly sensitive to weather conditions, particularly very cold winters or extended dry spells.

Development of the market

Although at times Sweden's inflation-linked government bond programme has been fraught with challenges, as the Swedish National Debt Office (SNDO) put it, one "cannot try inflation-linked bonds for a short time or hesitate along the way…the strategy must be carefully thought-out and long-term…the SNDO has issued inflation-linked bonds every year since 1994, although in some years the demand has been sluggish. In that case, the SNDO reduced the volume…but by nevertheless continuing to issue these bonds, we have clearly demonstrated that we believe in the growth of this market[1]." Ongoing commitment and proactive assessments on the part of issuing authorities as to whether the product suits the domestic investor base have been a key feature of the Swedish linker programme.

Historically, we can distinguish three separate phases in the development of the Swedish linker market. The first phase, roughly from 1994 until 1996, was when the programme was poorly understood by investors and auctions were frequently undersubscribed. During the second phase, from about 1997 to 2001, Sweden's inflation-linked government bond programme underwent numerous reforms that helped develop the market further. Lastly, from about 2002, the programme reached a mature phase, with linkers enjoying stable demand from investors while evolving into a full-fledged debt management instrument for the issuing authorities.

In April 1994, after consultations with the government and the central bank, the SNDO decided to launch a programme of government inflation-linked bonds and started with a zero-coupon 20y instrument linked to the Swedish consumer price index, the SGIL 0% 4 Jan 2014 bond, auctioned via a single price auction. The SNDO judged that a large portion of the bids were priced too low and it consequently issued only SEK1.2bn of the bond versus an initial SEK3.5bn target. The lack of investor demand at this first auction was a harbinger of limited acceptance of the new product in the following three years or so and indeed, while the balance of linkers rose from SEK3.1bn in 1994 to SEK73.4bn in 1996, at times the SNDO was forced to cancel auctions, with breakeven inflation rates generally declining.

[1] "Ten years with inflation-linked bonds – a new asset class has been established," SNDO, 2004.

FIGURE 3

Swedish Government inflation-linked bonds

Loan number	Issue date	Redemption date	Initial maturity	Floored?	Coupon rate (%)	Amount outstanding (including inflation compensation, SEK bn)	Amount outstanding (nominal amount, SEK bn)
3110	9 Feb 2015	1 Jun 2019	4	Yes	0.125%	16.29	15.45
3102	3 Jun 1996	1 Dec 2020	24	No	4.0%	51.59	38.24
3108	15 Sep 2011	1 Jun 2022	11	Yes	0.25%	36.52	34.38
3109	11 Feb 2014	1 Jun 2025	11	Yes	1.0%	25.98	24.68
3112	15 Feb 2016	1 Jun 2026	10	Yes	0.125%	16.90	16.03
3113	6 Feb 2017	1 Dec 2027	11	Yes	0.125%	11.14	10.72
3104	19 Apr 1999	1 Dec 2028	30	Yes	3.5%	35.42	27.44
3103	23 Jun 1998	1 Dec 2028	30	No	3.5%	0.001	0.001
3111	30 Apr 2015	1 Jun 2032	17	Yes	0.125%	17.92	16.84
Total						**211.76**	**183.77**

Source: Swedish National Debt Office, 28 December 2018

The long duration of the first bond (20y versus 8y for the longest-maturity nominal bond) is one explanation for the cool reception for this new instrument and the decline in spot inflation, from about 2.5% in mid-1994 to 0% by August 1996, also likely contributed. To deal with this issue, in January 1995 the SNDO issued SEK500mn of a 9y zero-coupon bond (0% April 2004 issue), a bond that it sold throughout the year in small quantities at weekly auctions. But even this bond had to be withdrawn from auction on multiple occasions.

The second stage of the Swedish inflation-linked government bond market proved to be even more challenging as the CPI dipped into negative territory from September 1996 to May 1997 (average -0.4% y/y) and from July 1998 to February 1999 (average -0.7% y/y), due to sharp falls in the owner-occupied housing sub-component of the CPI (mortgage interest costs fell as the Riksbank cut rates) and fundamental core CPI disinflation. In addition, equity markets were overall bullish and central government finances were stronger, leading to concerns about the SNDO's long-term commitment to foster the inflation-linked programme. However, the SNDO took a proactive and flexible stance, tackling the problem from various angles. The linker market-related reforms implemented during this stage can chronologically be summarised as follows:

1. The SNDO allowed private investors to purchase inflation-indexed bonds through primary dealers after each auction (June 1995) and later in 1997 it introduced retail-oriented inflation-indexed bonds (available to individuals and small companies and organisations).
2. Implementation of switch auctions (officially called "exchange transactions") enabled dealers to move from less popular zero-coupon inflation-linked bonds to coupon-bearing linkers (June 1998); the first such auction was held on 23 June 1998, when dealers could switch from the 0% April 2014 bond to a new issue to the 3.5% Dec 2028 bond. In the following years, switch auctions played an important role in the restructuring of the SNDO's debt portfolio.
3. The addition of deflation floors on the principal payment to all inflation-linked bonds that would be issued in the future (from April 1999) was a feature officially motivated by the need for the "international harmonisation[2]" of the Swedish inflation-linked market, although the deflationary experience was likely another objective reason behind this move. The first bond with a deflation floor was sold in April 1999 (the 3.5% Dec 2028 bond), being the destination of the 3.5% Dec 2028 non-floored bond issued in the previous year. Thus, both bonds had the same coupon and maturity and terms were set at even yields. A

[2] "*Swedish Debt Policy*," Erik Thedéen, February 2000.

second switch auction was held five days later, enabling conversion from the seasoned 0% 2014 bond into a new issue, the 3.5% Dec 2015 bond. Within the space of one year, the SNDO designed switch auctions both from non-floored zero-coupon bonds to non-floored coupon-bearing bonds, and from non-floored bonds to floored bonds.

At the time of writing, with the exception of two issues, all Swedish inflation-linked bonds have deflation floors. Regarding the addition of deflation floors, we note two points. First, the adoption of floored bonds did not negatively affect the performance of non-floored bonds but rather helped the overall stability of the market. Whereas around 1998-1999, when Sweden experienced deflation, breakevens turned negative (the 2y BEI reached nearly -50bp while the 10y BEI was just 18bp above zero) following the issuance of floored bonds, BEIs were stable at about 2% in early 2004 despite the arrival of another deflationary episode. Second, the price differential between floored and non-floored bonds of similar maturity through this period of low inflation (around 6bp) suggests the market consistently discounted the existence of the floor.

4. Lastly, to further promote the inflation-linked bond market and especially increase investor awareness, the SNDO introduced a new dealer system from 2000. This system was more demanding for the newly authorised inflation-linked bond dealers.

The third stage of the Swedish inflation-linked market (from about 2002) has been one where investor acceptance of the product has matured and the asset class has secured a stable place in the country's debt portfolio. In this phase, the SNDO has focused on operations to further encourage liquidity, such as buybacks, flexible auctions and offering non-competitive post auction options to dealers of up to 20%. The retail sector has been allowed to buy linkers directly online at the average auction yield. Arguably the most important development for maintaining liquidity was offering linker repo to dealers at 25bp below the central bank's overnight rate.

The outstanding balance of linkers (with inflation uplift) increased notably from December 2001 to its peak in September 2008, moving from SEK117bn to SEK225bn, with the share of linkers in total government debt rising commensurately. At the time of writing, the SNDO has a long-term target of 20% for the share of inflation-linked krona debt (inclusive of accrued compensation for inflation). This was reduced from 25% in the Guidelines For Central Government Debt Management 2015 (published in November 2014). In the proposed guidelines for 2019-2022 (published in September 2018), the SNDO states that the share of inflation-linked debt will be analysed in 2019 and that this share may need to be reduced in the longer term unless there are strong cost or risk arguments for retaining it at its present level. This followed an examination by the Swedish National Financial Management Authority (ESV) which noted that the limited borrowing requirement makes it more important to give priority to borrowing in nominal government bonds in order to safeguard that market. As at 28 December 2018, the outstanding balance of linkers is SEK184bn in nominal terms (SEK212bn including inflation compensation).

Even as the size of the Swedish linker market declined, the SNDO strived to maintain a well defined curve. Bonds were brought via small initial auctions, followed in the days immediately after by several switch auctions to build up their size. Switches proposed have been both in cash neutral and risk-neutral terms to cater for the needs of market participants. The SNDO proposed that it might bring a new long maturity 2039 benchmark in 2012, but this was not pursued after an investor consultation revealed limited interest.

Swedish linkers were initially excluded from the Riksbank's government bond purchase programme when it started in 2015, but they were subsequently included in 2016. On the investor demand side, the local insurance industry has been a key participant. The part-privatisation of the national pension system and the conversion of cash balances to government bonds at state entities in 2002 helped increase the size of the inflation-linked bond market, with the Swedish Nuclear Waste Fund in particular a natural holder. The explicit indexation of the national pension scheme to wage inflation led to linker purchases by several of Sweden's national pension funds. As mentioned above, the SNDO has facilitated the purchase of this product for retail investors as well. The decline in insurance holdings, particularly by life insurers, has been offset by an increase in holdings by international investors.

Features of Swedish linkers

Calculations for Swedish linkers are slightly more complex than for those markets that employ the standard Canadian model. Unlike the Canadian model, the prices for Swedish linkers are not expressed in real terms, but in nominal terms, including inflation uplift. However, the quoted real yield on Swedish linkers is consistent with the Canadian model. Inflation accrual is calculated in a very similar manner to the three-month lag model, using a three-month lag between the inflation release and the first of the month. However, day count conventions are different, as there is linear interpolation but assuming 30-day months. Hence, the reference day, d of the month is:

$$\frac{Minimum\ of\ [d-1, 29]}{30}\left(CPI_{t-2} - CPI_{t-3}\right) + CPI_{t-3}$$

This convention affects daily valuations, but all coupons are paid on the first of the month. Interest accrues on a European 30/360 basis. Bonds issued since 1998 have deflation floors, with the 2020 bond the only benchmark that does not. The settlement convention for Swedish linkers is T+2. The clean nominal price (ie, after inflation accrual) of coupon bonds is rounded to three decimal places before adding on accrued interest. The settlement price is then rounded to the nearest krona.

Non-government linkers and inflation swaps

The non-government inflation-linked bond market is not large in Sweden. Virtually all corporate issuance is maturity matched to government issues and holds the same bond conventions. While conceptually the well-defined bond market means that there is plenty of scope for a liquid inflation swaps market, the Swedish CPI swaps market still remains surprisingly underdeveloped.

INFLATION MARKETS

Denmark

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Prior to the first government issuance in May 2012, Danish CPI only occasionally traded in swap form. The market attracts interest from investors looking for highly-rated inflation-linked securities, although the still small size of the market means getting exposure to the market can be challenging.

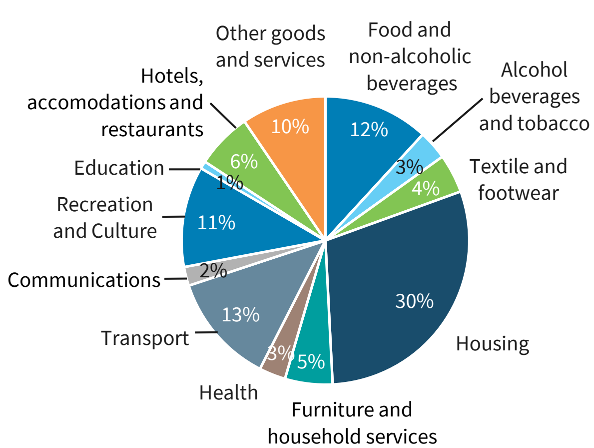
Consumer Price Index (CPI)

The Danish CPI (Forbrugerprisindeks) is a weighted chain-linked index, currently with index reference year 2015. The index can best be characterised as a fixed-weighted Laspeyres-type index (using the Young index formula) with annual links to the price reference period (for elementary aggregates) from December the previous year to the current month. The weights are updated on a yearly basis. From January 2001 until December 2015, the index was calculated with 2000 as the base year. As from January 2016, the index has been calculated with a 2015 base year. In addition, in Statistics Denmark's (DST) framework, calculations for the CPI are related to the EU Harmonized Consumer Price Index (HICP), which partly explains the high correlation of the Danish CPI and HICP. The main difference between the CPI and HICP is basket content (the CPI contains owner-occupied housing).

Danish inflation has been, at times, more correlated with HICP for Germany and the euro area than for Scandinavia peers Sweden and Norway. Indeed, Germany is by far Denmark's biggest trading partner, and, perhaps more importantly, Denmark's participation in the ERM II (the EU exchange rate mechanism) suggests the same exchange rate pressures as the euro area. Indeed, Danish monetary policy is set to keep the krone (DKK) stable vis-à-vis the euro (with a fluctuation band of 2.25%) by adjusting its policy interest rates or, in the short term, by buying and selling foreign currency in the market. This makes Denmark one of the very few countries now issuing inflation-linked bonds that does not have an explicit inflation aim as part of its monetary policy structure.

FIGURE 1

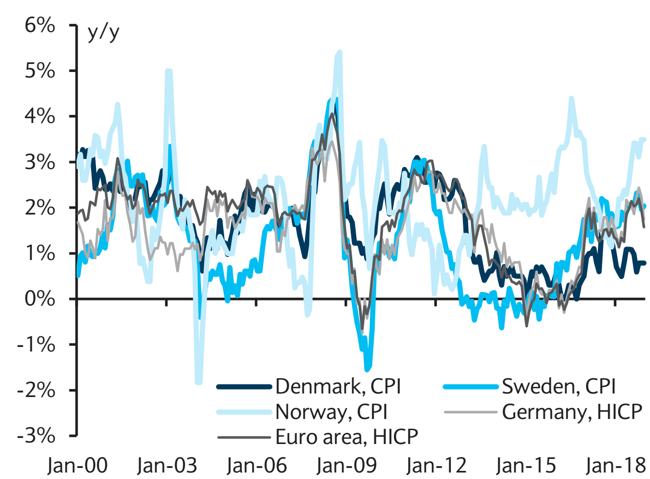
Danish CPI, sub-group weight, 2019



Source: Danmarks Statistik/Haver Analytics

FIGURE 2

Danish CPI more correlated with euro HICP than Swedish CPI



Source: Various Statistical Agencies/Haver Analytics, Barclays Research

Government issuance

Danmarks Nationalbank, which acts as agent for government issuance in addition to its central bank function, announced in its debt management policy for 2012 that it intended to issue a bond linked to Danish CPI. As discussed in its 2011 annual report, the largest Danish pension funds had DKK127bn (~$23bn) in inflation-linked bonds at the end of 2010, split between foreign government issues and domestic mortgage bonds. The significant distortions to euro inflation-linked bond markets in late 2011 appear to have encouraged domestic interest in government supply.

The DGBi 0.1% Nov 2023 was issued in May 2012 with an initial size of just under DKK6bn. The structure of the bond is a standard Canadian format 3m lag with a deflation floor and coupons paid annually. The bond was reopened frequently until October 2014, but the next tap came only in January 2016. The second linker, DGBi 0.1% Nov 2030, was issued in February 2018, and its size has been gradually built through switch operations in which the DGBi23 was bought back. The 15 November maturity is the standard for Danish nominal government bonds. Following the Annual Index Governance Review in October 2012, Denmark was announced as being eligible subject to satisfying the market size rule for inclusion in the Barclays World Government Inflation-Linked Bond (WGILB) and Global Inflation-Linked (Series-L) indices. The DGBi Nov 2023 therefore joined both indices effective from the March 2014 month-end rebalancing, having satisfied the market size criterion at the 2013 year-end quarterly review.

Non-government market

Danish CPI-linked bonds formed a significant sub-sector of the callable mortgage bond market until 1999. Most mortgage bond issuers had some inflation-linked issues, as did the KommuneKredit municipal agency. The potential for development of a large derivatives market is limited by the fact that most Danish pension liabilities are nominal. Other than the property sector, in which pension funds are more likely to invest directly, the only clear payment of Danish CPI comes from infrastructure projects. There has been occasional issuance of Danish CPI-linked notes, but in euros rather than Danish krone. For example, there was a 2019 bond issued to fund the transport link to Sweden, a scheme which also saw inflation-linked issuance in Sweden. The Danish CPI issue reached over €600mn by 2005, but a significant proportion was bought back subsequently. Also in 2005, there was evidence of activity in inflation swaps given that natural asset-swapping issuers including German agency KfW issued a long Danish CPI-linked issue in euros.

INFLATION MARKETS

Australia and New Zealand

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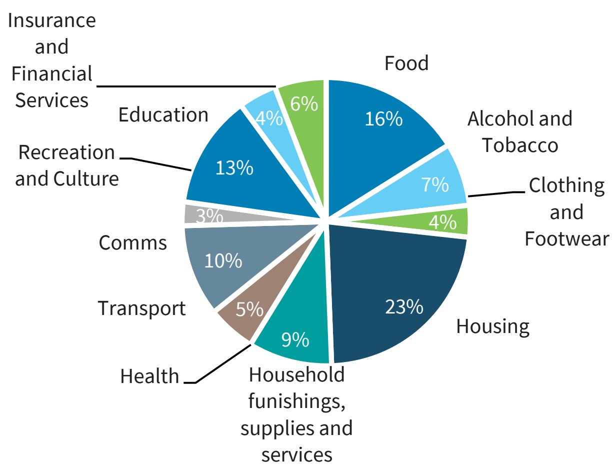
The Australian government issued inflation-linked bonds (commonly called Treasury Indexed Bonds, TIB) from 1985 until 2003, when it suspended its TIB programme due to ongoing budget surpluses. It restarted TIB issuance in 2009. New Zealand followed suit in 2012 with a 2025 issue followed by a new 2030 bond in 2013, which entered the Bloomberg Barclays WGILB index benchmark at the end of 2013. Both countries enjoy considerable popularity among global linker investors as highly rated diversifiers from the major inflation-linked markets, although relatively modest supply can make significant structural allocations challenging.

The Australian CPI

Australian inflation-linked government bonds, and the majority of AUD-denominated inflation structures including swaps, are indexed to the *Weighted Average of Eight Capital Cities: All-Groups Index*, more commonly known as the Australian CPI[1]. The Australian CPI is published and maintained by the *Australian Bureau of Statistics (ABS)* on a quarterly basis (three months ending March, June, September and December; the CPI figures are typically released within one month of the end of the quarter). CPI figures are compiled separately for each state capital city and the overall CPI is derived by weighting price movements (or price relatives) between the base and current period by their shares of total household expenditure in the base period. The composition of the CPI basket is based on the pattern of household expenditure observed in the weighting base period with information about consumption trends of Australian households coming from the ABS 2015-16 Household Expenditure Survey (HES) for the 17th series of the CPI. No changes to the classification structure of the Australian CPI were made in respect of the 17th series.

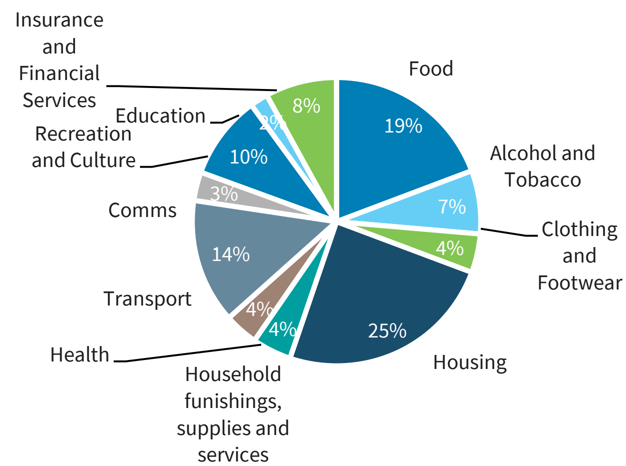
Meanwhile, the CPI basket is divided into 11 major groups, each representing a set of goods and services (Figure 1). These groups are further divided into 33 subgroups, and the subgroups into a total of 87 expenditure classes. The ABS provides a comprehensive overview of construction of its CPI in its information paper: *Consumer Price Index: Concepts, Sources and Methods*[2]. The ABS generally reviews the construction of the index at

FIGURE 1
Australian CPI composition (2018)



Source: ABS, Barclays Research

FIGURE 2
New Zealand CPI composition (2018)



Source: Statistics New Zealand, Barclays Research

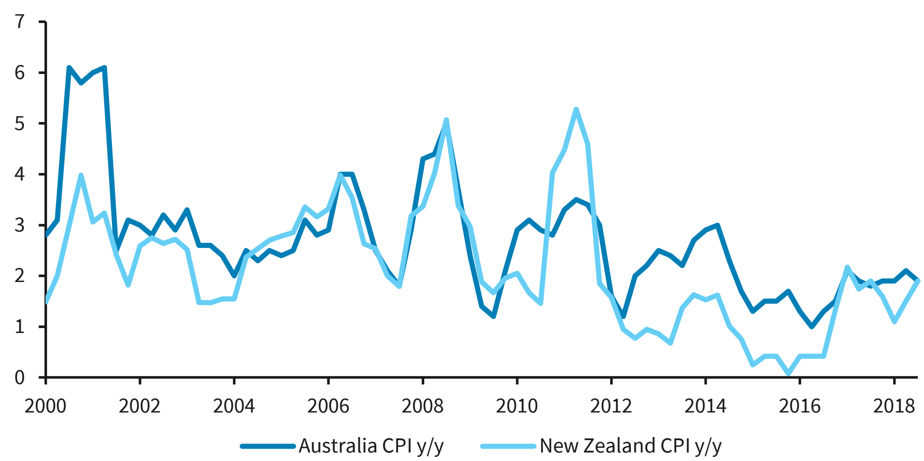
[1] The eight cities are the six state capital cities (Sydney, Melbourne, Brisbane, Adelaide, Perth, Hobart) plus Darwin and Canberra.
[2] Australian Bureau of Statistics, "Australian Consumer Price Index: Concepts, Sources and Methods", 2017,

approximately six-year intervals, with the timing generally dependent on the availability of results from the Household Expenditure Survey. The reference base period for the CPI is also updated, but at less frequent intervals. From Q3 12, the reference period for the index was updated to 2011-12 = 100.0, from 1989-90 = 100.0; the reference period remained the same for the 17th series as for the 16th.

In the comprehensive review of CPI calculation methodology undertaken in 1998, the ABS decided that the index would be modified from a measure of the change in living costs of employee households to a general measure of price inflation for the household sector. As a result, the population covered was expanded from wage and salary earning households to include all metropolitan households. Weights were revised to reflect new expenditure patterns and the expanded population coverage. More recently, the 17th series CPI was introduced in November 2017, with item weights being revised in line with 2015-16 HES expenditure patterns[3]. Australia introduced a Goods and Services Tax (GST) in 2000, which was responsible for the spike in the Australian CPI in 2000.

The Australian CPI is an important economic indicator not only for the bond market but also for the central bank, which adopted inflation targeting in 1993. The Reserve Bank of Australia's monetary policy aims to achieve an inflation rate of 2-3%, on average, over the cycle. As noted on the RBA website, "This is a rate of inflation sufficiently low that it does not materially distort economic decisions in the community. Seeking to achieve this rate, on average, provides discipline for monetary policy decision-making, and serves as an anchor for private-sector inflation expectations."[4]

FIGURE 3
Australian and New Zealand CPIs



Source: ABS, Statistics New Zealand, Barclays Research

New Zealand CPI

The New Zealand CPI shares many features with its Australian counterpart – it is published quarterly and comprises of 11 main subgroups with broadly similar weightings. A comprehensive guide to the CPI is published by Stats NZ[5]. The CPI is based on spending on goods and services by New Zealand households at June 2017 quarter prices (unusually the NZCPI uses a base level of 1000), based on information from the 2012/13 and 2015/16

[3] For further details on the Australian CPI please refer to the Guide to the Consumer Price Index published by the ABS (http://www.abs.gov.au/ausstats/abs@.nsf/mf/6440.0).
[4] https://www.rba.gov.au/inflation/inflation-target.html
[5] https://www.stats.govt.nz/assets/Uploads/Reports/Consumers-price-index-review-2017-revised/consumers-price-index-review-2017-revised.pdf

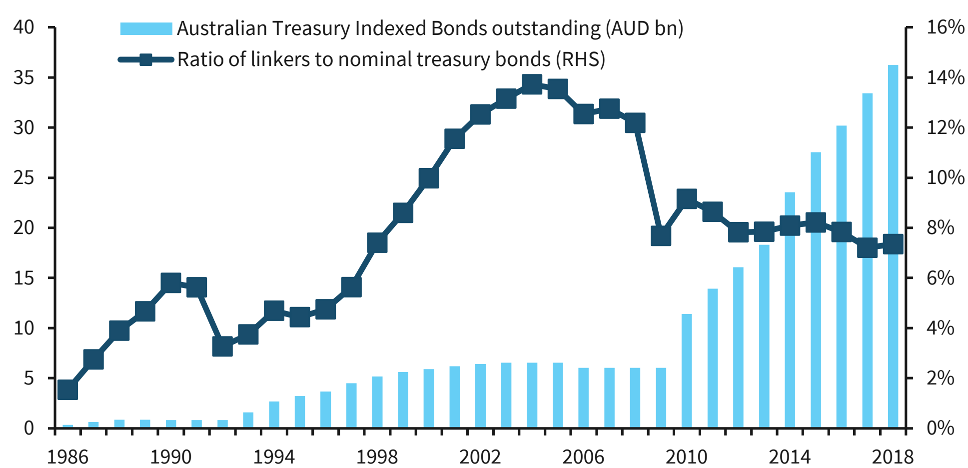
Household Economic Survey and other sources. The New Zealand CPI forms the basis of the Reserve Bank of New Zealand's inflation target, which aims to maintain CPI inflation of between 1-3%, on average, over the medium term, with a focus on keeping future average inflation near the 2% target midpoint. The New Zealand CPI has generally tracked the Australia CPI reasonably closely since 2001, when the effects of the Australian VAT dropped out of the index. However, New Zealand CPI spiked higher following the Christchurch earthquakes of 2010-11 which spurred significant construction spending. Thereafter inflation fell sharply in New Zealand, due to falling dairy prices and telecommunications prices as a result of increased broadband data caps and decreases in cellular communications tariffs, respectively. Australian and New Zealand inflation rates diverged in Q1 2018 as a result of atypically large movements in air transport costs in New Zealand relative to seasonal averages.

The Australian government bond market

Australia's first index-linked bond was issued by the State Electricity Commission of Victoria in August 1983. Two years later in July 1985, four Treasury Indexed Bonds (TIBs) were issued by the Commonwealth government for a modest total size of AUD100mn. Two of these issues were capital-indexed bonds (CIB), while the other two were rarer interest-indexed bonds (IIB), paying a fixed coupon plus an inflation accrual on the principal every period (the principal, however, was not adjusted for inflation at redemption). The maturities of these first bonds were 10y and 20y. As the Australian government's fiscal situation improved sharply from 1988, against a backdrop of limited appetite for inflation-linked securities among investors, the Treasury ceased issuing linkers. It even bought back some of the existing bonds as part of its debt reduction policy.

FIGURE 4

Australian Treasury Indexed Bonds outstanding



Note: Mid-year levels Source: Australian Office of Financial Management

However, the government resumed its index-linked issuance programme in 1993, with supply being "tailored to identify market demand"[6]. Between 1988 and 1993, the domestic inflation market became more sophisticated as a result of issuance by a number of state governments and growing demand for long-term linkers from the emerging superannuation or pension fund industry. Under the new programme, only capital-indexed bonds were brought to the markets, all with long maturities. The size of linker supply picked up considerably, increasing on average by about AUD640mn a year over 1993-2000, from AUD1.6bn to AUD5.9bn (Figure 4). However, TIB liquidity was generally low as the bonds were issued largely to buy-and-hold investors. Annual turnover averaged a modest AUD12bn during 2001-06 versus AUD410.3bn for nominal Commonwealth Government Securities (CGS), ie, less than 3% of

[6] Commonwealth Debt Management Report, 1996.

that of regular government bonds despite the size of the total market being around 10% of the nominal market[7]. The number of TIBs issued was not large (the inflation-indexed programme never had more than five bonds), and additional supply came in the form of reopening seasoned bonds on average five or six times a year.

FIGURE 5

Australian government inflation-linked bonds

	Issue date	Redemption date	Coupon	Face value (AUD bn)
Australia IL 4.00% 2020	14 Oct 1996	20 Aug 2020	4.00%	3.0
Australia IL 1.25% 2022	28 Feb 2012	21 Feb 2022	1.25%	6.1
Australia IL 3.00% 2025	8 Oct 2009	20 Sep 2025	3.00%	7.2
Australia IL 0.75% 2027	23 Aug 2017	21 Nov 2027	0.75%	4.2
Australia IL 2.50% 2030	21 Sep 2010	20 Sep 2030	2.50%	4.6
Australia IL 2.00% 2035	26 Sep 2013	21 Aug 2035	2.00%	4.0
Australia IL 1.25% 2040	11 Aug 2015	21 Aug 2040	1.25%	3.6
Australia IL 1.00% 2050	18 Sep 2018	21 Feb 2050	1.00%	3.8

Source: Australian Office of Financial Management as of 11 January 2019

The Australian Treasury announced the suspension of the TIB programme with the publication of its budget in 2003. This announcement followed a one-year period of analysis and consultation with more than 90 domestic and foreign market participants, which sought to determine whether the CGS market was a viable going concern given the sharp fall in the Commonwealth government's financing requirement over the previous few years and the abundance of cash available from the sale of government assets (the Australian government's net debt had fallen from 18.5% of GDP in 1995-96 to 1.3% of GDP by 2004-05). On purely economic grounds, the very favourable fiscal conditions implied active issuance of government securities was not required. On the other hand, there was concern about banks' disproportionately large role within the financial markets and hence it was argued that the CGS market should be maintained. The government's review concluded that an interest rate market predominantly comprising bank issuance and corporate paper would be vulnerable to economic shocks, thus posing significant threats to financial stability and the accessibility of refinancing capital for corporates. As a result, the decision was taken to support government debt liquidity, and was structured in such a way that it supported the 3y and 10y Treasury bond futures contracts; but there was no room for a continuation of the TIB programme.

In 2009, the inflation-indexed government bond programme was revived after a six-year hiatus. In an announcement regarding the issuance of Commonwealth government bonds in May 2009, the Australian Office of Financial Management (AOFM) stated that resumption of linker supply "could assist in the debt financing of long-term infrastructure, since Treasury Indexed Bonds (TIB) would serve as both a pricing benchmark and a risk management tool… indexed financing can be attractive for those infrastructure projects whose revenues are linked to inflation… in addition, indexed instruments have advantages for investors with inflation-linked liabilities". We believe there are at least two more reasons for the resumption of inflation-indexed bonds not explicitly stated in the AOFM note. First, similar to other countries affected by the 2007-09 global financial crisis, the government's expenditure base had increased sharply while tax revenue had plunged, leading to Australia's first budget deficit in seven years, which was also the largest on record (AUD57.6bn, or nearly 5% of GDP in 2009). Second, double-digit negative returns on Australian households' mandatory superannuation (pension) funds owing to financial

[7] Australian Financial Markets Association, "2006 Australian Financial Markets Report."

market volatility, combined with proposals to raise the age at which individuals can access these funds, had been steering debate on asset management in the direction of safer investment guidelines, and linkers fitted this description.

Following consultation with various market participants, the AOFM decided to issue the new linker at the beginning of October 2009 via syndication, with an announced supply size of “at least” AUD1bn. The actual amount sold was four times larger, at AUD4bn. As a result, the Australian government inflation-linked bond market expanded by 66% in 2009 alone. Another important development was the expansion of the AOFM’s securities repo facility to include TIBs (both seasoned bonds and the new 2025 bond). This change contributed to improvement in secondary-market liquidity, as also happened overseas.

The AOFM has allowed the TIB market to continue to grow since the programme resumed, allowing the curve to develop by adding new issues alongside regular reopenings. A 2030 issue was brought via syndication in September 2010, for an initial size of AUD1.26bn, followed by a 2022 10y benchmark in February 2012, which was launched for AUD0.9bn. The real yield curve was extended out to 2035 in September 2013, with a new 2018 launched at the end of April 2014. A further curve extension came in August 2015 with the launch of a 2040 indexed bond followed by a new 2050 in September 2018; a new 10y 2027 was launched in August 2017. In recent years, annual issuance of Australian government linkers has been around AUD6bn, with a typical regular tap size of AUD150mn. The most recent new bonds, the 2027 and 2050 maturities, were launched via syndication for AUD3bn and 3.75bn respectively.

Technical features of Australian inflation-linked bonds

As is the case with other international linker markets, both income and capital generated by TIBs are indexed to inflation. Australian linkers are similar to old-style UK index-linked bonds in that the next coupon amount is always known on or before the current coupon payment date. According to the prospectus for Treasury Index Bonds published in 1995, “the amount of inflation indexation in any given coupon period is equal to the average percentage change in the Consumer Price Index over two quarters ending in the quarter, which is two quarters prior to that in which the next interest payment falls”. This means that the bonds have a six-month indexation lag compared with eight months in the UK. The interest on Australian linkers is accrued on an actual/actual basis, and the bonds are quoted on a yield basis. Interestingly, while conventional bonds pay semi-annual coupons, inflation-indexed bonds pay coupons on a quarterly basis. Australian linkers trade ex-dividend for seven days prior to the payment date. Furthermore, as is the case with other developed linker markets, these securities contain an embedded put at maturity that protects against deflation over the life of the bond. Unlike other markets that offer an inflation floor, however, capital-indexed bonds protect both coupon and principal from deflation over the life of the bond.

The calculation of interest and principal payments for Australian index-linked bonds is significantly different than for US, Canadian, Euro and Swedish bonds. The settlement price for AUD100 face value of Australian government inflation-linked bonds is provided by the following formula.

$$P = V^{f/d}\left[g(x + a_n) + 100V^n\right] K_t \quad \frac{(1+p/100)^{-f/d}}{100}$$

Where:

- **V** = 1/(1+i), with **“i”** being the annual percentage real yield (quoted real yield) divided by 400. For example, if the annual yield is 2.5%, then “i” is equal to 2.5/400, or 0.00625.
- **“f”** is the number of days from the date of settlement to the next interest payment date.

- **"d"** is the number of days in the quarter ending on the next interest payment date.
- **"g"** is the fixed quarterly interest rate payable (equal to the annual fixed rate divided by 4).
- **"x"** is a valued of either 0 or 1 depending on whether there is an interest payment at the next interest payment date; "x" is 1 if there is an interest payment and 0 if there is no interest payment (ie, the bond is trading ex-dividend).
- **"a_n"** is the sum of the power series or V, with the highest power being **"n"** (the number of full quarters between the next interest payment date and the date of maturity). Mathematically,

  $a_n = V + V^2 + \ldots + V^n = \sum_j V^j$, where $j \in [1,n]$
- **"Kt"** is the nominal value of the principal at the next interest payment date (whether or not there is an interest payment due). Kt can also be expressed as **Kt = Kt-1*(1+p/100)**, where Kt-1 is the cash value at the previous payment date. If there has been no previous payment date, Kt-1 is equal to AUD100. Note that Kt and Kt-1 are rounded to two decimal places.
- **"p"** is the average percentage change in the CPI over two quarters ending in the quarter which is two quarters prior to that in which the next interest payment falls; for example if the next interest payment is in November, then "p" is based on the average movement in the CPI over the two quarters ended in the June quarter preceding. Mathematically expressed, "p" is (100/2)*[(CPIt/CPIt-2)-1], where CPIt is the CPI for the second quarter of the relevant two-quarter period, and CPIt-2 is the CPI for the quarter immediately prior to the relevant two quarter period. "p" is also known as the "Australia CPI factor average change (ACIF)" and is regularly calculated by the Reserve Bank of Australia (RBA). These figures are also available on Bloomberg as ACIF Index.

Interest payments for Australian linkers are calculated as **$g*K_t/100$**, where "g" and "K_t" are the variables defined in the calculation of settlement prices above. Interest payments are rounded to the nearest cent (ie, with 0.50 being rounded up). Moreover, no interest payment is based on a nominal value of less than AUD100. If the nominal value of the principal falls to below AUD100, then the interest payment would be based on a nominal value of AUD100. Subsequent interest and/or principal payments in such cases will be reduced by the difference between the fixed interest payment that was paid in the period and the payment that would have been made under the above formula except for this provision.

The New Zealand government bond market

New Zealand initially introduced inflation-indexed bonds in 1996 with a 2016 maturity bond. However, issuance ceased in 1999 and the bond was not subsequently tapped since. Linker issuance resumed in October 2012, with a 2025 issue launched by syndication and a 2030 launched via the same method a year later in October 2013. A 2035 issue followed in November 2014 and a 2040 in March 2017 to extend the real yield curve which now comprises the 2025, 2030, 2035 and 2040 issues. These bonds are tapped with fairly regular frequency, but in modest size compared to most active developed market sovereign inflation issuers. The technical features of the bonds are almost identical to Australian Treasury Indexed Bonds, and so we have not duplicated the pricing formulae although we note that the explanatory notation used by the NZDMO differs slightly from the AOFM. We recommend consulting the Information Memorandum for NZ linkers for further details.

INFLATION MARKETS

Brazil

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Brazil has been issuing inflation-linked bonds since 1964. Having been the dominant form of local debt during periods of hyperinflation, linkers fell to a small share of national debt until 2003. Subsequently, there was a major push towards increased linker issuance to replace floating-rate and foreign-currency debt, even if the effort lost momentum after 2014. In December 2018, the notional of inflation-linked bonds was equivalent to approximately USD275bn, or c.27% of total federal debt.

Inflation targeting

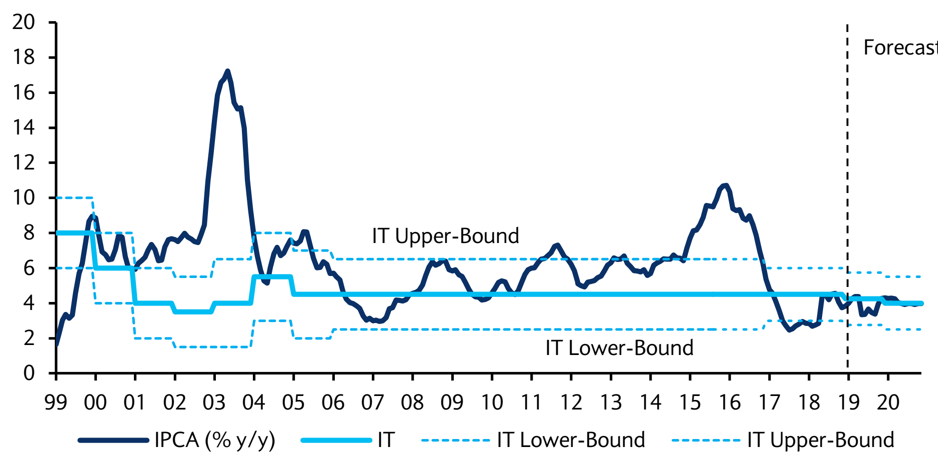
Brazil's inflation targeting (IT) regime has been tested consistently since it was implemented in 1999. However, it was during its 10th anniversary – when the Brazilian economy weathered the global financial crisis surprisingly well – that we believe the regime finally paid dividends. For the first time, Banco Central do Brasil (BCB) was able to implement countercyclical monetary policy, helping to minimize the downturn of economic activity when capital flows dried up dramatically and the BRL was depreciating substantially.

The 2008-09 crisis proved the Brazilian IT regime to be a very successful framework for monetary policymaking. There have been no formal changes to the framework since then, but BCB's modus operandi has changed throughout the years. During President Rousseff's administration (2011-2016), inflation was allowed to float closer to the upper bound of the target range (then at 4.5% ±2.0%). While the BCB's sole mandate is to keep inflation within the target range, its toolkit was adjusted to include less-orthodox policy measures, such as the use of macro-prudential regulations in the credit market. Another challenge faced by the IT regime has been Brazil's persistently loose fiscal policy stance, which has historically overloaded BCB's efforts in keeping inflation anchored, pressuring the Selic rate up.

After the appointment of Governor Goldfajn in May 2016, the IT regime was strengthened by improved BCB market communications. Inflation expectations converged toward the target and remained anchored there supported by the i) firm and reiterated commitment to pursuing the center of the target band, with ii) normalization in regulated prices in 2015/16 that were previously kept artificially low; and iii) Brazil's deepest recession. However, we still believe the country's fiscal situation remains a medium-term challenge to monetary policy transmission.

FIGURE 1

The Brazilian inflation-targeting regime (targets and IPCA)



Source: IBGE, BCB, Barclays Research

Figure 1 plots the IPCA price index y/y change (Brazil's official inflation target rate, as measured at the end of each calendar year) with our forecasts until end-2020, the bands and midpoint targets of the IT regime since it was implemented. After a volatile initial few years, reflecting both domestic and external shocks and, more recently, a strong adjustment in relative prices in 2015-2016, inflation ended 2017 at 2.9%, breaching the lower-bound of the target range for the first time ever. In 2018, it remained below the center of the target, at 3.7%, and we expect inflation to converge back to the center this year.

Each June, the National Monetary Council (recently redesigned to include the minister of the economy, the BCB governor and the secretary of finance) sets the three-year-ahead midpoint targets, along with their fluctuation range. After 11 years targeting 4.5% ± 2.0pp, the fluctuation band was narrowed to 4.5% ±1.5pp in 2017 and 2018. The target was reduced to 4.25% ± 1.5pp in 2019, and it is set to drop another 25bp in 2020 and in 2021, to 4.00% ±1.5pp and 3.75% ±1.5pp, respectively.

The BCB governor is nominated by the Brazilian president and, like other members of the BCB board, must be approved by the Senate. Currently, there are no fixed mandates for the board or the governor, but the Bolsonaro administration has announced plans to grant formal autonomy to the BCB already in 2019 (thereby introducing fixed mandates as a way of shielding board members from undue political pressure).

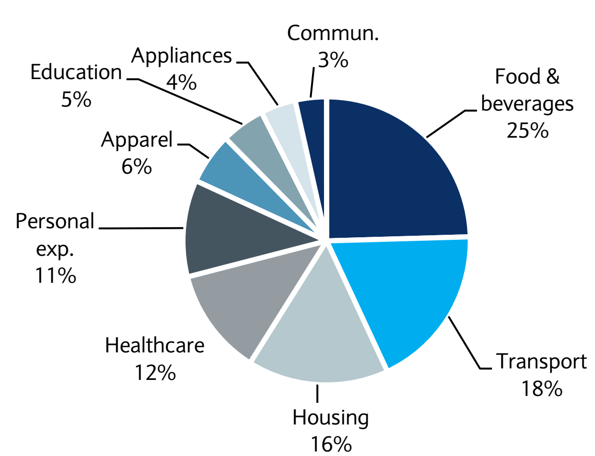
Indexation

Brazil developed several inflation indices during its hyperinflation period. The most important ones are the IPCA (BZPIIPCA Index <GO> in Bloomberg) and IGP-M (IBREIGPM Index <GO> in Bloomberg).

The IPCA (December 1993 = 100), calculated by the national statistics agency (IBGE), is the official national consumer price index (and the measure of inflation targeted by the central bank). IBGE typically publishes it around the fifth or sixth business day of each month, covering the period of the previous calendar month. In other words, the February index, released in early March, reflects average prices during February, and the m/m change for February represents the full-month February average compared with that for January.

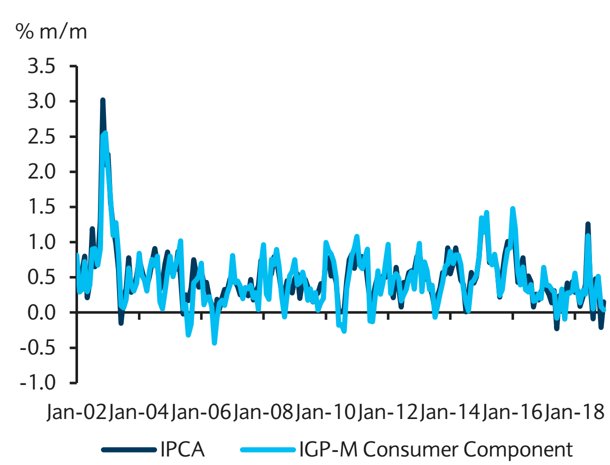
IBGE announced in late 2011 the new weighting structure for the IPCA inflation index valid as of 2012. The index was constructed based on the most recent household consumption survey, taken in 2008-09, and reflects the consumption patterns of families with incomes of

FIGURE 2
IPCA weights (%) as of December 2018



Source: IBGE, Barclays Research

FIGURE 3
IPCA and IGP-M CPI component (% m/m)



Source: IBGE, FGV, Barclays Research

one up to 40 times the minimum wage. As is standard in CPI index calculations, the index weights are fixed. However, IBGE-reported weights move slightly each month, reflecting the changes in relative prices. Figure 2 shows the weights in December 2018, with food and beverages, transportation and housing having the largest shares. Geographical coverage currently comprises 16 metropolitan areas or cities, with São Paulo having by far the largest weight, at nearly 31%, followed by Rio de Janeiro (c.12%) and Belo Horizonte (c.11%). The cities of Vitoria and Campo Grande were included in the IPCA index in January 2014; Rio Branco, Sao Luis and Aracaju were added more recently, in May 2018.

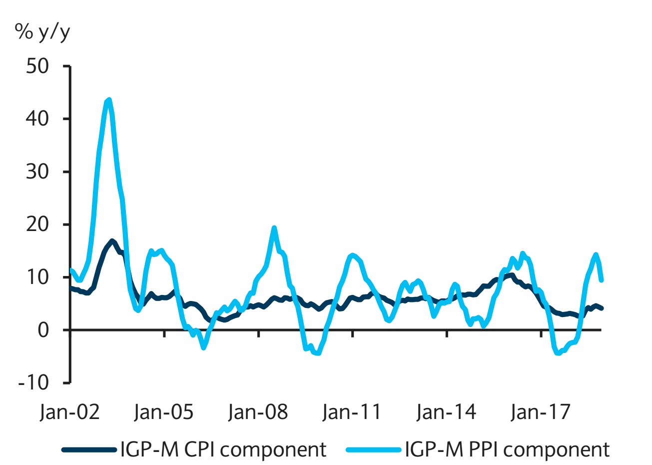
The IGP-M index (August 1994 = 100), published by the Getulio Vargas Foundation (FGV), a private institution, measures a broader set of prices. It consists of three components: a measure of producer prices ("IPA-M", 60% of the total); a measure of consumer prices ("IPC-M", 30% of the total); and a measure of construction costs, covering materials and labor ("INCC-M", 10% of the total). The IGP-M is also published monthly, typically on the second-to-last business day of each month. Instead of covering a full calendar month, it covers the 30-day period between the 21st day of a given month through the 20th day of the following month. The consumer price component tends to behave similarly to the IPCA (Figure 3), but the wholesale price component is considerably more volatile, partly because of the prevalence of raw foods/commodities in the index and partly because of exchange rate movements, which can affect tradable goods prices significantly (Figure 4). As a result, inflation, as measured by the IGP-M, fluctuates more widely than IPCA inflation. Changes in the BRL have a faster and higher rate of pass-though into the IGP-M than into the IPCA.

Both inflation indices I_t are updated only once a month and evolve as a step function. To adjust the current price of the bonds correctly (see next section), one needs to account for accrued inflation from the last date the index was updated to the settlement date of the bond (generally T+1). The market convention is to use the official Brazilian Association of Financial and Capital Market Companies (ANBIMA) inflation forecast pro rata, so we have:

$$I_t^{'} = I_t \left(1 + i_A\right)^{n/N}$$

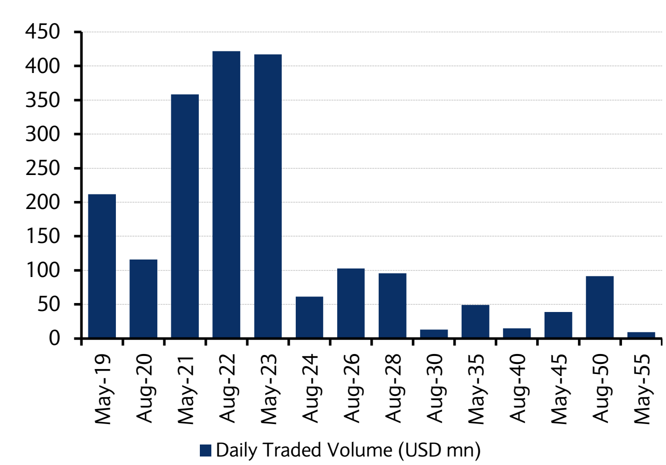
where *n* is the number of Brazilian business days between the evaluation date and the last day of the previous IPCA period coverage; *N* is the number of Brazilian business days between the last day of the previous IPCA period coverage and the last day of the next IPCA

FIGURE 4
IGP-M wholesale and CPI components



Source: FGV, Barclays Research

FIGURE 5
Traded volumes of NTN-B bonds by maturity (daily average in USD mn) – December 2018



Source: BCB, Barclays Research

period coverage; and i_A is inflation as projected by ANBIMA. Special attention should be paid to the dates when there are releases of other inflation indices, since they are generally correlated with IPCA or IGP-M or both. ANBIMA's inflation projection might change according to other data releases, affecting the value of the linkers.

Government bonds: NTN-Bs and NTN-Cs

The Treasury used to issue two inflation-linked securities: NTN-Bs (BNTNB Govt <go> in Bloomberg) and NTN-Cs (BNTNC Govt <go> in Bloomberg). The former have their principal indexed to IPCA. They generally have semiannual payments of fixed-rate coupons on the indexed principal, though some zero-coupon bonds have been issued with indexed principal. NTN-Cs are similar to NTN-Bs, but with principal indexed to IGP-M.

Until 2005, the market for NTN-Cs was substantially larger than that of NTN-Bs. However, demand for IPCA-linked securities increased over the years, given IPCA's central role within the inflation-targeting regime. Furthermore, from a supply perspective, the combination of 1999's currency devaluation and the high FX pass-through into the IGP-M led the Treasury to shift towards IPCA-linkers. NTN-Cs issuance has ended and, as of December 2018, NTN-Bs account for about 92% of the total outstanding amount of inflation-linked securities, or BRL962.4bn (Figure 6).

FIGURE 6
NTN-Bs outstanding

					Outstanding	
Maturity date	Issue date	Coupon	Coupon frequency	Day count	BRL bn (uplifted notional)	% total
May-19	Jan-14	6.00	Semi-annual	bus days/252	72.5	8%
Aug-20	Jan-09	6.00	Semi-annual	bus days/252	60.8	6%
May-21	Jan-16	6.00	Semi-annual	bus days/252	70.0	7%
Aug-22	Oct-11	6.00	Semi-annual	bus days/252	143.0	15%
Mar-23	Mar-02	6.00	Semi-annual	bus days/252	0.1	0%
May-23	Jan-14	6.00	Semi-annual	bus days/252	84.7	9%
Aug-24	Oct-03	6.00	Semi-annual	bus days/252	52.0	5%
Aug-26	Jan-16	6.00	Semi-annual	bus days/252	45.8	5%
Aug-28	Jan-18	6.00	Semi-annual	bus days/252	6.0	1%
Aug-30	Feb-10	6.00	Semi-annual	bus days/252	34.2	4%
May-35	Mar-06	6.00	Semi-annual	bus days/252	64.7	7%
Aug-40	Feb-10	6.00	Semi-annual	bus days/252	47.8	5%
May-45	Sep-04	6.00	Semi-annual	bus days/252	75.1	8%
Aug-50	Feb-10	6.00	Semi-annual	bus days/252	147.1	15%
May-55	Jan-15	6.00	Semi-annual	bus days/252	33.9	4%
*May-19	various	-	bullet	bus days/252	8.8	1%
*Aug-24	various	-	bullet	bus days/252	8.7	1%
*May-35	various	-	bullet	bus days/252	6.0	1%
*May-45	various	-	bullet	bus days/252	1.1	0%
				TOTAL	962.4	

* Bonds only available for individual investors through "Tesouro Direto" program
Source: National Treasury, Barclays Research

Liquidity is often poor for NTN-Cs, as a sizeable portion of the outstanding bonds are held by buy-and-hold pension funds, which also have long-term IGP-M liabilities acquired in the past. NTN-Bs, on the other hand, trade up to USD2bn on a daily basis, depending on the tenor (Figure 5). NTNs are quoted on a yield basis using the Brazilian business/252-day count convention and annual compounding. All IPCA-linkers have 6% real coupons. However, due to the local convention, the effective coupon c' (paid every 6m) is given by: $c' = (1+c)^{\frac{1}{2}} - 1$, where c is the annual coupon.

Linkers have their principal indexed from a base date that does not coincide with the issuance date; it is set at July 15, 2000, for all NTN-Bs. Therefore, newly issued bonds start with a large inflation adjustment and a nominal invoice payment necessary to acquire a bond that is materially above par. The yield-to-price formula is given by:

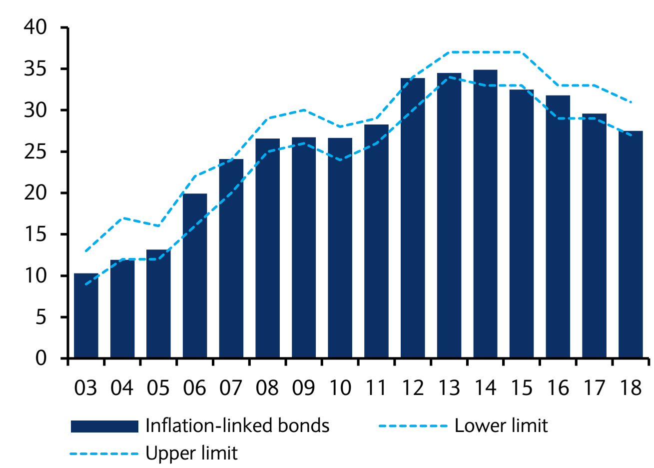
$$P_t = 1000 \frac{I'_t}{I_0} \left[\sum_{i=1}^{n} \frac{c'}{(1+Y)^{ti}} + \frac{1}{(1+Y)^{tn}} \right]$$

Where *t*, *ti* and *tn* are the times (Brazilian business/252-day convention) to settlement date, coupon dates, and maturity date, respectively; $c' = (1+c)^{\frac{1}{2}} - 1$ is the effective coupon; I_0 is the inflation index at the base date; I'_t is the current index level; Y is the quoted yield; and P_t is the current price of the bond.

Government debt structure

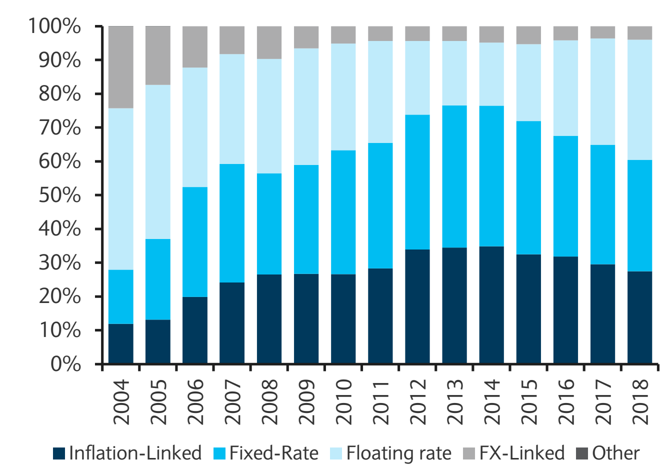
The federal government has worked on improving the quality of public debt since 2001, when the National Treasury started publishing the guidelines for annual debt through the Annual Borrowing Plan. Broadly speaking, its main aim was to minimize the debt's vulnerability, reduce the long-term financing costs and ensure the maintenance of prudent risk levels. From a more detailed perspective, we stress the aims of the most important measures: 1) gradually increase the proportion of fixed-rate and inflation-linked share of the debt while reducing that of the FX and Selic-rate shares; 2) lengthen the debt's maturity; and 3) implement both strategies reducing the average cost of debt.

FIGURE 7
Inflation-linked bonds (% federal government debt) and target (annual borrowing plan)



Source: National Treasury, Barclays Research

FIGURE 8
Federal public debt composition



Source: National Treasury, Barclays Research

Results of this strategy became more apparent during the 2000s: by 2014, the floating and FX-linked share of debt dropped significantly, to 24% of the total federal debt, from 72% 10 years earlier. The fixed-rate and inflation-linked components moved from 28% in 2004 to 76% at the end of 2014. From 2005 to date, the average duration of the public debt increased to 4.1y from 2.8y, while the yield of the government bonds declined considerably.

The debt management gains affected more than just public finances. Reducing the FX/Selic component enhanced the perception of fiscal solvency in periods of stress, such as H2 15. In previous crises, the stop-and-go cycle of foreign capital caused the depreciation of the BRL, leading the BCB to start a monetary policy tightening cycle to rein in inflation (observed and expected) and stem the process of currency depreciation. A weaker BRL and higher Selic rate would raise the debt-to-GDP ratio, feeding into a vicious cycle of worsening fundamentals and a weaker BRL. However, a larger share of fixed-rate and inflation-linked debt (smaller FX and Selic) broke this cycle, along with large international reserves.

Focusing on the evolution of the inflation-linked component, its share as a percentage of total federal debt grew to 35% by 2014, from 12% in 2004 (Figure 7 and Figure 8), although it recently declined to 27% at end-2018. Conversely, floating-rate bonds are regaining share since 2016 as the Treasury takes advantage of a historically-low Selic rate.

From 2005-15, the average duration of NTN-Bs increased from 4.9y to 7.7y, standing at 7.4y in December 2018, while the yield of IPCA-linked bonds dropped considerably. For example, the yield on the NTN-B maturing in May 2045 declined to 3.9% by end-2012 from 9% in late 2005 (Figure 10), and it is currently trading around 5%. In December 2018, foreign investors held 11.2% of federal domestic debt, but they are more concentrated in fixed-rate bonds (NTN-Fs) than in NTN-Bs. While they hold 53% of the outstanding stock of NTN-Fs, their share in NTN-Bs is less than 2%.

The Brazilian Treasury's 2019 Annual Borrowing Plan suggests the increasing share of floating-rate bonds (LFTs) will persist this year, at the expense of fixed-rate and inflation-linked bonds. According to the government, "The increase in the share of LFTs is directly related to the recurrent primary fiscal deficits. Despite representing greater exposure of public debt to variations on the reference interest rate (Selic), the LFTs are issued with maturities of around six years and thus avoid the concentration of maturities in the short term, serving as an alternative to short-term fixed-rate bonds." Moreover, the expected increase for 2019 in the relative share of floating-rate bonds "is more related to the low volume of maturing bonds than to an expectation of larger volumes of issuances compared to the previous year."

According to the financing plan, the total stock of outstanding debt in Brazil should rise in 2019 to, at most, BRL4.3tn (the lower bound is BRL4.1tn, from BRL3.9tn in 2018), of which the share of Selic-linked debt should increase to 38-42%, from 36% last year. Meanwhile, the sum of fixed-rate and inflation-linked debt should decrease to 53-61% from 60% in 2018 (inflation-linked bonds should reach 24-28% of the debt).

Taxation

Local residents in Brazil pay a withholding tax of 15-22.5% on the income from bonds, with the precise bracket depending on the holding period (22.5% if held for less than 180 days; 15% for periods above 720 days; and intermediate rates for holding periods in between).

Since early 2006, the withholding income tax rate applicable to sovereign local bonds has been set to zero for foreign investors not in tax havens (see *http://idg.receita.fazenda.gov.br/* for a list of these). Thus, qualifying foreign investors are exempt from withholding taxes. Non-resident investors domiciled in tax havens are taxed at the same rates as local investors.

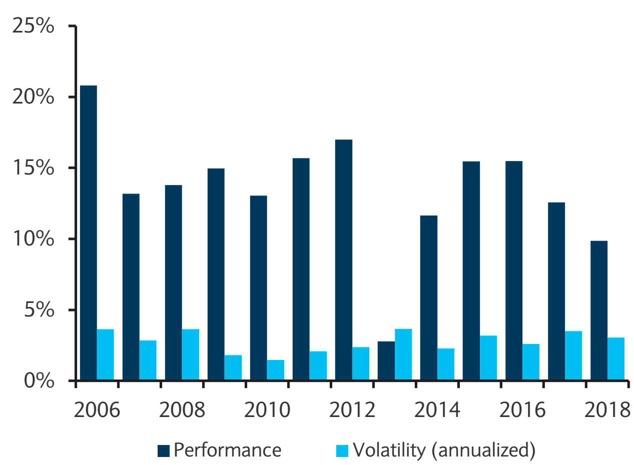
It is important to point out that a zero tax rate is different from a non-existent tax. Any new tax in Brazil has to be approved by the National Congress (both the Chamber of Deputies and the Senate), which could entail political costs. Therefore, it is much simpler for the executive branch to raise the rate on a tax that already exists. The IOF tax on foreign capital flows is a good example. In October 2009, the government raised the IOF tax for fixed income to 2% from zero; in October 2010, it raised it to 4%, finally hiking it to 6% less than 30 days later. The tax is now zero again on all fixed-income inflows (except on external loans with a maturity of less than 180 days); foreign direct investment has always been exempt from the IOF tax. Also, in December 2011, the government reduced the IOF tax levied on foreign equity inflows to zero from 2.0%. There is no discrimination between long- and short-term flows.

In July 2011, the government announced a new IOF tax on local USD derivatives markets. It was levied on all derivatives contracts with settlements that were influenced by FX changes (ie, USD options, futures and FRAs), so it was not applied to local deposit rates, commodities or other contracts. The 1% IOF was also levied on domestic investors to prevent increases in short USD positions, but the government has lowered it back to zero.

These measures were aimed at containing BRL appreciation, given government concerns over the industrial sector's performance and competitiveness and the country's overall growth rate. The government started to unwind theses measures when market turmoil related to Fed tapering monetary stimulus placed significant pressure on EM FX in 2013. However, in any event, the taxation of foreign flows remains in the government's toolkit.

FIGURE 9

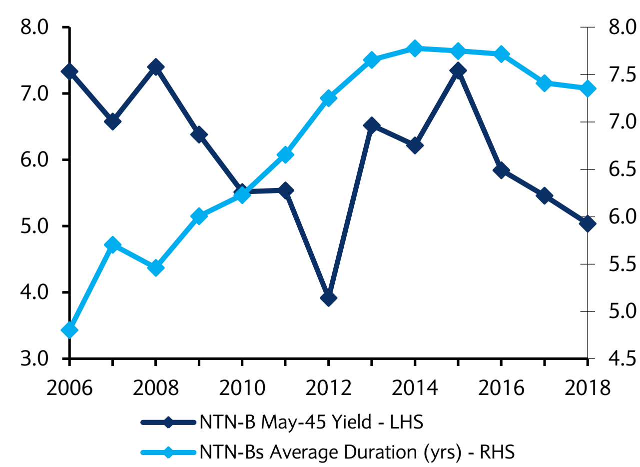
Performance and annual volatility of IMA-B 5*



Note: *IMA-B 5 is an index created by ANBIMA to value a portfolio of NTN-Bs with bonds maturing in up to 5y. Source: Bloomberg, Barclays Research

FIGURE 10

IPCA-linked debt duration and NTN-B May45 yield



Source: National Treasury, Bloomberg, Barclays Research

Other inflation-linked assets and derivatives

The market for corporate linkers in Brazil remains underdeveloped, with limited interest from foreign investors. This largely reflects low liquidity. Moreover, foreign investors do not enjoy the exemption from withholding taxes when purchasing private debt instruments (non-government inflation linkers are included here), which they benefited from when buying government debt.

In late 2010, however, the Brazilian government announced a set of measures to encourage long-term financing in Brazil, by basically creating incentives to foster investment projects in the country. The measures comprised two main parts: tax incentives for long-term corporate bonds earmarked for investment projects, and the creation of a fund to stimulate the liquidity of those bonds in the secondary market.

Households and foreign investors purchasing long-term fixed-rate or inflation-linked bonds that were linked to investment projects and had a minimum duration of four years became exempt from withholding taxes. In December 2011, the government also cut the IOF tax on foreign inflows for infrastructure debentures to zero from 6%.

According to ANBIMA, the inflation-linked market (private and government) represents c.23% of the total fixed income market. The government is by far the largest presence, accounting for 90% of those bonds, which leaves private issuance at 10%. Among the private fixed income market, inflation-linked assets account for 13%

On the derivatives side, onshore inflation-linked swaps over IPCA and IGP-M are available, but with very limited liquidity and concentrated on short tenors (up to 2y). Longer tenors may be found with very large bid/ask spreads or coinciding with the maturity dates of bonds. These swaps can be registered in CETIP (OTC) or BM&F (the main local exchange) and are usually traded as zero coupon, but can also be coupon bearing. The leg of the swap linked to inflation pays the changes in the inflation index plus a real rate coupon that is quoted at the onset of the trade. The other leg of the swap is usually the accumulated overnight rate (CDI), as is the case for the IPCA futures contract (WLA <Index> on Bloomberg), but it can also be fixed Libor plus spread or other formats.

Offshore total-return swaps are common for foreign investors looking to work around the burden of opening and managing local accounts in Brazil. Dealers with an onshore presence buy the bonds on their books and pass the total return to offshore investors though an ISDA swap. The funding leg of the swap may be CDI, the local overnight rate, or Libor, if the client wants to keep the FX exposure along with the local interest rate exposure. The reimplementation and subsequent increases in the IOF tax significantly increased international investors' interest in total-return swaps. Regular offshore swaps against CDI or Libor may also be found on a limited basis and with fairly wide bid/ask spreads. Since the local inflation swap market is not well developed, the few dealers quoting the offshore swap need duration hedges using the local linkers, leaving their books with basis risk and cash flow mismatches.

INFLATION MARKETS

Mexico

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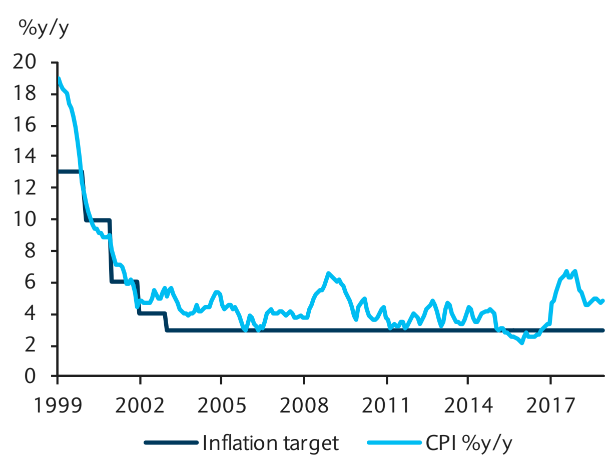
Mexico has been issuing inflation-linked bonds (UDIBonos) since 1996, with maturities close to 30 years. These securities represented 25% of outstanding government domestic bond debt as of January 2019 (UDI272bn, c.USD89bn equivalent). The investment unit (UDI) is unusual in that it fixes off a CPI index that is published twice monthly, rather than monthly. Pension funds are the largest holders of government UDIBonos with 51% of the total, while foreigners hold about 3.2% as of January 2019, despite no restrictions or withholding tax for international investors.

Indexation

Mexico's current inflation-linked bond market started in May 1996 as a result of the "Tequila crisis" in late 1994, as higher inflation led to accelerated amortisation of loans in real terms. This created an incentive to issue credit in UDI (unidad de inversion, or investment unit) to preserve real value. The central bank (Bank of Mexico, or Banxico) adopted an inflation-targeting regime in 1999 with an initial 13% target for that year, but with the objective of bringing inflation down to 3% by 2003 and beyond. The latter has remained the target with a tolerance range of +/- 1%. As Figure 1 shows, Banxico has been fairly successful not only in obtaining the desired disinflationary path, but also in keeping inflation within the tolerance band. Deviations from target are usually above the upper band due to supply shocks from perishable food prices and, more recently, gasoline price adjustments, which are usually administered by the Ministry of Finance through changes in the implicit tax given a certain retail sale price.

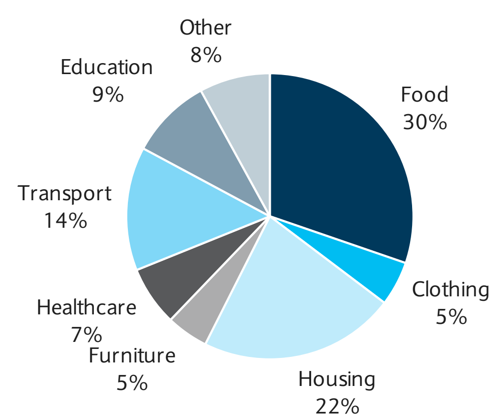
Mexico CPI (Indice Nacional de Precios al Consumidor – INPC), which was released by the Banxico until 2011, is currently calculated bi-weekly by the National Statistics Institute (INEGI), which releases the data on its webpage (www.inegi.org.mx) according to an annual calendar. The release occurs close to the 10th and 25th days of each month for the previous fortnight. The CPI considers fixed weights, and the survey methodology was updated in 2018. The index is based on the second fortnight of July 2018 and is built on a representative consumption basket from household expenditure surveys made between 2012 and 2014. Price information is collected in 55 cities and metropolitan areas. As Figure

FIGURE 1
Inflation dynamics



Source: INEGI, Banxico, Barclays Research

FIGURE 2
Current CPI weights*



*Last update was on July 2018. Source: INEGI, Banxico, Barclays Research

2 shows, the food component has the heaviest weight in the index (30%), followed by housing (22%). INEGI also reports a breakdown of the headline index into core (75.6% of the total) and non-core (24.4%) items. While core inflation is fairly stable over time, non-core prices inject considerable volatility to the index, particularly of perishable food items.

UDIBonos have a face value of 100 UDIs (ie, one hundred investment units). The value of the UDI is adjusted according to observed inflation; it is currently 6.245026 MXN per UDI (as of January 25, 2019, MXUDI Index in Bloomberg; see Appendix for the UDI calculation).

UDIBonos can be issued for any term as long as it is a multiple of 182 days, since the securities pay interest in pesos every six months. The real interest rate that these securities pay is fixed by the federal government upon issuance and is specified in the auction announcement. Interest is calculated given the days elapsed between payment dates, on the basis of a 360-day year, and paid at the end of each payment period.

$$I_J = VN * N_J * \frac{TC}{360}$$

Where:

I_J = Interest to be paid at the end of period J

TC = Annual coupon interest rate

VN = Face value of the security in investment units (UDIs)

N_J = Term in days of coupon J

The securities are placed through auctions in which participants submit bids for the amount they desire to purchase at the price they are willing to pay denominated in UDIs. In the primary auctions, the federal government often offers securities originally issued prior to their auction date. In these cases, auctions are carried out at clean prices (with no accrued interest), which means that investors have to add the accrued interest of the current coupon to the allotted price according to the following formula:

$$I_{accJ} = VN * d * \frac{TC}{360}$$

Where:

I_{accJ}= Accrued interest (rounded up to 12 decimal points and in UDIs) during period J

d= Days elapsed between the issue date or the last interest rate period (J – 1), whichever applies, and the valuation date.

For the purposes of the placement, interest payments and amortization, the conversion to domestic currency is at the value of the UDI on the day corresponding payments are made. The UDI Index (MXUDI Index <Go> in Bloomberg) is released twice per month by Banxico. It is a function of the bi-weekly inflation index and dates back to April 4, 1995. By day 10 of each month, Banxico publishes index values for the period between days 11 and 25 of that month. On day 25, it publishes values for the period between days 26 of the month and day 10 of the next month. In each period, the UDI Index changes by the daily geometric equivalent of the corresponding bi-weekly inflation rate according to:

$$UDI_t = UDI_{t-1} \times (1+\pi)^{1/n},$$

where π is the most recent reported bi-weekly inflation rate and n is the number of days between the releases (see Appendix for details).

The UDIBonos market

The UDIBonos are UDI-denominated euro-clearable semi-annual (182-day) coupon-bearing bonds auctioned by Banxico as agent of the Treasury (MUDI Govt <Go> in Bloomberg). As of January 10, 2019, c.UDI272bn notional (approximately MXN1,697bn or USD88bn) of these bonds was outstanding. UDIBonos represent 24.7% of the c.MXN6.871trn (USD360bn) of Mexican government domestic bond debt outstanding (includes Cetes, MBonos, UDIBonos and Bondes D), a historical high proportion and a substantial increase from its lower level of 8% in 2004. The government remains interested in developing the UDI market in light of pension funds' need to hedge inflation-linked liabilities.

UDIBonos are quoted in real yields, with a typical bid-ask spread of 1.5-3bp; liquidity as of January 2019 was concentrated in the on-the-run Dec25 and Nov40 issues. The average trade ticket is MXN20mn. Given their bullet structures, the real yield calculation is simply the yield-to-maturity of the bond quoted in UDI. The total return will depend on the realisation of the UDI Index, which will affect the interest accrued and principal of the bond. Hence, other than the half-monthly inflation periods and short lag, the calculations are conceptually similar to those of the Canadian model.

FIGURE 3
UDIBonos issued

Maturity Date	Issue date	Coupon	Coupon freq.	Day count	Outstanding (UDI bn)	% of total
Jun-19	Jul-09	4.00	Semi- annual	act/360	29.7	11.1
Dec-20	Feb-11	2.50	Semi- annual	act/360	35.8	13.4
Jun-22	Aug-12	2.00	Semi- annual	act/360	32.2	12.1
Dec-25	Dec-05	4.50	Semi- annual	act/360	42.6	16.0
Nov-28	Apr-17	4.00	Semi- annual	act/360	21.3	8.0
Nov-35	Dec-05	4.50	Semi- annual	act/360	23.1	8.7
Nov-40	Mar-10	4.00	Semi- annual	act/360	45.1	16.9
Nov-46	Jun-14	4.00	Semi- annual	act/360	36.6	13.7

Source: Bloomberg, Barclays Research

As of January 10, 2019, domestic investors held 97% of the total outstanding amount of UDIBonos, with local pension funds the single key holders (52% of the total). Foreign investors, who are not subject to withholding taxes or any other local Mexican taxes on purchasing government securities, held just 3% of the outstanding amount of these bonds, an important decrease from its peak of 16% in April 2013.

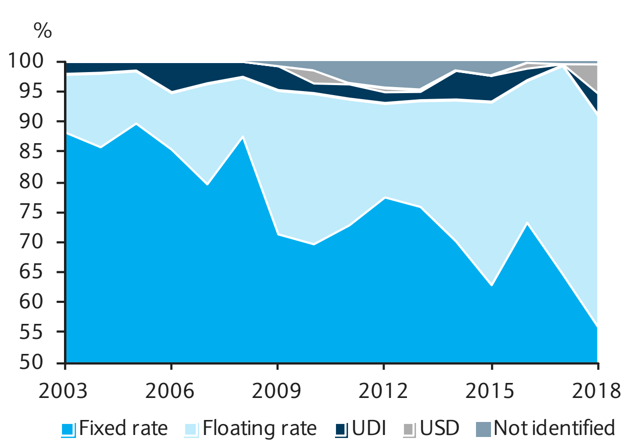
Inflation derivatives and non-government UDI debt

OTC inflation-linked swaps are traded in UDI/Libor and UDI/TIIE formats. The former are offshore fixed real-for-floating cross-currency swaps, with one counterparty paying/receiving a fixed UDI rate (semi-annual, Act/360) and the other receiving/paying a six-month USD Libor floating rate. Cross-currency basis risk is present in this type of swap. UDI/TIIE swaps are fixed-for-floating real rate swaps, in which one counterparty pays/receives a fixed UDI (real) rate and the other receives/pays the 28-day TIIE floating nominal rate. In both formats, the notional amount is exchanged at the start of the contract. In general, liquidity is lower than in the UDIBonos market, with typical bid/ask spreads of around 20bp. 5y and 10y maturities exhibit the most liquidity, while 30k/50k DV01 are traded weekly.

Private sector issuance of medium- and long-term UDI-denominated securities has been on the rise since 2003; nonetheless, it has a fairly stable participation rate in relation to other instruments, constituting 3.8% of total private sector issuance on average (Figure 4). UDI-denominated debt gained momentum between 2006 and 2008, but much of this acceleration came from issuance securitised against inflation-linked mortgages, a flow that fell away as global credit conditions deteriorated in the second half of 2008. Momentum returned from late 2009 to mid-2010 and resurged again in 2014 to 2015: while historical average monthly issuance was UDI0.5bn during those periods, the monthly average reached UDI0.8bn. At the end of 2018, the market showed some dynamism as they issued UDI1.6bn in the last two months of the year.

FIGURE 4

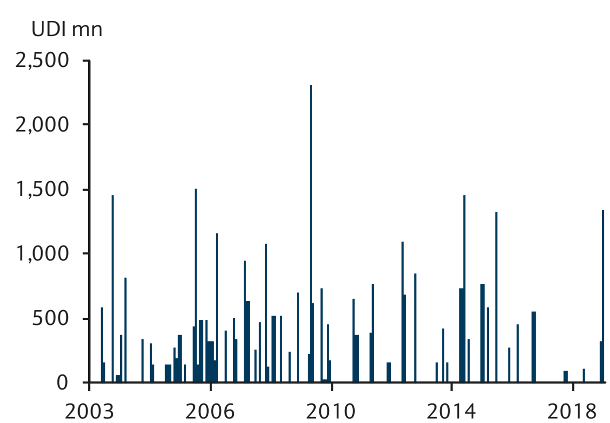
Private sector annual debt issuance by instruments



Note: Data up to December 2018. Source: Banxico, Barclays Research

FIGURE 5

Monthly private UDI debt issuance



Note: Data up to December 2018. Source: Banxico, Barclays Research

Appendix: UDI calculation

The UDI is calculated as follows:

$$UDI_{d,m} = UDI_{d-1,m} * \sqrt[n]{\frac{CPI_q}{CPI_{q-1}}}$$

Where:

d= Number of the day of the month "m"

m=month corresponding to "d"

$UDI_{d,m}$ =UDI value at day "d" month "m"

Depending on the number of day "d", the formula it is adjusted and considers different CPIs:

1. For days between the 11th and 25th day of the month "m"

n=15

CPI_q=Consumer Price Index of the second fortnight of the month immediately previous to month "m".

CPI_{q-1}=Consumer price index of the first fortnight of the month immediately previous to month "m".

2. For days between the 26th of month "m" and the 10th day of month "m + 1"

n=Number of days between the 26th day of month "m" until the 10th day of the month "m + 1".

CPI_q=Consumer Price Index of the first fortnight of the month "m".

CPI_{q-1}=Consumer price index of the second fortnight of the immediate previous month to month "m".

3. For days between the 1st day and the 10th day of month "m".

n=Number of days between the 1st day and the 10th day of month "m".

CPI_q=Consumer Price Index of the first fortnight of the month immediately previous to month "m".

CPI_{q-1}=Consumer price index of the second fortnight of the second month before month "m".

Argentina

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The change in government in December 2015, the subsequent change in leadership at the national statistics agency (INDEC), and the implementation of an inflation-targeting regime renewed interest in inflation linkers in Argentina. We expect issuance of inflation-linked instruments, such as the new BONCER and ARGCER, to continue.

CER inflation-linked index

Inflation-linked bonds were first issued in 2002 and linked to consumer prices via the Coeficiente de Estabilización de Referencia Index (CER). This index, launched in February 2002, is published daily by the central bank and calculated using the geometric mean of the changes in the consumer price index (CPI), with a one-month lag. CPI is calculated by the Instituto Nacional de Estadistica y Censos (INDEC), while the CER is calculated by the central bank.

Since July 16, 2017, the CER has been based on a new National CPI index, launched by INDEC in that month. The National CPI measures price levels across the entire country. The base of the index is December 2016. The survey on which it is based is taken in 24 provinces of the country, plus additional cities for a total of 39 urban areas. This permits the disaggregation of the index into six regional areas: GBA, Cuyo, Northeast, Northwest, Pampean and Patagonia. The new methodology adopted the UN Statistics Division's COICOP international consumption classification structure, enabling the data to be disaggregated into 12 different groups, as opposed to the nine reported in the previous IPC-GBA index. The new CPI index is broken down into the following groups (weights in parentheses): food and non-alcoholic beverages (27%); alcoholic beverages and tobacco (4%); clothing and footwear (10%); housing, water, electricity, gas and other fuels (9%); household equipment and maintenance (6%); health (8%); transport (11%); communication (3%); recreation and culture (7%); education (2%); restaurants and hotels (9%); and other goods and services (4%). Within the first 10 working days of each month, INDEC publishes the index for the previous month.

Prior to the current CPI Index, which has national coverage, the CER was calculated using CPI measures published by INDEC that were based on prices surveyed for the Greater Buenos Aires Metropolitan Area. The exception was the period between March 26 and June 25, 2016, during which the CER index was based on the CPI of the province of San Luis. This exception was a result of the fact that following the change in government in December 2015, the new leadership of the INDEC declared a statistical emergency. CPI statistics were deemed unreliable until the new CPI series was adopted and published.

The CER-linked bond market

As of September 2018, government CER-linked debt totalled USD16.4bn (including loans and other non-marketable debt), or 5.4% of Argentina's total outstanding debt.

Argentina's government had stopped issuing inflation-linked debt in 2005. The earlier controversy over the measurement of the CPI eroded the appeal of this market to institutional and other long-term investors, at whom these assets were originally targeted. In addition, the nationalisation of pension funds in October 2008 reduced the traditional sources of demand for this kind of instrument.

However, the Macri administration, which took office in 2015, successfully resumed the issuance of CPI-linked debt in July 2016, with a BONCER issuance, followed by other tenures of the same bond that were less liquid than the first. In March 2018, the Treasury issued the ARGCER, a bond with a trigger clause that in practical terms has become an inflation-linker.

The structure of Argentina's marketable inflation-linked debt can be summarised as follows:

1. Bono del Tesoro con Ajuste por CER (BONCER)
2. Bonos de la Nación Argentina con Ajuste por CER (ARGCER)
3. Bonos de reestructuración (par/discount/quasi par)
4. Bonos de Consolidación (BOCON)
5. Bonos Garantizados (BOGAR)

1. Bonos del Tesoro con Ajuste por CER (BONCER)

In July 2016, Argentina's government issued ARS 8.23bn of BONCER – a Treasury bond with CER adjustment that matures in 2021. BONCER pays a 2.5% annual coupon semi-annually (on 22 January and 22 July) until maturity. This is the most liquid of all BONCERs. Other BONCERs have been issued, but are held mostly by the national pension fund (Anses), and liquidity in the secondary market is limited.

FIGURE 1
BONCER bonds structure

Bond	CCY	Issue date	Maturity	Type	Coupon	Amortization
BONCER 2021	ARS	July 18, 2016; reopening Aug 18, 2016	Jul 22, 2021	Bullet	2.5% S/A; 30/360	Am: Fully amortized on maturity. The capital will be adjusted by the value of CER.
BONCER 2020	ARS	Oct 28, 2016	Oct 28, 2020	Bullet	2.50% S/A; 30/360	Am: Fully amortized on maturity. The capital will be adjusted by the value of CER.
BONCER 2019	ARS	Dec 15, 2017	Apr 15, 2019	Bullet	4.25% S/A; 30/360	Am: Fully amortized on maturity. The capital will be adjusted by the value of CER.
BONCER 2023	ARS	Mar 6, 2018	Mar 6, 2023	Bullet	4% S/A; 30/360	Am: Fully amortized on maturity. The capital will be adjusted as per adjustment clause.
BONCER 2025	ARS	Apr 27, 2018	Apr 27, 2025	Bullet	4% S/A; 30/360	Am: Fully amortized on maturity. The capital will be adjusted as per adjustment clause.

Source: Ministerio de Economia y Finanzas, Barclays Research

2. Bonos de la Nación Argentina con Ajuste por CER (ARGCER)

In February and March 2018, Argentina issued ARGCER 2019 and ARGCER 2020, respectively. These bonds are generally known as "Gatillo", or trigger-clause bonds. The ARGCER 2019 has already matured. The ARGCER 2020 is not strictly an inflation-linker, but becomes one if inflation between March 2018 and March 2019 is above a breakeven threshold. In practical terms, this bond has already become an inflation-linker, considering that inflation has printed 30.8% between March 2018 and December 2018. The ARGCER 2020 bond pays upon maturity the greater of 1) the amortization plus the capitalized interests at a nominal monthly rate of 1.6012% and 2) the original amount of capital adjusted by CER + 4%.

FIGURE 2

ARGCER bond structure

Bond	CCY	Issue date	Maturity	Type	Interest payment/ Payment conditions	Amortization
ARGCER 2020	ARS	Mar 6, 2018	Mar 6, 2020	Bullet	*Interest:* Nominal monthly rate of 1.6012%, that capitalizes monthly from the issue date until maturity. *Payment condition:* on the maturity date, the payout will be the greater between 1) the nominal value adjusted by CER plus interests capitalized monthly between March 6, 2019, and March 6, 2020 exclusive, and 2) the nominal value adjusted by CER + 4%.	Am: Fully amortized on maturity.

Source: Ministerio de Economia y Finanzas, Barclays Research

3. Bonos de reestructuración (par/discounts/quasi par)

In February 2005, Argentina extended a global exchange offer to holders of its defaulted debt. Of the USD82bn of eligible debt, about 76% was tendered by holders, who, in exchange, received par, discount, or quasi-par bonds denominated in ARS, USD, EUR or JPY. Discount and quasi-par bonds carried haircuts of 66.3% and 30.1%, respectively. All of these bonds incorporated a GDP-linked unit (or GDP warrant, as it is usually called in the market), which began to trade separately in November 2005. The government also issued par/discounts and quasi-pars regulated by Argentine local law and linked to inflation. The pars and quasi-pars were targeted at long-term local investors. As a result, trading in those bonds is less liquid than in the discount (particularly in the quasi-par, which was customised for buy-and-hold private pension funds). Figure 3 summarises the structure of these bonds.

FIGURE 3

Par/discount and quasi-par bond structure

Bond	CCY	Issue date	Maturity	Type	Coupon	Amortization
Par	CER	31 Dec 03	31 Dec 38	Step-up cpn/ sinking fund	0.63% first 5y, 1.18% 6-15y, 1.77% 16-25y, 2.48% thereafter*. S/A; 30/360	20 equal S/A instalments starting June 30, 2029
Discount	CER	31 Dec 03	31 Dec 33	Step-up cpn/sinking fund/capitalised	2.79% first 5y, 4.06% 6-10y, 5.83% thereafter*. S/A; 30/360*	20 equal S/A instalments, starting September 30, 2024 - Cap: 3.04% first 5y, 1.77% 6-10y, 0% thereafter
Quasi-par	CER	31 Dec 03	31 Dec 45	Step-up cpn/sinking fund/capitalised	0% in the first 10y, 3.31% thereafter*. S/A; 30/360	20 equal S/A instalments, starting June 30, 2034. - Cap: interest fully capitalised in the first 10y

Note: *Principal is adjusted for inflation using CER Index (T-10 business days)/Initial CER (1.4549). Source: Ministerio de Economia y Finanzas, Barclays Research.

4. Bonos de Consolidación (BOCON)

Bonos de Consolidación (BOCON) were issued by the national government to restructure its obligations to pensioners and suppliers. They are divided into Bocones de Deudas Previsionales (Pre 8 and Pre 9) and Provedores (Pro 11, Pro 13 and Pro 12). The Pre 08 and Pro 12 are the most liquid BOCON bonds.

An earlier series of BOCON was issued as reparation to families of victims who were jailed or "disappeared" during the military dictatorship. Re-openings of BOCON have taken place opportunistically over the past few years for amounts within those originally authorised in 2002 or for additional amounts authorised through new decrees. Individual re-openings are not reported. Figure 4 summarises the structure of some of the most liquid BOCON issues.

FIGURE 4
BOCONs structure

Bond	CCY	Issue date	Maturity	Type	Coupon	Amortization
PRO 13	CER	15 Mar 04	15 Mar 24	Sinking fund	2%* monthly; 30/360	Am: 120 equal monthly instalments of 0,83% except the last one of 1.23%, starting April 15, 2014

Note: *Principal is adjusted for inflation using CER index (T-10 business days). Source: Ministerio de Economia y Finanzas, Barclays Research

5. Bonos Garantizados (BOGAR)

Issued by the Fondo Fiduciario de Desarrollo Provincial (a trust), BOGAR bonds were used to restructure the debt of a number of provinces. Payment is secured by government guarantee, which, in turn, is secured by a pledge of up to 15% of the province's portion of shared tax revenues. Beyond that, payment is guaranteed by central government, the financial intermediation tax and remaining fiscal resources (net of what corresponds to the state-managed social security system).

FIGURE 5
BOGAR structure

Bond	CCY	Issue date	Maturity	Type	Coupon	Amortisation
BOGAR18	ARS	4 Feb 02	4 Feb 18	Sinking fund	2%* monthly; Actual/365	156 monthly rising payments, starting March 4, 2005, capitalised thru September 4, 2002
BOGAR20	ARS	4 Feb 02	4 Oct 20	Partially capitalised	2%* monthly; Actual/365	Partially capitalised: first 3y of the 2% cpn: 60% will be paid in cash, 10% will be capitalised and 30% represents the haircut. From February 4, 2005-August 4, 2005, the 2% coupon was capitalised. Paid in cash thereafter.

Note: *Principal is adjusted for inflation using CER index (T-5 business days)/Initial CER (0.9999). Source: Mecon

CER and real yield calculations

CER calculation

CER are units of account, whose value in pesos is indexed to the Argentine CPI. The CER index was fixed at 1 ARS on 2 February 2002 and tracks the Argentine CPI with a one-month lag:

$CER_t = F_t * CER_{t-1}$ where F_t is Daily CER factor

The Daily CER factor F_t is calculated as follows:

a) $F_t = \left(CPI_{j-2} / CPI_{j-3}\right)^{1/k}$ for days 1-6 of each month, the CER is based on the geometric mean of CPI variation, between the second and third month previous to the current month;

b) $F_t = \left(CPI_{j-1} / CPI_{j-2}\right)^{1/k}$ for day 7 to the last day of each month, the CER is based on the geometric mean of CPI variation during the previous month,

where *k* is the number of days in the current month and *j* is the current month.

The CER time series may be viewed on Bloomberg using the code ACERCER <Index>.

Real yield-to-maturity calculation

To calculate the real yield to maturity for CER-linked bonds, the first step is to set up the entire real cash flows structure (including amortisation and capitalisation). Because these real cash flows are essentially deterministic, to calculate the real yield to maturity, it is sufficient to solve for R in the equation:

$$Price = \sum_{t=1}^{n} \frac{c(t)}{(1+R/q)^{qt}}$$

Where $c(t)$ is the cash flow at time t (in years) and R is the real yield to maturity q -compounded.

The only complication in this formula is adjusting the quoted all-in peso market price to take into account the change in the CER Index since inception:

$$Price = \frac{Mkt\,Price}{CER_{T-d} / CER_0}$$

where $Mkt\,Price$ is the peso price quoted, CER_{T-d} is the index level for T-d (where T is the payment and d specific number of days) and CER_0 is the base index level, fixed at inception of the specific bond. Figure 6 summarises $\frac{CER_{T-d}}{CER_0}$ for the most liquid CER-linked bonds:

FIGURE 6

Change in CER Index adjustment

Bond	CER Index at issuance	Settlement convention
BONCER 21	6.2639	T-10
BODEN 14	1.5178	T-10
par, DISC	1.4549	T-10
BOGAR 18	0.999	T-5

Note: T= payment date, d number of days. Source: Ministerio de Economia y Finanzas, Bloomberg, Barclays Research

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The use of inflation-indexation is widespread in the Chilean economy. After the introduction of the unidad de fomento (UF) in the 1960s, the role of the UF as a unit of account grew significantly. Domestic debt instruments are mostly UF-denominated, and there is a liquid market for UF-linked derivatives. In terms of government debt, both the Treasury and the Central Bank (BCCh) issue inflation-linked debt.

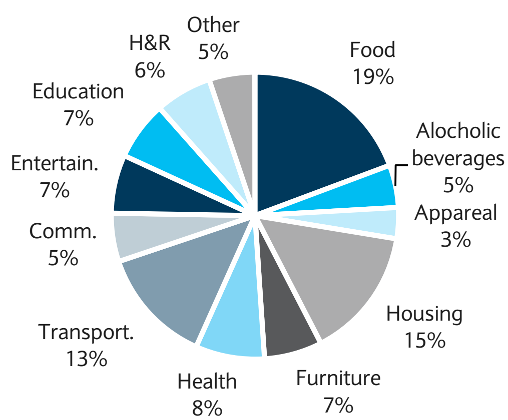
Indexation: An inflation-linked product pioneer

In 1959, Chile's economy underwent an ambitious liberalization program that included, among other measures, the deregulation of the financial sector. Interest rate ceilings and high inflation resulting in years of negative real rates had a negative effect on Chileans' propensity to save. Policies such as the indexation of savings accounts by the state-owned bank, the issuance of inflation-indexed bonds, and, crucially, the creation of the "unidad de fomento" (UF) in 1967, the world's first successful indexed unit of account[1], made the recovery of savings possible; private financial savings grew from less than 1% of GDP in 1965 to 2% in 1971 and today represents.

Since the 1960s, the role of the UF as a unit of account in Chile's economy has consistently expanded, with mortgages, car loans, taxes, pension payments, real estate, and even child support payments UF-denominated; most 90-day bank deposits offer rates in terms of UF, and 93% of the corporate bonds outstanding at year-end 2018 were UF-denominated. Finally, around 48% of government debt outstanding is UF-linked.

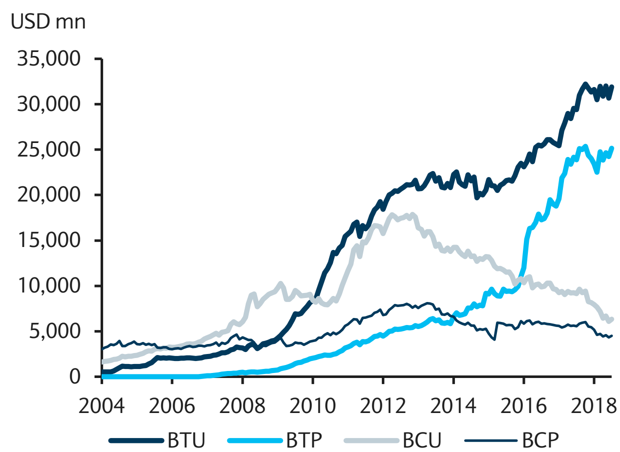
Widespread use of CPI indexation in Chile stems from the hyperinflation of the 1950s. Today, the central bank targets a 3% inflation target (+/-1%) over a two-year horizon. The BCCh's ample credibility is reflected in inflation expectations as measured by the BCCh's survey firmly anchored at 3% throughout the 2y policy horizon.

FIGURE 1
CPI based 2018=100 weights



Source: INE, Barclays Research

FIGURE 2
Cumulative BCCh and government bond issuance (USD mn)



Note: Data as of November 2018. Source: BCCh, Barclays Research

[1] Shiller, Robert J. (1998). "Indexed Units of Account: Theory and Assessment of Historical Experience," *Cowles Foundation Discussion Paper No. 1171*.

The CPI is calculated by the National Institute of Statistics (INE). During the first eight days of each month, INE releases the previous month's CPI. To measure CPI, INE calculates a weighted average of price changes of a set of products. Each product's price is weighted by its relative importance in a basket of goods and services chosen to reflect the consumption of the typical urban household. With the data released on 8 February 2019, this basket will reflect new weights from the latest consumption survey conducted in 2016 and 2017. The base of the new index is set in 2018. CPI releases are not subject to revisions.

Since 1967, inflation indexation has been based almost exclusively on the UF. The UF is a lagged interpolation of the monthly CPI, and has been subject to daily adjustments since 1977. The UF Index (CHUF Index <go> on Bloomberg) is calculated and published by the central bank. The formula for computation of the UF on day t is:

$$UF_t = UF_{t-1} \times (1+\pi)^{1/d}$$

where π is the inflation rate for the second calendar month preceding the calendar month in which *t* falls, if *t* is between the first and the ninth day of the month, and the calendar month preceding the calendar month in which *t* falls, if *t* falls between the 10th and last day of the month. *d* is the number of days in the calendar month in which *t* falls, and the inflation rate is rounded to one decimal place. Because the inflation rate for a calendar month depends on the CPI for that month and the preceding month, in any calendar month the UF will depend on the CPI of each of the three preceding months.

The UF-linked bond market

In Chile, both the Treasury and the BCCh issue inflation-linked debt. Public sector issuance of UF-linked debt has been decreasing since 2012, particularly in the case of the central bank. Although the BCCh historically had been the largest issuer of inflation-linked bonds, since 2010 the Treasury has become the country's main indexed bond issuer. Since August 2002, the BCCh has been actively seeking to re-profile domestic public debt, and since 2009, it has almost exclusively issued CLP-denominated debt, including BCPs, and avoided issuing such instruments as inflation-linked PRBCs (5y, zero-coupon 'pagares'), PTFs (floating rate 'pagares'), and PRCs (coupon-bearing 4y/20y 'pagares'). However, when the BCCh has sought to influence the FX market via sterilized interventions, it has issued inflation-linked bonds or BCUs ('Bonos del Banco Central de Chile'; BCUCL Govt <go> in Bloomberg). These bonds are standard bullet bonds with semi-annual interest payments, issued in tenors of 5y, 10y, 20y and 30y. As of November 2018, UF-linked debt amounted to 28% of the BCCh's total debt, a significant decline from the 57% that averaged in 2012. In fact, there has not been any new issuance since August 2013.

As noted, the Chilean government issues BTUs ('Bonos de la Tesoreria General de la Republica en UF'; BTUCL Govt <go> on Bloomberg) using the BCCh as its agent. BTUs are UF-denominated standard bullet bonds. The government's supply of debt depends on Chile's financing needs. On the demand side, the market for inflation-linked bonds is dominated by local pension funds.

FIGURE 3

BCUs and BTUs outstanding

Maturity date	Issue date	Coupon	Coupon frequency	Day count	Outstanding UF (mn)	% total
BCUs						
May-19	May-09	3.00	Semi-annual	act/365	1.0	0.6
Feb-21	Feb-11	3.00	Semi-annual	act/365	44.0	28.4
Mar-22	Mar-12	3.00	Semi-annual	act/365	23.0	14.9
Sep-22	Sep-02	5.00	Semi-annual	act/365	8.4	5.4
Mar-23	Mar-13	3.00	Semi-annual	act/365	11.0	7.1
May-28	May-08	3.00	Semi-annual	act/365	11.5	7.4
Feb-31	Feb-11	3.00	Semi-annual	act/365	28.0	18.1
Feb-41	Feb-11	3.00	Semi-annual	act/365	28.0	18.1
				TOTAL	154.8	

Maturity date	Issue date	Coupon	Coupon frequency	Day count	Outstanding UF (mn)	% total
BTUs						
Jul-19	Jul-09	3.00	Semi-annual	act/365	9.3	1.2
Jan-20	Jan-10	3.00	Semi-annual	act/365	15.1	1.9
Mar-21	Mar-15	1.50	Semi-annual	act/365	122.5	15.8
Jan-22	Jan-12	3.00	Semi-annual	act/365	1.7	0.2
Mar-23	Mar-18	1.30	Semi-annual	act/365	25.9	3.3
Oct-23	Oct-03	4.50	Semi-annual	act/365	9.1	1.2
Jan-24	May-14	3.00	Semi-annual	act/365	2.9	0.4
Aug-24	Sep-04	4.50	Semi-annual	act/365	4.0	0.5
Sep-25	Sep-05	2.60	Semi-annual	act/365	0.9	0.1
Mar-26	May-15	1.50	Semi-annual	act/365	182.3	23.5
Mar-27	Mar-07	3.00	Semi-annual	act/365	0.4	0.0
Mar-28	Mar-08	3.00	Semi-annual	act/365	1.4	0.2
Mar-29	Mar-09	3.00	Semi-annual	act/365	1.0	0.1
Jan-30	Jan-10	3.00	Semi-annual	act/365	4.5	0.6
Sep-30	Mar-18	1.90	Semi-annual	act/365	23.3	3.0
Jan-32	Jan-12	3.00	Semi-annual	act/365	2.5	0.3
Jan-34	May-14	3.00	Semi-annual	act/365	0.8	0.1
Mar-35	Mar-15	2.00	Semi-annual	act/365	150.8	19.5
Mar-38	Mar-08	3.00	Semi-annual	act/365	3.3	0.4
Mar-39	Mar-09	3.00	Semi-annual	act/365	5.1	0.7
Jan-40	Jan-10	3.00	Semi-annual	act/365	24.7	3.2
Jan-42	Jan-12	3.00	Semi-annual	act/365	13.5	1.7
Jan-44	May-14	3.00	Semi-annual	act/365	163.9	21.1
Jul-50	Jan-19	2.10	Semi-annual	act/365	6.3	0.8
				TOTAL	774.8	

Source: Bloomberg, Barclays Research

Chile applies a flat 4% tax on interest earned by foreigners in the domestic market. This rate applies to the BCU rate, not to earnings (in general, the Chilean tax system considers tax bases that are CPI deflated). Capital gains, however, are subject to more cumbersome treatment. The general rule for bonds is that they pay the general income tax, which is 35% for foreigners. However, if the investor is domiciled in a country with which Chile has a double-taxation treaty, the tax is zero.

UF derivatives

Linkers also have a presence in derivatives. In particular, there are two swaps traded OTC that involve inflation-linked instruments: the UF/Camara swap; and the UF/Libor swap. The UF/Camara swap is a fixed-for-floating contract in which one of the counterparties pays/receives a fixed UF rate, while the other counterparty receives/pays a floating nominal rate that depends on the 'Indice de Camara Promedio' (ICP). The ICP Index reflects the funding cost incurred by local financial institutions and is published every day by Chile's banking association (*www.abif.cl*). The index depends on the 'Tasa Camara Interbancaria Promedio', which is the average O/N interbank interest rate set by the central bank. The UF/Libor swap is an offshore, fixed-for-floating cross-currency swap. The swap requires one of the counterparties to pay/receive a fixed UF rate, while the other receives/pays the 6m USD Libor floating rate.

In both the swaps described above, coupons are exchanged semi-annually and proper accounting follows an ACT/360-day count convention, with notional amounts exchanged at the start of the swaps. It is also possible to trade the floating real rate against fixed real rate swaps, where the nominal ICP deflated by the UF index pins down the floating real rate. These swaps are mostly traded in the interbank market, whereas foreign hedge funds are more active in nominal swaps. Local corporations use these markets for liability management.

Finally, there is also a liquid market of inflation rate forwards (up to 1y), in which investors can directly express their views on inflation rates. These forwards, combined with a nominal-swap position, can span the instruments necessary to trade UF-denominated swaps synthetically.

INFLATION MARKETS

Colombia

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Inflation-linked bonds were first issued in Colombia in 1967, and the market has grown steadily since then. About a fifth of government debt is linked to CPI via the UVR indexing unit. Recent tax reforms have boosted international investor interest in these instruments.

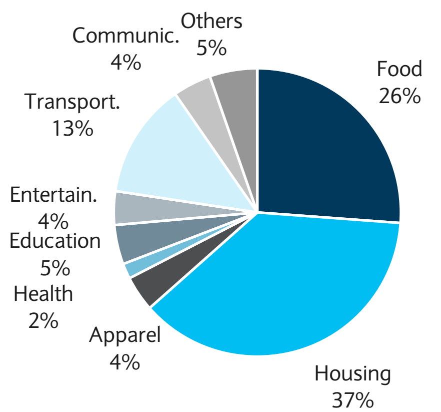
Indexation

Colombia's central bank (Banrep) conducts monetary policy within an inflation-targeting framework adopted in 1999. Since 2010, Banrep has set its inflation target in line with a long-term goal of 3% (within a +/-1% tolerance range), the culmination of a process of gradual target reductions and inflation convergence that started in 1993. Banrep's monetary policy has tended to be among the most hawkish in Latin America. However, in recent years, monetary policy decisions have been made amid uncertainty about the impact of the oil price decline on the economy. The 2014-15 oil-price slump and the significant COP depreciation that followed drove inflation and inflation expectations away from the target range. Banrep responded by tightening policy, which slowed activity and helped bring inflation back to a declining trend. More recently, transitory factors, including the effects of El Niño and other supply shocks on food prices added to inflationary pressures, but inflation finally returned to the target range in 2018. Recent fluctuations in oil prices have not significantly affected energy prices because they are relatively heavily regulated and typically reflect international prices more smoothly and with a lag.

CPI inflation is calculated monthly by the statistics office (Departamento Administrativo Nacional de Estadistica – DANE). DANE recently completed its decennial methodological update to CPI, replacing the 2008 methodology. The CPI has December 2018 as its base, with the consumption basket weights fixed and representing the consumption budgeting survey of 2016-17 (Figure 1). Geographical coverage includes the urban population of 38 cities (extended from 24 under the 2008 methodology). The CPI represents average monthly prices and is released by the fifth day of the following month.

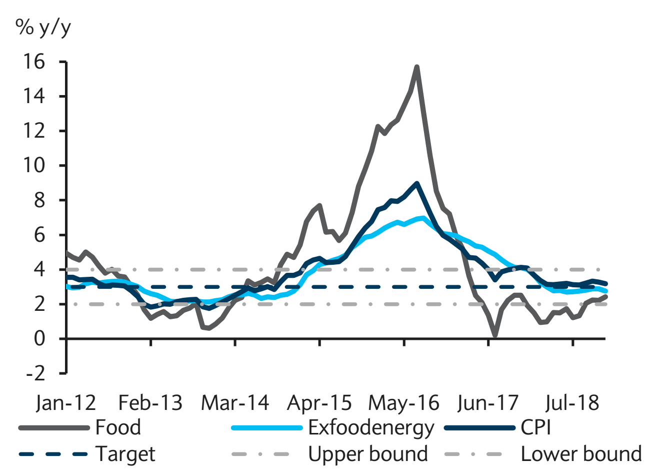
Since August 2000, the inflation indexing unit has been the 'Unidad de Valor Real' (UVR Index <go> in Bloomberg), which is calculated/published by Banrep based on DANE's CPI inflation rate for the previous month. The UVR Index is adjusted daily between the 16th day

FIGURE 1
CPI weights (base 2018)



Source: DANE, Barclays Research

FIGURE 2
Inflation dynamics



Source: DANE, Banrep, Barclays Research

of the current month and the 15th day of the following month. For any day t within this period, the UVR is given by:

$$UVR_t = UVR_{15} \times (1 + \pi_{m-1},1)^{t/d}$$

where UVR_{15} is the index value in day 15 of the previous month, π_{m-1} is the previous month's m/m inflation rate and d is the number of days in the period.

The UVR-linked market

There are two types of linkers, but the UVR-denominated are the most liquid (SENC1 <go>, second page in Bloomberg). These are fixed-rate, coupon-bearing bonds. As of end-December 2018, total gross domestic debt was COP309trn (USD99bn), of which coupon-bearing TES bonds (nominal and UVR-linked) accounted for 94.7%. Fixed-rate, UVR-denominated debt represented nearly 32.3% of the aforementioned total.

Liquidity varies significantly depending on market sentiment. In a rallying market, the typical bid/ask spread is 5bp for the most liquid paper and 10bp for its illiquid counterparts. When the market is under pressure, the liquid bonds' bid/ask spread widens to 10bp, while quotes for other bonds are practically non-existent. Average volumes for UVR bonds on days when trading occurs reach about COP 900bn (notional) and 150k DV01. The average ticket size is UVR50mn, though many days can pass without activity in this market.

The UVR/Libor OTC is a swap that used to trade but is now practically non-existent. This swap was an offshore fixed-for-floating cross-currency swap in which a counterparty paid/received a fixed UVR rate (semi-annual, Act/360) and the other received/paid 6mth USD Libor floating. When and if prices are provided, bid/ask spreads are very wide. When inflation-linked corporate deals occur, activity in this market rises, although this is sporadic.

Taxation

Foreign investor participation in the UVR-linked bond market was historically limited because such investors were subject to withholding tax on income and capital gains, in addition to a 0.4% financial transaction tax. However, successive tax reforms have reduced the income tax on profit derived by foreign portfolio investors (from 25% to 14% in 2012, and to 5% in 2018) so long as they are not resident in jurisdictions identified as tax havens by the Colombian government. This has boosted the participation of foreign investors in the local bond market from 4% at the beginning of 2013 to about 26% as of December 2018.

INFLATION MARKETS

Uruguay

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The expansion of CPI-linked debt instruments has been underway in Uruguay since 2002. The government has made efforts to create a local currency market in light of widespread financial dollarization and high inflation expectations.

Uruguay's CPI-linked debt totals USD9.0bn. The biggest markets are those for Treasury and BCU notes. The inflation-linked bond market was created as part of a consistent effort to provide a dollar substitute and continues apace. To foster this market, in 2002 the Uruguayan government replaced the old Unidad Reajustable (UR), which was adjusted with a wage index, with a newly created Unidad Indexada (UI), adjusted with the CPI.

CPI and the Unidad Indexada (UI)

The CPI is calculated monthly by the national statistics agency, INE, and released during the first five days of each calendar month for the previous month. The index is based on March 1999 and prices are collected in Montevideo.

The UI was introduced in June 2002 and set at 1 Uruguayan peso per UI. It is calculated and published by the INE. The level of UI is calculated daily from the sixth day of the month to the fifth day of the following month, using CPI levels from the previous month. Specifically, the daily factor $UI_{d,,M}$ is computed according to the following formulas:

a) $UI_{d,M} = UI_{5,M-1}\left(\frac{CPI_{M-2}}{CPI_{M-3}}\right)^{\frac{d+D_{M-1}-5}{D_{M-1}}}$ from the first day of month M up to the fifth day;

b) $UI_{d,M} = UI_{5,M}\left(\frac{CPI_{M-1}}{CPI_{M-2}}\right)^{\frac{d-5}{D_M}}$ from the sixth day of month M to the end of the month,

where D_M represents the amount of calendar days in month M and CPI_M corresponds to the CPI level in month M.

Inflation-linked bonds

Since the creation of the UI, the government has issued several types of bonds linked to the index – in particular:

i) Treasury Notes: USD4.1bn outstanding

ii) Global bonds: USD4.9bn outstanding

iii) BCU notes: USD529mn outstanding

iv) Local bonds: USD33.8mn outstanding

Figures 1-2 detail the Treasury Notes and Global Bonds denominated in UI.

FIGURE 1

Treasury Notes

Bond	CCY	Outstanding amount (USDmn)	Maturity	Coupon	Amortization
Treasury Notes 12	UI	91.3	3/7/2020	4.25	33,3% 2018 / 2019 / 2020
Treasury Notes 13	UI	641.5	5/25/2025	4.00	33,3% 2023 / 2024 / 2025
Treasury Notes 14	UI	627.2	6/10/2020	4.00	Bullet
Treasury Notes 16	UI	123.2	1/27/2019	3.25	Bullet
Treasury Notes 19	UI	438.0	9/27/2022	2.50	Bullet
Treasury Notes 20	UI	409.0	4/30/2020	3.50	Bullet
Treasury Notes 21	UI	475.6	11/26/2025	4.00	Bullet
Treasury Notes 23	UI	339.0	6/17/2019	5.20	Bullet
Treasury Notes 24	UI	738.7	12/29/2021	5.25	Bullet
Treasury Notes 25	UI	169.7	7/24/2030	2.90	Bullet

Source: Ministerio de Economia y Finanzas, Barclays Research

FIGURE 2

Global bonds

Bond	CCY	Outstanding amount (USDmn)	Maturity	Coupon	Amortization
URUGUA UI 4.25% 2027	UI	919.9	04/05/27	4.25	33,3% 04/05/2025 to 2027
URUGUA UI 4.375% 2028	UI	2139.9	12/15/28	4.375	33,3% 12/15/2026 to 2028
URUGUA UI 4% 2030	UI	1004.5	07/10/30	4.00	33,3% 06/26/2028 to 2030
URUGUA UI 3.7% 2037	UI	880.7	06/26/37	3.70	33,3% 06/26/2035 to 2037

Source: Ministerio de Economia y Finanzas, Barclays Research

INFLATION MARKETS

India

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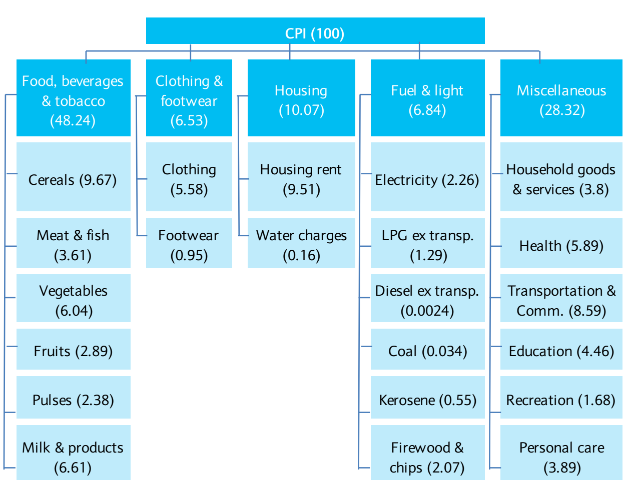
India issued its first 10y ILB in June 2013 using a standard Canadian format linked to WPI inflation, but with a four-month lag. Since late 2013, however, the CPI has replaced the WPI to become the key inflation measure tracked, and, hence the RBI has stopped issuing WPI-linked ILBs. The RBI issued a CPI-linked ILB in 2014, but only for retail investors, and demand was weak. Outstanding inflation linked IGBs (IIGS 2023) account for INR11.5bn against INR5.5trn of outstanding government bonds.

The consumer price index (CPI) and its major constituents

India introduced a new consumer price index (CPI) series in 2011. Following a report in January 2014, the RBI made the new CPI (combined) as the key measure of inflation, and adopted "flexible-inflation targeting" as its new monetary policy framework. This was a marked change from the institution's historical bias of focusing on wholesale price index (WPI) inflation. Under the new monetary policy framework, the RBI adopted a glide path for CPI inflation and set targets for the end of the first, second and the third years at 8%, 6%, and 4% (+/- 2%), respectively. During the inflation-targeting (IT) regime, India's CPI inflation has almost always been within the target band; headline CPI averaged significantly lower during these years compared with the pre-IT period.

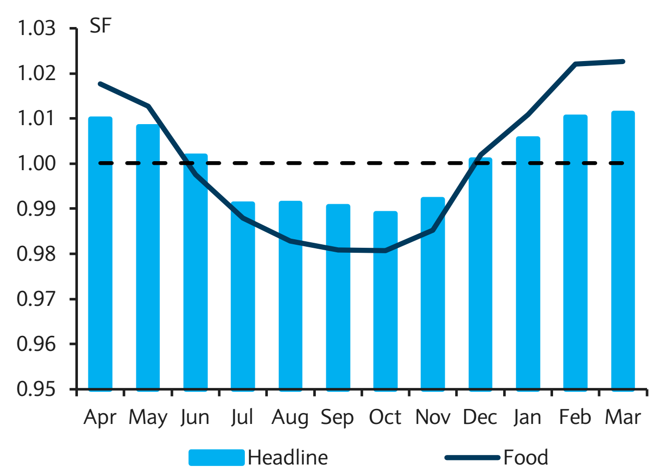
The new CPI series captures household inflation, reflecting an overall retail price index. The weighting pattern of the series is based on the NSSO's Round of Consumer Expectation Survey data. The headline CPI index is compiled and published by the Ministry of Statistics and Programme Implementation (MOSPI). The CPI basket is broadly divided into six segments: food & beverages (weight ~46%); tobacco (~2%); clothing & footwear (6.5%); housing (~10%); fuel and light (~7%); and miscellaneous (~28%). The CPI index excluding food and energy is referred to as the headline core CPI inflation (weight ~47% of overall CPI) in India. The CPI is released monthly; typically, provisional data are released around the 12th day of the following month. The CPI basket is modified periodically. However, the time between revisions is not rigid. The base year for the current basket is 2012=100.

FIGURE 1
CPI and its major constituents



Source: GoI, Barclays Research

FIGURE 2
Seasonality remains high in case of CPI; food items the key source of seasonality



Note: SF – Seasonal factor. Source: Haver Analytics, Barclays Research

In June 2016, the RBI Act was amended to set up a six-member monetary policy committee (MPC). The committee formed in September 2016 is currently responsible for making monetary policy decisions required to achieve the CPI inflation target (4% +/-2%). The MPC consists of three members from the RBI (including the Governor, the Deputy Governor responsible for monetary policy, and another nominated official) and three non-RBI members appointed by the government. The three external members are appointed for a period of four years (or until further orders, whichever is earlier) and are not eligible for re-appointment. Decision on the monetary policy front is taken on a majority vote of the six-member committee; however the Governor holds the right of a deciding vote in case of a tie. The MPC meets about six times a year. On the 14th day following a meeting, the minutes of the proceedings of the MPC are published. The minutes include: resolutions adopted by the MPC; the vote of each member on the resolutions; and a statement from each member on the resolutions adopted. Every six months, the RBI also publishes a document called the Monetary Policy Report, which typically explains the source of inflation and the inflation forecast for the following six to eighteen months.

Government bonds

Market development

The Indian government started issuing a 10y WPI-linked inflation-linked bond (ILB) in June 2013, and re-opened the issue seven times, taking the total amount outstanding to INR65bn (USD1bn). The government's main motivation for issuing linkers, however, is to offer Indian retail investors an inflation-protected savings vehicle as an alternative to gold. However, the CPI replaced the WPI as the key inflation measure tracked by the central bank and government. As the RBI's emphasis on the WPI reduced, the government stopped issuing WPI inflation linked bonds. In January 2016, the RBI announced a buyback of outstanding ILBs linked to the WPI through reverse auctions, following the de-emphasis of the WPI.

With the CPI now the key inflation metric in India, the RBI the launched the Inflation Indexed National Saving Securities – Cumulative (IINSSC) scheme in December 2013. Only retail investors were eligible to invest in these bonds and institutional investors are not allowed (*click for RBI web link* for FAQs). These bonds are not tradable in the secondary market. Going forward, if the government decides to issue new ILBs to institutional investors, they are likely to be linked to the CPI, and the WPI-linked ILB may never be re-opened again.

Calculations

The tenor of the first bond issued under the RBI's IINSSC scheme was 10y (2023 bond). The principal is linked to the CPI with a three-month lag. As the bond also includes a minimum fixed rate of 1.5% per annum, this level acts as a floor, ie, negative inflation will not be recognized. The bond has a semiannual settlement. Interest is accrued and compounded in the principal on a half-yearly basis and will be paid along with principal at the time of redemption. More details can be found at the RBI's website.

Foreign participation

Bonds under (IINSSC) scheme are currently only available to retail investors.

Tax implications

According to the RBI, IINSSC bonds are taxed similarly to IGBs and receive no special treatment. The interest on the bonds, consisting of both the fixed interest of 1.5% and the variable component linked to the inflation rate, is taxable as interest income and not as capital gains. Since the original amount invested will be redeemed on maturity at face value, there is no capital gain or loss on maturity and hence no capital gains tax will be levied.

Israel

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In Israel's domestic bond market, the CPI-linked bonds issued by the sovereign and corporates are in the majority. However, the share of bonds linked to CPI has been falling, as the sovereign issuer has been reducing the issuance of linkers and floating rate bonds in favour of shekel (unlinked) bonds.

CPI calculation

The inflation reference for linked bonds in Israel is the consumer price index (CPI). This is calculated and published on the 15th of each month by Israel's Central Bureau of Statistics. CPI is calculated from a monthly survey of about 1,300 goods and services, by form or by phone, of c.3,000 stores, business and households in c.100 localities. The weightings in the basket are based on the household expenditure survey and are changed every few years. Revisions to the basket tend to be modest. Housing and house maintenance costs have increased in the share of the index, while education and culture has declined over the past fifteen years.

FIGURE 1
Israel's CPI basket (weights of different components)

	2003	2010	2018
Food	16.99%	18.39%	16.66%
Housing and house maintenance	32.91%	31.31%	34.33%
Furniture and home equipment	4.75%	3.75%	3.69%
Clothing & footwear	2.90%	3.20%	3.24%
Health	4.85%	5.22%	5.83%
Education & culture	12.93%	12.53%	11.87%
Transport	20.26%	21.14%	19.34%
Miscellaneous	4.41%	4.46%	5.04%

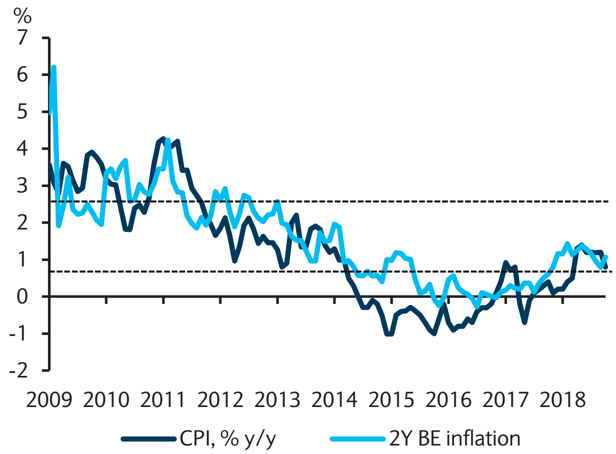
Source: Central Bureau of Statistics

Formal inflation-targeting regime

The Bank of Israel Law of 2010 formally entrenched the inflation target as the monetary regime. The inflation target is 1-3% annual CPI growth. The monetary policy council meets eight times a year to decide on policy rates and exchange rate policy. The central bank's exchange rate policy decisions are also framed around the inflation target. As Figure 2 illustrates, while inflation had been in the target range from 2009-2014, it was below the lower band until the beginning of 2018. During the past several years, external factors such as lower commodity and energy prices, along with increasing online shopping, have kept inflation at very low levels.

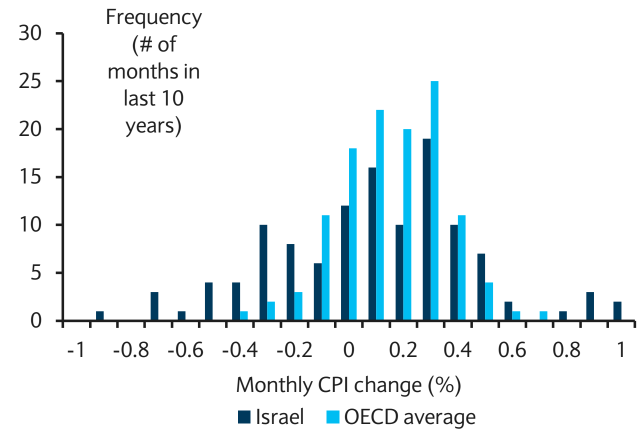
The central bank has kept interest rates low for a long period due to these price forces. The policy rate was held at 0.1% between February 2015 and November 2018, when it was raised to 0.25%, the first hike in seven years, as inflation had returned to the target band. With inflation still contained, and despite the possibility of loose money eventually feeding through to fast credit and price growth in the economy, we do not expect a need for drastic policy change this year.

FIGURE 2
Inflation has kept within the target range…



Source: Central Bureau of Statistics, Bloomberg, Barclays Research

FIGURE 3
… but the tails on monthly changes are still greater than the CPI changes in other economies



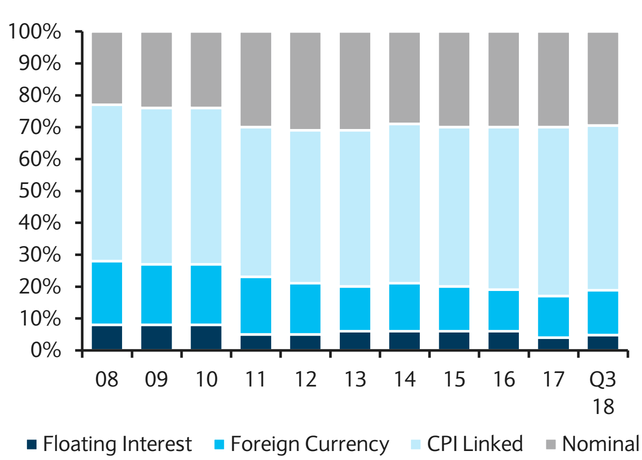
Source: Central Bureau of Statistics, Haver Analytics, Barclays Research

Large and stable linker market

As of Q3 18, the total amount outstanding of tradable government CPI-linked bonds in Israel was ILS171bn, with another ILS228bn in non-tradable "designated" bonds. CPI linkers were 39% of all tradable bonds. The sovereign linker market comprises the traditional "Galil" bonds, of which only two remain, and a more conventional type of CPI-linked bond, of which there are nine traded. The latter have been issued from 2006 onwards, and the main difference from the Galil bonds is the absence of a deflation floor for the value of the bond's principal and coupon. This can have pricing implications during downturns in inflation, particularly because the positive and negative tail risks on CPI changes have been large in Israel historically (Figure 3). With the low inflation prints in the past few years, we expect the old style Galil bonds to command a small premia over the new instruments.

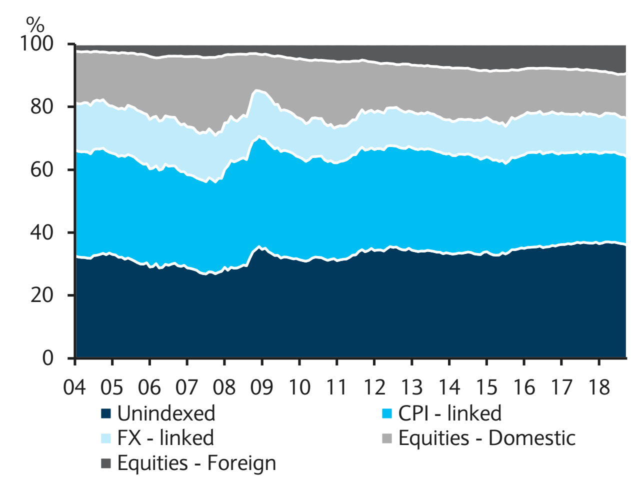
The newer inflation-linked bonds have a longer maturity (out to 30y) than the Galil bonds, which were originally up to 30y, but now have a remaining maturity of only about 5y. The

FIGURE 4
Structure of government debt (including non-tradable)



Source: Ministry of Finance, Bank of Israel, Barclays Research

FIGURE 5
Israel's private sector financial asset holdings (%)



Source: Ministry of Finance, Bank of Israel, Barclays Research newer CPI-linked bonds are tapped on a monthly basis. While the sovereign linker market is still very large, the nominal curve has caught up in terms of depth and breadth. The sovereign nominal curve is now longer in maturity than the CPI linkers and in most maturity buckets is traded more actively. The exception is at the longer end, where the linker is still more liquid. We think the Ministry of Finance will continue to reduce the share of CPI-linked and floating bonds in sovereign debt and increase the shekel (non-linked) share, mainly due to the increased issuance of non-tradable "designated" bonds (which are all CPI-linked).

Calculations

The annual coupons on Galil bonds are fixed real rates, while the value of principal is enlarged by the rate at which CPI has increased between the base date and the latest inflation observation. Indexation has a one- to a one-and-a-half-month lag; for example, the base CPI for a Galil bond issued on 20 August 2012 is the CPI for July 2012. Both the coupon and redemption value of Galil bonds in Israel have implicit floors against deflation. By contrast, the value of the principal of the new inflation-linked bonds can rise and fall with the change in CPI relative to the base CPI (ie, the latest CPI when the bond was first issued). Another difference between Galil bonds and the new CPI-linked bonds is the method of computing interest payments. For Galil bonds, a multiplicative formula is used:

$$R = \{ (1+ r/100) ^ (T/365) -1 \} * 100$$

Where R = interest rate for the interest period; r = the fixed interest rate and T= number of days in the interest period.

For the new CPI-linked bonds, the interest payment is computed more simply as:

$$R = r*T/365$$

The key difference between Israeli inflation-linked bonds and those of most other markets is that there is no official daily referenced index; thus, the principal and coupon can have step moves according to the release of the latest CPI report.

The format of the linkage is as follows:

Principal payment = (M 1 / M 0) * 100

Coupon payment = (M 1 / M 0) * 100 * Real Coupon

Where M 1 = latest CPI at the time of payment and M 0 = base CPI, or CPI known when the bond was first issued.

The quoting convention is to use full uplifted prices. The latest CPI report is used to compute the index ratio from time of issue; this ratio is used to deflate the uplifted price and, hence, derive the implied real yield. As mentioned above, this induces volatility in the yield levels around CPI release dates.

Inflation derivatives

It is possible to trade inflation swaps on request, and much of the current activity in this sphere is undertaken by Israeli corporates hedging their balance sheet exposures. One of the more common products is real rate swaps in which the floating leg is 3m Telbor and the fixed leg is the real rate uplifted again by the ratio of the most recent CPI index over the CPI index at start. This market is likely to grow over the coming years as local corporates and banks adopt more sophisticated approaches to liability management and foreign interest in creating global inflation exposure increases.

INFLATION MARKETS

South Africa

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The South African inflation bond market remains one of the most represented curves within the emerging market arena, consisting of ten bonds that extend to a maturity of 2050. The National Treasury offers ZAR760mn worth of this scrip per week, but liquidity in the secondary market remains patchy. Corporate issuance of inflation linked paper is sparse. Linker bonds are predominantly owned by the local pension fund community, while foreign participation is limited. Although the Reserve Bank remains a vigilant inflation-fighting central bank, breakevens tend to trade significantly above the prevailing inflation rate and inflation expectation surveys, partly because linkers are considerably less liquid than nominal bonds and also because there is increased need for pension funds to match their liabilities.

Market overview

Linker turnover is considerably less than nominal bonds

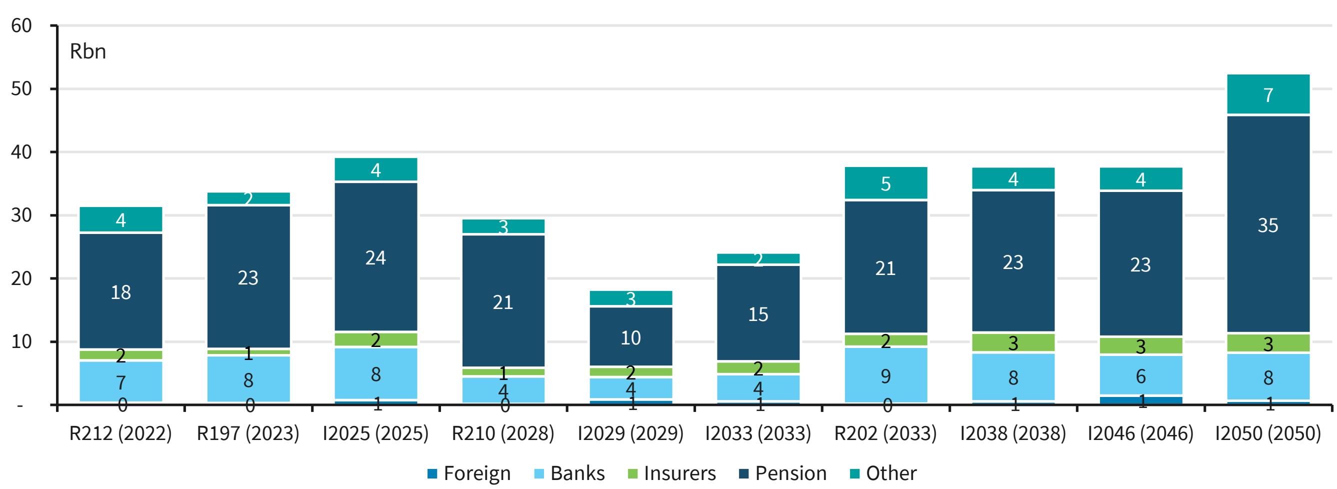
South Africa first issued inflation-linked bonds in March 2000, launching the CPI-linked 6.25% March 2013, known as the R189, and underlining a policy commitment to low and stable inflation over the medium term.

However, issuance in the primary market has increased significantly over the past decade

Over the past decade, the Treasury has increased the pace and the magnitude of issuance. Initially, the Treasury conducted only monthly linker auctions, but weekly allotments became the norm after 2004. The size of the weekly allotments was erratic between 2004 and 2009 (between ZAR100mn and ZAR600mn), before becoming a consistent ZAR600mn between 2009 and 2011. Weekly issuance continued to increase thereafter and peaked at ZAR800mn per week between 2013 and 2015. However, subsequent weekly issuance reverted to ZAR650mn as the Treasury managed to issue considerably more of its funding requirements through nominal non-competitive auctions. On 26 March 2019, the National Treasury announced that due to an increase in the borrowing requirement, planned weekly linker sales are increasing to ZAR760mn. However, market demand is typically not strong enough for the full amount of offered linker issuance to be taken up. The amount of government-backed inflation-linked paper currently in issue stood at R561bn as of 31 January 2019 ($42bn), representing 26% of the total SA government bond market (ex-bills) – broadly in line with the National Treasury's indicative target of 20-25%. The Treasury has also indicated that the average term-to-maturity of linkers should range between 14 and 17

The National Treasury is within its risk benchmark guidelines

FIGURE 1
Breakdown of ownership per bond (as of February 2019)



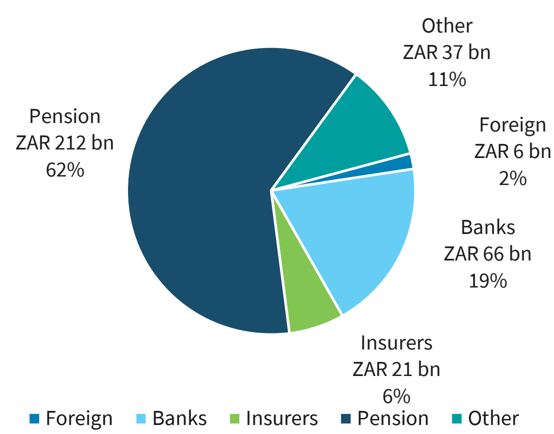
Source: National Treasury, Barclays Research years. At present, the average maturity stands at 15.3 years (as of March 2019), which implies that the Treasury theoretically can afford to issue more longer-dated scrip and still remain within these issuance guidelines. The average duration of the South Africa government inflation-linked bond market was just over 10y in March 2019.

Local pension fund managers own the bulk of the linker market

The vast majority of inflation-linked government bonds are held by the local pension fund community and domestic monetary institutions, with combined holdings of circa 60% of the total market. Pension funds buy linkers to guard their assets against rising inflation while banks (20% of the market) use linkers to match their inflation-linked liabilities. Insurance companies own c.6% of the linker market, while foreign ownership stands at a mere 2% (Figure 2).

FIGURE 2

Breakdown of overall South Africa inflation-linked bond ownership (February 2019)



Source: National Treasury, Barclays Research

Real rate and inflation derivatives

The inflation-linked derivatives market has only taken off since 2003, as banks became willing to facilitate corporate hedging in the form of real rates and pension fund investment via annuities. Currently, it consists mainly of zero-coupon real-rate swaps and zero-coupon breakeven inflation swaps, with the former being more frequently traded. While a few option trades have occurred, they are not a regular feature. As in other global sectors, inflation pricing in the derivative and cash markets moved significantly out of line in late 2008, with cash bonds quoted relatively cheaply. Such pricing prompted the first significant volume of asset swap buying of government linkers, and this trading has continued, allowing swaps to benefit from the improved liquidity of the expanding bond market.

When swap trading began, it quickly developed into a more liquid market than bonds, as it was mainly an inter-bank market, rather than a buy-and-hold one. While the swaps market does not have the consistent weekly liquidity injection of auctions, these do create activity if there is asset swap flow. In recent years, liquidity has dried up, with more frequent trading in the bonds. There is less of a structural constraint on taking long/paid real yield positions in the swap market – but the repo market is developing, with aid from the SARB's reverse repo facility, which enables investors to take on short positions in the bonds to some degree. Liquidity has tended to be notably worse than the nominal swaps market.

Inflationary trends

South African inflation has been structurally lower since the SARB was explicitly given a price stability mandate in 2000

South Africa's Finance Minister Trevor Manuel announced the introduction of an inflation-targeting regime in 2000, in which the South African Reserve Bank (SARB) was mandated to keep consumer inflation within a 3-6% target band. Between 2000 and 2009 the SARB targeted a CPIX measure (headline inflation less mortgage rate costs), while all inflation linked products referenced the headline inflation measure instead. However, since 2009, both the reference rate and the target rate now refer to the headline measure. Since the adoption of this inflation targeting, consumer inflation has been at or below the upper limit of the target range 70% of the time, reflecting a great deal of success in holding inflation down and managing expectations, especially if one considers that in the decade prior to the introduction of inflationary targeting, consumer inflation was below 6% only 20% of the time. What's more, over the past year or so, the SARB has emphasised that that it would like to anchor both inflation and inflation expectations around the mid-point of the target range.

Inflation has become less susceptible to exchange rate developments

South Africa's consumer inflation basket is scheduled to be reviewed every four years by Statistics South Africa, shortly after the income and expenditure of households survey is carried out. The basket was last updated in December 2016 (Figure 3) and the high weighting of services is quite noticeable. As one would expect, services inflation is typically less volatile than goods inflation; thus the current basket is, unsurprisingly, not very susceptible to shifts in the exchange rate and/or international food and energy prices. To be clear, apart from the weakness in demand-pull inflation pressures as growth slowed post the global crisis, we believe that the high weight of services (51.3% currently versus 50.14% in 2012 and 45.8% in 2008 and 42.86% in 2000) also explains to some extent why FX pass-through has been relatively weak, allowing inflation to remain relatively stable and within the target band close to 90% of the time since the inception of the current basket.

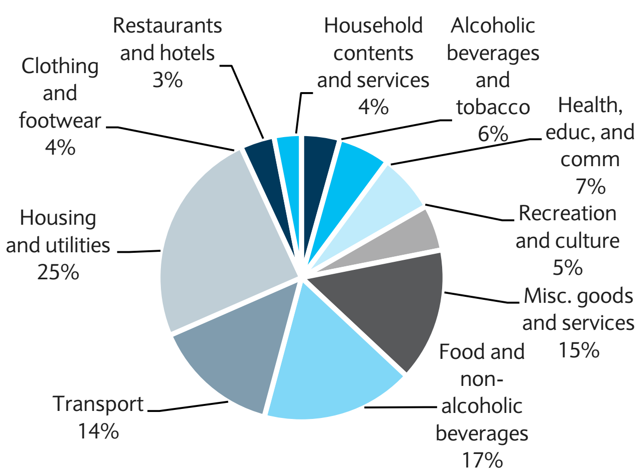
At the next basket reweighting, we expect services categories to continue gaining in importance as the economy becomes increasingly developed in nature. We believe that the key sub-indices that the market will focus on are electricity because of the huge tariff increases granted by the regulator to Eskom, water and insurance because they have been rising faster than the basket, and finally household content and food because of the weak growth here.

Food prices and inflationary expectations also need to be closely monitored

Inflation expectations, as surveyed by the Bureau for Economic Research, and as measured by the implied breakeven between nominal bonds and their equivalent inflation linked counterparts are a key input in the SARB's policy decision function. The former in particular

FIGURE 3

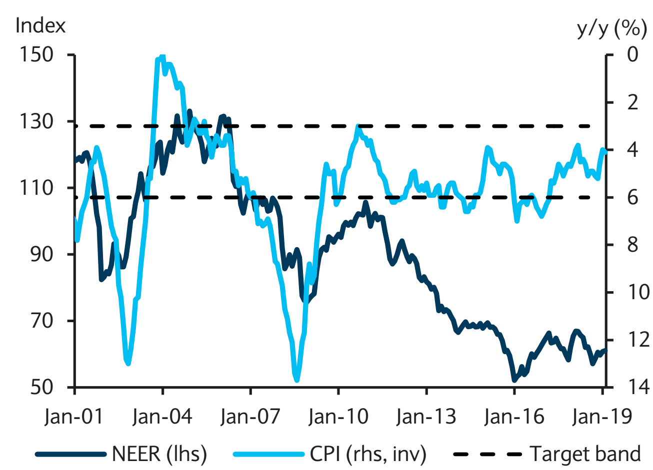
The latest consumer inflation basket has proportionately more weight for the services categories



Source: Stats SA, Barclays Research

FIGURE 4

Inflation and the exchange rate have decoupled due to a change in the CPI basket and a weak economy



Source: Stats SA, Bloomberg, Barclays Research is highly regarded by the Committee, as survey respondents – especially labour and business – are actually responsible for setting prices within the economy.

Calculations

South African government inflation-linked bonds carry a principal deflation floor and are quoted on a real yield basis; with inflation indexation calculated using a slightly augmented Canadian methodology. For settlement on the first day of any calendar month, the CPI from four months previous is the reference CPI for that date. This means that South African linkers have a lag that is a month longer than those in Canada, the US or the euro area.

Each day has its own distinct reference index. The first day of each month has a reference index equal to that of the CPI of four calendar months earlier – eg. for 1 December 2018, the CPI is for August 2018 and for 1 January 2019 the CPI is for September 2018. Reference indices for intervening days are calculated by straight-line interpolation.

This formula is used to calculate a reference CPI for the official original issue date, or "Base Reference index". For settlement date or cash flow payment date "t", a reference CPI is then calculated. The reference index and the base index are rounded to 5 decimal places. These provide an index ratio for the value date:

Index Ratio Rate = Reference CPIt/Reference CPIBase

For settlement amounts, real accrued interest is calculated as for ordinary South African bonds. Dirty price and accrued are each multiplied by the index ratio to arrive at a cash settlement amount. For coupons paid, the (real) semi-annual coupon rate is multiplied by the index ratio, and likewise for the par redemption amount (with the cash value subject to the par floor).

Taxation

South African inflation-linked bonds pay interest on a semi-annual basis, with a 10-day "books closed" ex-dividend period. However, international investors are not subject to withholding tax, making investment relatively straightforward. For domestic investors, such bonds fall under section 24J of the Income Tax Act of 1962. Interest on bonds is taxed on a yield-to-maturity basis. Coupon payments and the difference between the acquisition cost and the nominal value of the bond are defined as interest and are liable for income tax. Basically, inflation-linked bonds are treated like floating-rate instruments. The tax liability is determined and paid annually, taking into account any adjustments in the principal amount and the coupon payments as a result of changes in the CPI.

INFLATION MARKETS

Thailand

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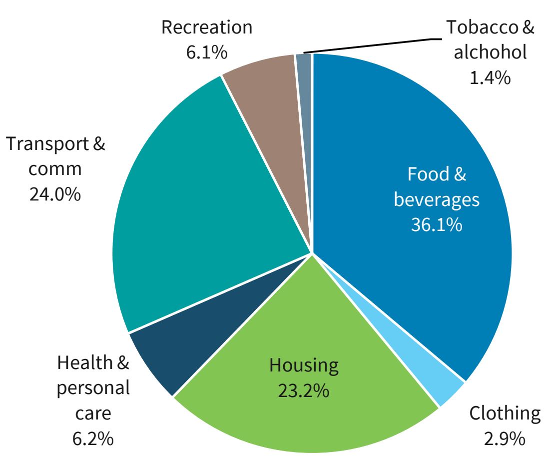
Thailand started issuing ILBs in 2011 and currently has two bonds outstanding (2021 and 2028). It uses a standard Canadian format, with a floor on principal at par. The bonds are linked to headline CPI, which has been averaging around the low end of the BoT's target range. As of 31 December 2018, the ILB market amounted to THB208bn (1.7% of ThaiGBs). The government has not auctioned any inflation linkers since 2015.

CPI

The inflation index used is the headline CPI, calculated and published by the Ministry of Commerce. The inflation index is broadly divided into three main sections – raw food, energy, and core inflation. In terms of basket composition, raw food has a weight of 15.69% and includes perishable items, such as cereals, meat, fish, vegetables and fruits, and is typically the most volatile component of the CPI basket. Energy, which represents 11.75% of the basket, is dominated by retail fuel and cooking gas prices, and is loosely regulated by the government through a number of tax levies. Core inflation represents 72.56% of the basket, and is the most stable component. It includes mainly services, processed foods and durable goods, such as clothing. CPI data are usually released on the first working day of the month and are seldom revised. The weights of the basket are changed every five years, with the most recent in January 2017.

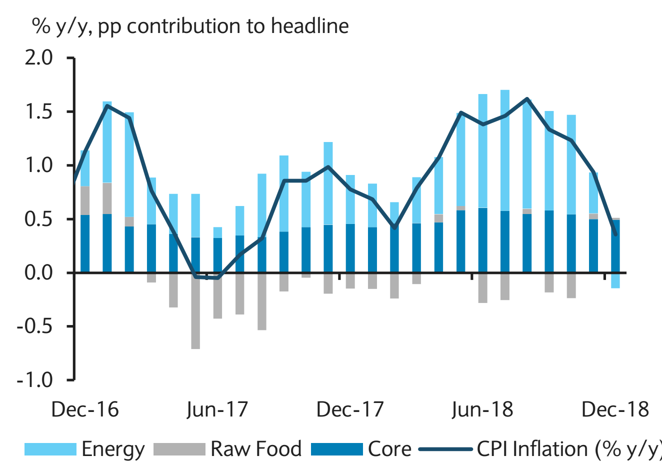
Inflation targeting: The Bank of Thailand has conducted monetary policy under a flexible inflation-targeting framework since May 2000. This regime was adopted after the Asian Financial Crisis. Until the end of 2014, the MPC targeted core inflation (ex-food and energy prices) within a range of 0.5-3.0%. In January 2015, the government approved a new target, headline inflation (target range of 1.0-4.0%), with an objective of making central bank communication clearer to the public. The target band width is approved every December by the cabinet as per the BoT Act 2008. The MPC and Minister of Finance have approved an annual average of headline CPI between 1-4% as target for 2019 as well as the medium-term inflation target. The change in the benchmark target reflected the Monetary Policy Committee's (MPC) view that because the public is more affected by changes in headline inflation, communication of the central bank's policy stance would improve if the target was

FIGURE 1
Breakdown of CPI by major category (base year = 2015)



Source: CEIC, Barclays Research

FIGURE 2
CPI has been driven by food and fuel prices in recent years



Source: Haver Analytics, Barclays Research headline CPI. If inflation breaches the target, the MPC must explain why and what policy action it is taking in response, and the period within which it expects inflation to return to target.

Inflation has been underperforming: Thailand's inflation linkers have historically offered a hedge for inflation not just in Thailand, but also for the region as a whole. However, persistently low headline inflation has limited the appeal of the country's inflation-linked bonds. The pass-through of crude oil price movements to energy costs is relatively unimpeded despite the presence of a fuel subsidy (Figure 3; "Thailand to use fuel subsidy to help consumers as global oil price rises," *Reuters*, 22 May 2018). According to our analysis, Thailand has shown the fourth largest-pass through impact from lower oil prices in the Asia Pacific region (since October 2018), behind the Philippines, South Korea and India. For Thailand, we estimate that a fall in crude prices by USD10 decreases headline CPI by approximately 0.57pp, which is one of the highest oil-sensitivities in the region.

Seasonality for CPI: Similar to other linker markets, the performance of Thai ILBs is subject to seasonal fluctuations, which has implications for carry trades. As shown in Figure 4, there is strong seasonality for inflation to rise more in H1 of each calendar year, as this period includes the end of the harvesting season and the Songkran festival, which is the celebration of the Thai New Year. As a result, retail sales and prices tend to show a general pick up during January-April.

Government bond

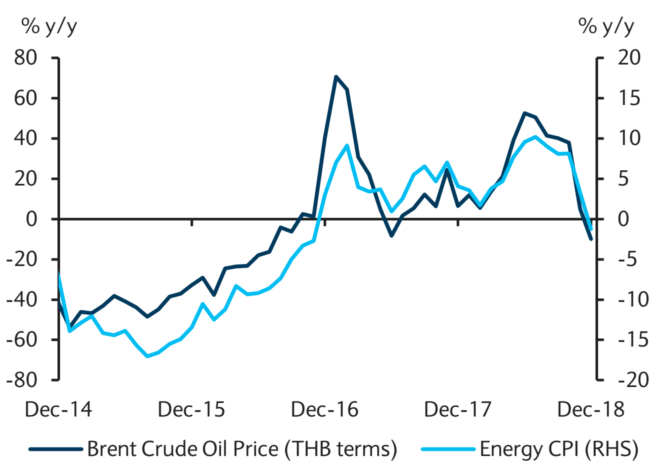
Market development: The first ILB was issued in July 2011 with a 10y tenor and a semiannual real rate coupon, in order to expand the Treasury bond market base to resident investors and foreigners. The inaugural bond was reopened at quarterly auctions until the amount outstanding reached THB100bn (USD3.2bn). In 2013, the Debt management office auctioned a new 15y bond (ILB283A) to develop an ILB curve. Currently, the ILB283A has an outstanding maturity value of THB107bn (USD3.4bn). Because of the recent trend of relatively low inflation, linker issuance has been put on hold since September 2015.

Calculations

- Similar to global linkers, Thailand linkers are also quoted using a standard Canadian model, with a floor on the principal at par. The cash flows are based on the headline inflation index, with a three-month lag.

FIGURE 3

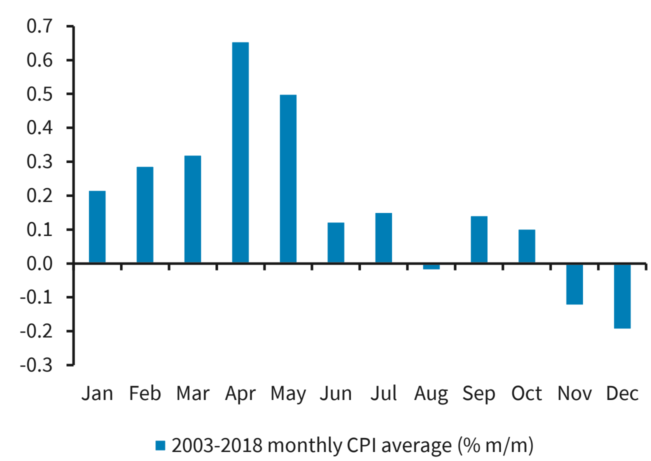
The pass-through of crude oil price movements to energy costs is relatively unimpeded



Source: Haver Analytics, Bloomberg, Barclays Research

FIGURE 4

Seasonal patterns for CPI in Thailand



Source: Bloomberg, Barclays Research

- For inflation-linked bonds, the principal is indexed to inflation and subsequent coupons reflect adjusted principal. The factor by which to adjust interest and principal payments is known as the index ratio.

- $$IndexRatio = \frac{CPI_t}{CPI_{IssueDate}}$$

- **Coupon Payments**: Subsequent coupon payments are made by multiplying the fixed real coupon by the monthly index ratio, and likewise for final redemption value. Similar to the normal Canadian model, the coupon payments are quantified only after the start of the accrual period when the reference CPI is released (the reference date is three months before the payment date).

- **Accrued Interest**: Accrued interest is paid on the linearly interpolated CPI between the second- and third-month-back-CPI, as shown in the index below.

$$Index = CPI_{m-3} + \frac{(t-1)}{D_m} \times (CPI_{m-2} - CPI_{m-3})$$

Where CPI_{m-x} is the CPI index x months back of settlement month m; D_m is the number of days in month m; t is the day of the month on which settlement takes place.

- **Index Rebasing:** While the inflation basket is adjusted after five years, the rebasing or index rebalancing should not have any impact on the retrospective index ratios, and would only affect the forward-looking inflation ratio.

Taxation

- **Interest income:** There is no withholding tax on interest income from Thailand government bonds for foreign investors.

- **Capital gains:** The capital gains tax is 15%, unless exempted. As per Stock Exchange of Thailand regulations, institutional investors from 28 countries are exempt from capital gains taxes. These countries include Canada, France, Germany, Hong Kong, Italy, Singapore, Switzerland and the UK. Institutional investors from the US are taxed at 15% on capital gains. However, if the US investor is a US bank operating out of the US, the gains would qualify as business profits and would likely be exempt from Thai tax.

Settlement

- The BoT is responsible for the settlement of government bonds and uses a Real-Time Gross Settlement (RTGS) system that provides DvP (delivery vs. payment) facilities. Settlement convention is T+2 but can vary by bilateral agreement.

- Foreign investors can settle the bond via Euroclear and Clearstream. Investors with Euroclear accounts can trade with dealers that also have Euroclear accounts, and the same holds true for Clearstream. However, access through a Euroclear-Clearstream bridge is not possible.

INFLATION MARKETS

Hong Kong

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The Hong Kong government issued 3y retail inflation-linked bonds (iBond) during 2011-16. Each works like a FRN, with only the coupon, and not principal, linked to the composite CPI. The annual coupon is the average of y/y CPI for the past six months, with a floor of 1%. The government stopped issuing these bonds in 2016 and has issued HKD3bn of 3y Silver Bonds for HK residents aged 65 and older. This is linked to inflation, but subject to a minimum of 2% and has no secondary market. Outstanding iBonds (iBond 2019) aggregate HKD10bn against HKD105.9bn of outstanding government bonds.

CPI

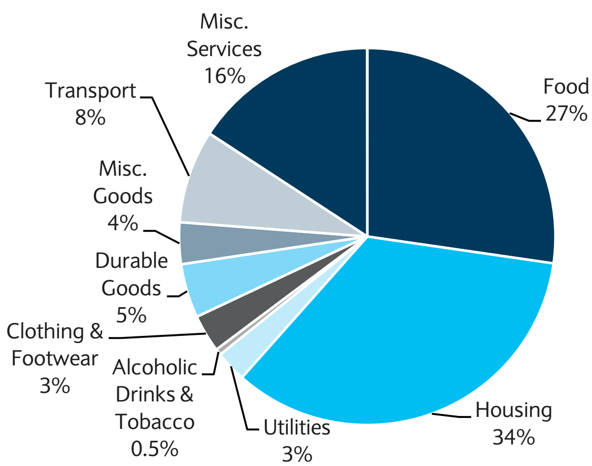
The Consumer Price Index (CPI) is compiled and published by the Census and Statistics Department of the HKSAR Government (C&SD). Different series of CPIs are compiled to reflect the impact of consumer price changes on households in different expenditure ranges. The CPI(A), CPI(B) and CPI(C) are compiled based on the expenditure patterns of households in the relatively low-, medium- and relatively high-expenditure ranges, respectively. The Composite Consumer Price Index – which is the floating-rate index – is compiled based on the overall expenditure pattern of all the above households taken together to reflect the impact of consumer price changes on the household sector as a whole. Different expenditure weightings are used to compile the different CPI series. These weightings are determined every five years based on the results of a new Household Expenditure Survey (HES). The period in which a HES is conducted forms the “base” of a CPI series. The most recent HES was conducted in 2014-15, and the CPI is now being compiled and published based on that survey.

Government bond

Market development

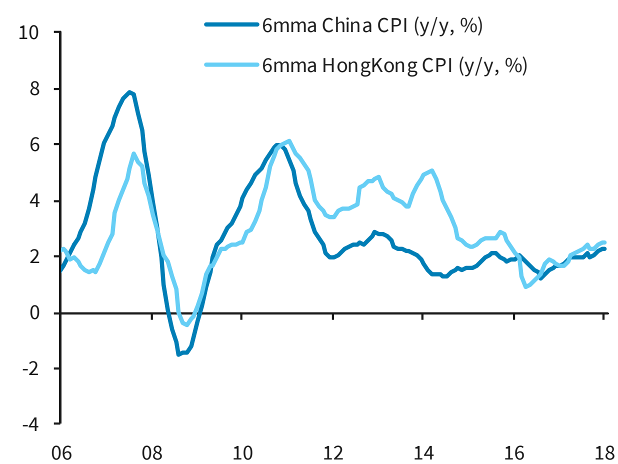
In July 2011, Hong Kong issued HKD10bn of 3y inflation-linked bonds (matured in July 14), its first inflation-linked bond, which was offered only to domestic retail investors as part of the government’s retail bond issuance program. This was followed by five similarly sized 3y bond issues during 2012-16, and zero issuances since 2017-18.

FIGURE 1
Breakdown of CPI by major category



Source: CEIC, Barclays Research

FIGURE 2
HK CPI and China CPI



Source: Bloomberg, Barclays Research

- **Amount Outstanding:** The above-mentioned bonds were issued at six auctions, with current total amount outstanding of HKD10bn (USD1.28bn), will be due in June 2019, available only for retail investors.

Calculations

- **Principal:** Only the coupon – not the principal – is linked to the headline inflation rate. The HKSAR government will repay 100% of the principal amount of the retail bonds at maturity.

- **Coupons:** The 2014-15 based Composite Consumer Price Index was used in determining the annual interest rate. The interest paid every six months is based on the following formula and is fixed 10 days ahead of the coupon date (rounded to two decimal places, with a day-count convention of actual/365).

Annual Interest Rate = Max (Average (y/y CPI for the six recent months), 1%)

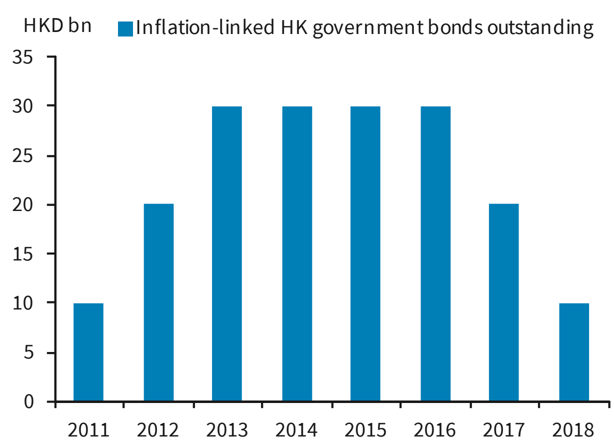
- **Accrued interest:** This is calculated in the same way as for a normal FRN.

Taxation

- No capital gains tax, profits tax or withholding tax or stamp duty is payable in Hong Kong on capital gains from the resale of retail bonds.

FIGURE 3

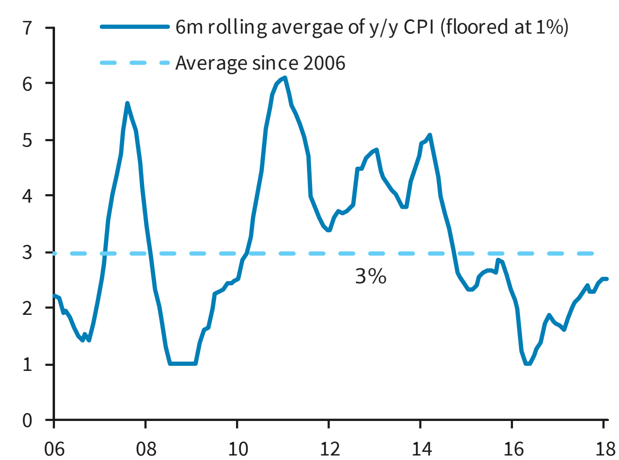
Inflation-linked HK govt bonds outstanding amount



Source: Wind, Barclays Research

FIGURE 4

Rolling 6m average inflation



Source: Wind, Barclays Research

INFLATION MARKETS

South Korea

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South Korea issued its first 10y inflation-linked bond in March 2007 using a standard Canadian format, linked to the headline CPI rate. In order to increase demand, the MoSF introduced a par floor on bond principal starting from June 2010. As of 31 December 2018, the KTBi market amounted to KRW9.5trn (1.7% of KTBs). The government auctioned KRW0.94trn of 10y KTBi in 2018 (KRW2trn in 2017), relative to overall KTB issuance of KRW97trn. The BoK's target for inflation for 2019 onwards is 2%.

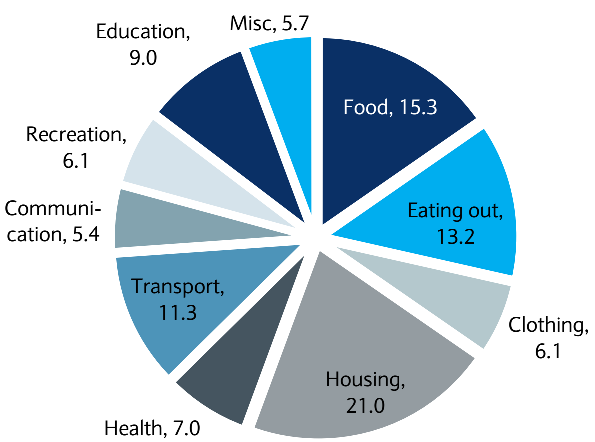
CPI

The reference index for computing the inflation adjustment factor for South Korea's first linker bond is the headline Consumer Price Index (CPI), which is not seasonally adjusted. Since 1998, the Bank of Korea (BoK) has applied inflation targeting, with a target set in consultation with the government. On 26 December 2018, the BoK announced it will no longer set a three-year inflation target. Instead, the central bank set an open-ended annual year-on-year inflation target of 2%, from January 2019 onwards (2016-2018 inflation target: 2%; 2013-2015: 2.5-3.5%). The Bank will conduct its monetary policy with the aim of keeping CPI inflation stable over the medium term, while considering symmetrically the risks of inflation remaining persistently above or below the target, according to its statement.

The central bank said the removal of the inflation target timeline reflects lower volatility in inflation, and the central bank will review the target every two years. An inflation assessment (which includes price developments, future inflation forecasts, and risks and monetary policy stance for achieving price stability) will be published twice a year to enhance communication to the public.

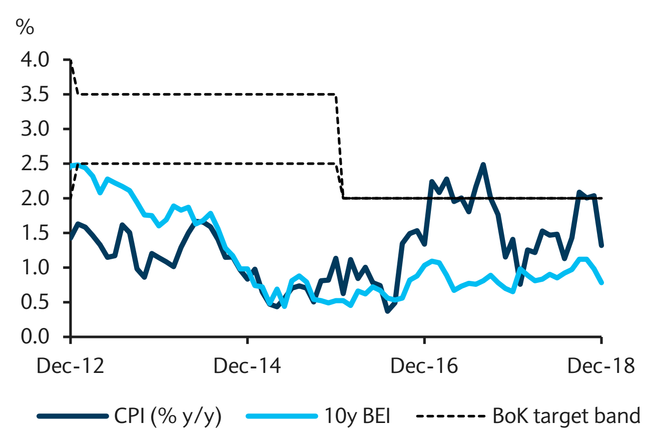
Since inflation targeting was adopted, inflation in Korea has been both better contained and more stable. For example, inflation averaged 5.2% in the past 40 years, compared with 2.0% in the past 10 years – with a standard deviation of 1.08%. The Korean National Statistics Office publishes CPI data on a month basis, usually on the first or second working day of the following month. There is strong seasonality of inflation in Korea. Usually, Q1 and Q3 have relatively high inflation due to Lunar New Year and Independence Day, and the "Chuseok" festival.

FIGURE 1
Breakdown of CPI by major category



Source: Haver Analytics, Barclays Research

FIGURE 2
CPI and breakevens



Source: Bloomberg, Haver Analytics, Barclays Research

Although the CPI has been used as a measure of inflation in South Korea since 1936, the country's economy has experienced considerable change since that time. These changes largely reflect the national shift from agriculture to heavy industry in the 1970s and 1980s, and the subsequent growth of the service sector in the 1990s. The major categories of goods and services and their weights in the CPI basket are shown in Figure 1. Major revisions to the index are made every five years to reflect changes in the consumption structure of urban households, while additional updates to weights are made two to three years after the main revision.

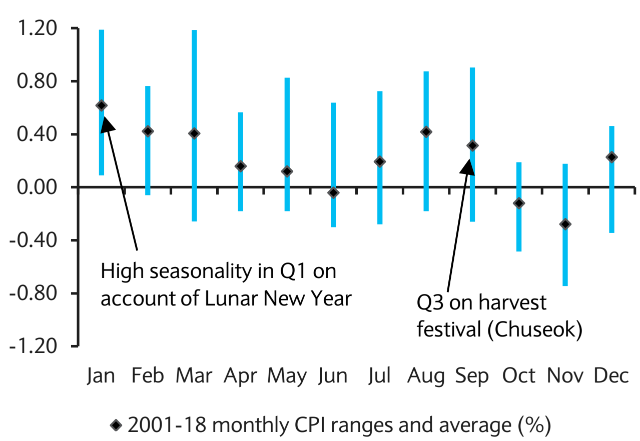
Government bonds

Market development

The Korean government first issued inflation-linked bonds in March 2007, when it launched the 10y CPI-linked 2.75% March 2017, known as a KTBi, in order to: 1) reduce interest expenses; 2) secure a stable funding base; 3) provide a benchmark for issuance of inflation-linked notes by the private sector; and 4) demonstrate the government's commitment to maintain stable prices. The government continues to express a commitment to expand the country's bond markets, including the KTBi segment; however, the global financial crisis led to a pause in issuance of linkers. The last auction of the 2017 series was in July 2008, and raised KRW61bn (c.USD61mn as of July 2008). A new issue scheduled for September 2008 was postponed due to the financial crisis, and KRW900bn of the existing issue was bought back by the Treasury in Q4 08.

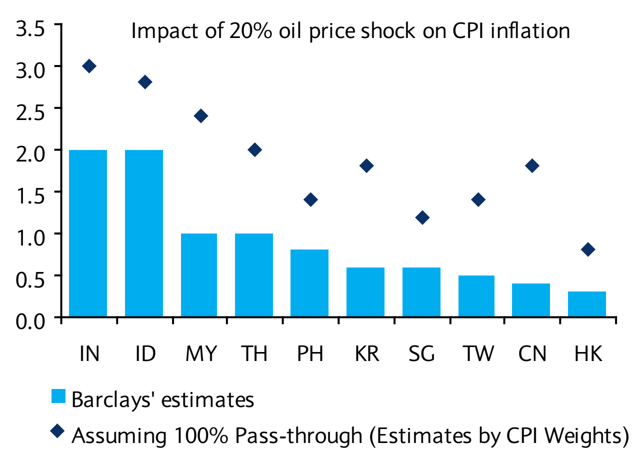
The Ministry of Strategy and Finance (MOSF) resumed 10y KTBi issuance in 2010 by introducing a new benchmark, June 2020s. Five other benchmarks, June 2021s, June 2023s, June 2025s, June 2026s and June 2028s, were subsequently introduced. To enhance the liquidity of on-the-run KTBis, the MOSF increased the fungible bond issuance period from one year to two years. To make linkers more attractive, the government put a guarantee on the principal amount of such bonds issued from 2010 onwards. Incentives to retail investors were provided by lowering the minimum auction bid to KRW100,000 from KRW1mn and allowing them to request the official quote level from primary dealers (PDs), unlike previously, when the offer rate was subject to a margin imposed by PDs. Tax incentives to retail investors have also been provided to support demand, but only for paper issued until 2014.

FIGURE 3
CPI seasonality



Source: Haver Analytics, Barclays Research

FIGURE 4
CPI sensitivity to oil prices, %



Source: Haver Analytics, Barclays Research

Nevertheless, secondary market liquidity for KTBis remains poor. As of 31 December 2018, KTBis outstanding totalled KR9.5trn, equivalent to just around 1.7% of the total KTB market. The investor base has also tended to be domestic buy-and-hold institutional investors, rather than trading accounts, which has limited the amount of secondary trading. For reference, bid-ask spreads for linkers are 5-10bp, compared with 1-3bp for 5y and 10y KTBs. In an effort to boost liquidity, the MoSF has instituted regular buybacks of KTBis.

Therefore, positioning through the primary market generally provides better entry levels. After 10y KTB auctions, which are typically held on the third Monday of each month, the 10y KTBi is allotted through a non-competitive allocation to each primary dealer up to 25% of their allocation at the 10y KTB auction. The BEI rate for the 10y KTBi is announced by the MoSF before the allocation.

Calculations

South Korean government inflation-linked bonds are quoted using the standard Canadian model. For settlement on the first day of any calendar month, the CPI from three months previously is the reference CPI for that date. A reference CPI value is calculated for every day based on the CPI values for three months and two months prior to the month containing the settlement date. The reference CPI for any day during the month is calculated by linear interpolation.

Reference CPI for day d of month t:

$$\frac{(d-1)}{m}\left(CPI_{t-2}-CPI_{t-3}\right)+CPI_{t-3}$$

d = day of the month – eg, 1st implies d=1
m = number of days in that month

The indexation factor is the reference CPI for the settlement date divided by the reference CPI for the base date. Coupons are accrued on an actual/actual basis and paid semi-annually.

The principal amount of a KTBi is linked to inflation. The first KTBi issue did not include a par floor on the principal amount, unlike the next two issues, which included this feature. The principal of a KTBi is calculated by multiplying the principal amount at the time of issuance by the coefficient of price fluctuations – ie, index ratio (CPI on the payment date/CPI on the issuance date). The calculation of interest is also adjusted accordingly.

Taxation

In general, foreign investors are subject to three taxes: a 14% withholding tax on interest income; a 20% capital gains tax; and an additional 10% “resident tax.” The last effectively raises the withholding tax to 15.4% and capital gains tax to 22%. These taxes only apply to bonds purchased since 13 November 2010. Interest income earned by non-residents on KTBs and MSBs settled on or before 12 November 2010 remains exempt. The tax treatment for KTBis is the same as that for KTBs.

Foreign investors need to obtain approval (ie, Investment Registration Certificate) from the Financial Supervisory Service (FSS) to invest in the Korean bond market. To invest, IRC holders are required to open an exclusive KRW/foreign currency cash account with their FX bank. A local custodian account is also required, as omnibus accounts of Euroclear and Clearstream have not been available since 1 January 2011.

Inflation Themes

Beyond Inflation Targeting—reconsidering tools, targets and theories

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Monetary policy makers are under pressure. Inflation targeting, the common policy framework that had worked so well since the early 1990s to rein in price gains, is struggling to lift inflation toward (a 2%) target. Still, the most commonly discussed alternatives seem to promise only limited help, while more radical proposals come with much larger risk. Hence, for investors the future monetary policy could be a future with fatter tails.

Secular factors, including demographic change, globalisation and technological progress have contributed to driving trend inflation lower and reducing economies' neutral interest rates. Inflation-targeting central banks thus regularly face the restriction of an effective-lower-bound (ELB) that limits their ability to lower the policy rate.

Central banks' reactions have evolved since the onset of the Global Financial Crisis. We have seen them deploy an array of new tools: quantitative easing (QE) programs to fund banks, negative interest rates policy (NIRP), yield curve control (YCC) and forward guidance (FG) — in various rounds and designs. Initially deemed unorthodox and extraordinary, these can now be considered part of the standard policy toolkit.

As inflation dynamics remain weak, the discussion is turning from tools to targets. Alternatives under discussion for the 2% inflation target currently used by many central banks range from merely fine tuning (eg, point target versus band) to increasing the target, to targeting price levels or average inflation, to targeting different variables altogether (eg, nominal GDP). However, none of these options seems evidently superior in theory, and when considering the challenges of real-world implementation, their costs may outweigh potential gains. Most likely, central banks may rather accept inflation lingering below official 2% targets for longer (BoJ, ECB), while also tolerating above-target inflation following longer periods of undershooting (Fed).

A step further could be more radical conceptual changes to monetary policy (abolishment of cash, helicopter money; modern monetary theory). These ideas typically challenge the conventional distinctions between fiscal and monetary policy. Instead, government debt issuance and money creation are seen as variations of the state's power to tax and to create money, where monetary policy, under certain circumstances, would accommodate or even outright finance fiscal-deficit spending as the way to create sufficient demand.

While not seriously considered now, such concepts could eventually gain more traction in the event of a serious economic downturn that renews the threat of deflation. In our view, the issue with these concepts is not so much that there are theoretically flaws in the way they might work. Rather, the more serious challenge is that politicians used to printing-press-facilitated spending may be unwilling to rein in their largesse once the deflationary threat is overcome.

For investors, particularly those buying debt, this could create a future with fatter tails. Constrained monetary policy implies a higher risk of deflationary scenarios with ever increasing nominal debt burdens. But aggressive experiments that blur the boundaries of fiscal and monetary policy could eventually result in sudden and sharp adjustments in expectations, with related swings in risk premia and exchange rates.

How Inflation Targeting came under pressure

A success story from the 1990s

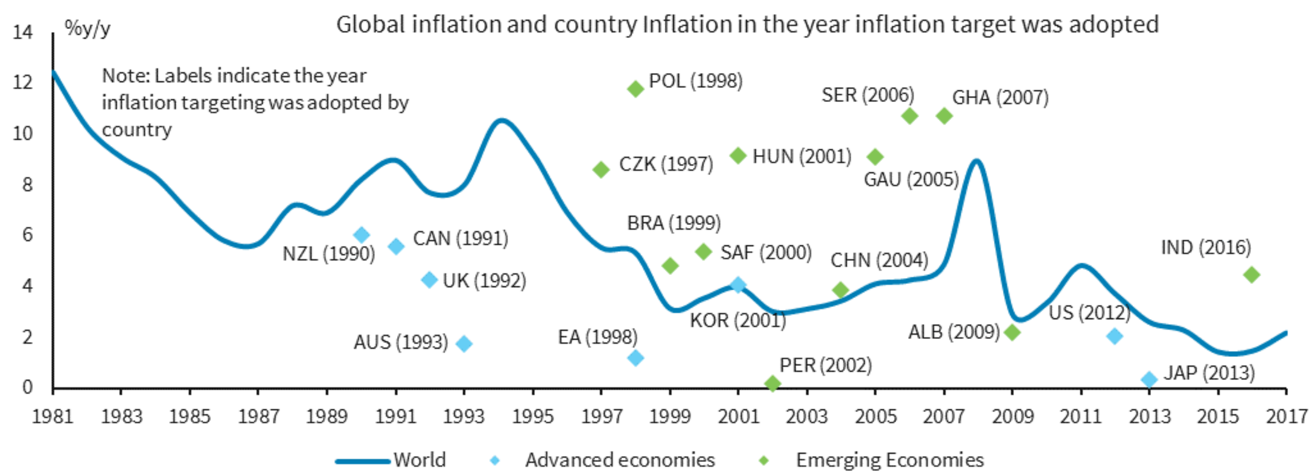
Monetary-policy regimes have changed over time. Inflation targeting (IT), which was 'born' in 1990, will soon have reached a life-span associated with other historical monetary-policy regimes: the Gold Standard (1870s-1914) and the Bretton Woods system (1948-1973), as well as the periods between wars (1919-1939) and between Bretton Woods and IT (1973-1990s)[1], when no single policy framework dominated. Although age in itself is certainly no reason to abandon a monetary-policy strategy, questions surrounding IT as a framework have been increasing at least since the GFC, with some having already declared "the death of inflation targeting."[2]

Inflation targeting offered a new framework following a period monetary policy experiments with mixed success

However, before delving into IT's challenges, it is important to understand its success. For a start, it arrived at the right time. IT offered a new conceptual framework after a number of false starts that followed the collapse of the Bretton Woods system, with attempts to actively manage perceived inflation-unemployment trade-offs, target money supply aggregates and run various forms of fixed exchange-rate regimes all tested and rejected. Almost all these experiments resulted in currency crises and/or high and volatile inflation; importantly, none had succeeded in anchoring public expectations. When New Zealand adopted IT in 1990, different types of exchange-rate pegs accounted for about two-thirds of monetary policy regimes in industrial countries. Accordingly, the 1992 ERM crisis motivated the adoption of IT in Europe. By the late 1990s, IT was also increasingly adopted in developing economies, amid CEE countries' transition to market economies and in the aftermath of the 1997-98 Asian financial crisis.

FIGURE 1

Inflation targeting spread across DM and EM economies since 1990, helping bring down and stabilize inflation globally



Source: World Bank, IMF, OECD, Haver Analytics, Barclays Research

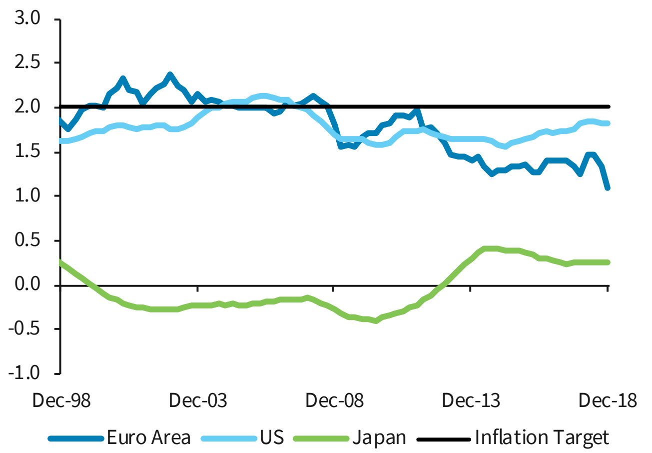
In contrast to the earlier policy experiments around 'indirectly' managing inflation through monetary aggregates or exchange rates, IT was grounded in more rigorous research-based findings. These pointed to central banks' inability to consistently achieve multiple goals with only one basic instrument (the policy interest rate) and to control real variables such as growth and employment (rather than just nominal ones) over a longer period. Moreover,

[1] For the purpose for this paper we define 'inflation targeting' loosely as a monetary framework that aims at achieving a certain rate of inflation (whether a point or within a band or a range; symmetric or not) by adjusting the short-term policy interest rate, under a flexible exchange rate regime. In this board definition, we consider all major central banks in advanced economies – including the Fed, ECB and BoJ – to be 'inflation targeters.'

[2] For example, see J. Frankel, May 16, 2012, "*The Death of Inflation Targeting*", Project Syndicate,

FIGURE 2

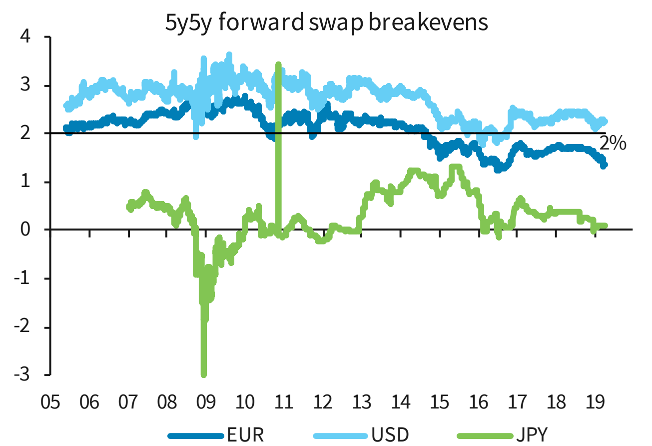
Trend inflation remains weak, especially in Europe and Japan



Source: OECD, Haver Analytics, Barclays Research

FIGURE 3

… and markets have come to expect soft inflation outcomes



Source: Barclays Research

research highlighted how high inflation harmed growth and the equitable distribution of income, and, perhaps most decisively, that expectations and credibility were crucial for the effectiveness of monetary policy.

Price stability mandate, institutional independence, transparency and accountability were IT's core elements

These insights pointed towards a framework in which monetary policy would be assigned one clear and credible objective: that of achieving and maintaining low inflation. In addition, policy credibility would be enhanced by strengthening the operational autonomy of the central bank, while at the same time ensuring a high degree of policy transparency and accountability. Thus, IT frameworks generally included a number of basic elements: (i) Central banks' explicit mandate to pursue price stability as the primary policy objective, combined with accountability for achieving this objective; (ii) a high degree of transparency of monetary policy strategy and implementation; (iii) explicit quantitative targets for inflation; and (iv) policy actions based on a forward-looking assessment of inflation pressures, taking into account a wide array of information.[3]

This framework helped boost central-bank credibility, which was crucial to anchoring inflation expectations and, in turn, stabilizing inflation outcomes. In addition to the institutional arrangements (central bank independence), credibility was achieved by emphasising rule–based policy making (eg, the Taylor rule) over discretion, clear mandates (ie, price stability/low inflation), and a strong aversion to monetary financing of fiscal deficits.

Credibility became crucial for anchoring expectations

The literature on the success of IT across economies is long. From 1990 to the GFC of 2008/9, the implementation of IT regimes was associated with low and stable inflation around official targets — 2% in most advanced economies — as inflation expectations settled around target. The rule-based monetary-policy approach of independent central banks was widely considered instrumental to the 'great moderation' that characterized the 2000s (until the GFC).

First doubts: Inflation Targeting's role in the Global Financial Crisis

Unsurprisingly, the GFC triggered many questions about the role that monetary policy had played in it. First, some questioned whether IT contributed to the build-up of financial imbalances. Did the fixation on consumer price inflation (CPI) — which indeed remained low and stable in the decade up to the GFC — prevent central bankers from paying attention to financial risks (ie, asset bubbles) that were accumulating in the background?

[3] One notable exception to assigning the central bank with a sole objective to pursue price stability is the Federal Reserve of the United States, whose mandate is interpreted as having dual objectives of price stability and full employment.

Second, IT was criticized for contributing to sub-optimal policy responses in the aftermath of the crisis. Did the fixation on consumer-price targets prevent central banks from the aggressive easing that was required in this situation? The ECB's rate hikes in 2008 and 2011 can be seen as examples of a central bank tightening policies in the face of adverse supply and terms-of-trade shocks (eg, higher oil prices), because it was fixated on the impact on consumer prices rather than on output and employment.

Overly narrow focus on CPI can become a potential weak spot

These arguments are not easily dismissed. However, missing financial vulnerabilities (Fed) or misjudging the true state of the economy (ECB), may be more adequately characterised as "policy mistakes" than inherent flaws of IT in principle. IT frameworks certainly provide for the flexibility to look through transitory above-target headline inflation, and they also do not prevent central banks from monitoring financial stability risks and enacting prudential measures to address them.

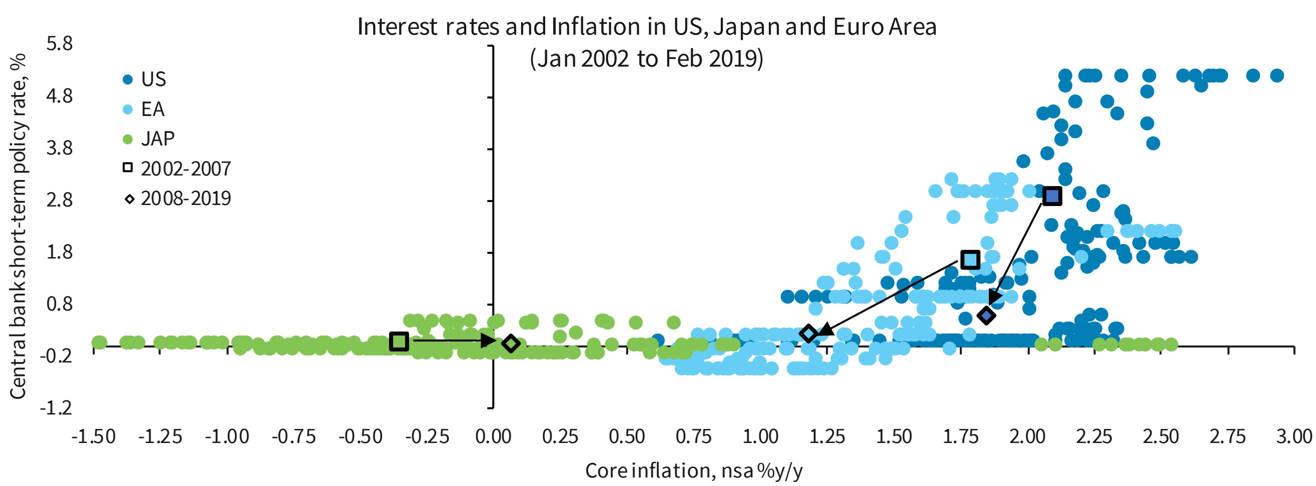
The new challenge: bringing back inflation in a low interest rate world

The challenge has shifted from above- to below-target inflation

IT's biggest challenge so far has turned out to be one that goes to its very core: inflation itself. But in contrast to the time of IT's birth, it is not that central banks wish to bring down inflation that is too high, but to spur inflation that is too low. A decade after the GFC, inflation has remained below official targets in most advanced economies, and at times has come perilously close to deflation even with sustained monetary-policy accommodation and strong labour-market recoveries. Certainly, differences remain across economies, with Japan's inflation remaining still closest to zero, the US having about reached 2% and the euro area somewhere in the middle. Even in the US, 2% has proven difficult to sustain despite full employment, a massive pro-cyclical fiscal boost, and still-accommodative monetary conditions. Hence, it seems as though there has been a fundamental change in economic relationships and, consequently, the effectiveness of monetary policy.

FIGURE 4

Closer to the 'trap': Europe and, less so the US, have moved closer to Japan's bad equilibrium of low rates and low inflation



Note: Inspired in part by Bullard, J. (2010), "*Seven Faces of `The Peril'* ", Bank of St. Louis Review, September/October 2010, 92(5), pp. 339-52, Source: OECD, BoJ, ECB, Eurostat, FRB, BLS, Haver Analytics, Barclays Research

Policy is implemented by the setting of the policy rate relative to the neutral level

Inflation targeting is implemented by adjusting short-term borrowing rates around what is considered an economy's equilibrium interest rate, the rate consistent with stable macroeconomic performance. This equilibrium or neutral rate, so-called r* (conceptually a real rate), is not observable but is nevertheless central for the models guiding policy in inflation-targeting regimes. When the interest rate is set above this equilibrium rate, the economy and inflation slow, and vice versa when policy rates are set below r*.

Within a modest positive range, the effectiveness of policy should be symmetric, with cuts as effective as hikes. Should inflation break out on the high side, and even if expectations become unanchored, the solution remains relatively straight forward: the central bank needs to tighten more aggressively (eg, the Fed under Paul Volcker, or some EM central banks that successfully achieved disinflation from high inflation environments). In principle, the policy interest rate just needs to be set sufficiently high for long enough that inflation outcomes decline and expectations move down again, even if at the expense of a slowing economy.

With low neutral rates, it is more likely that policy rates will be constrained by the lower bound

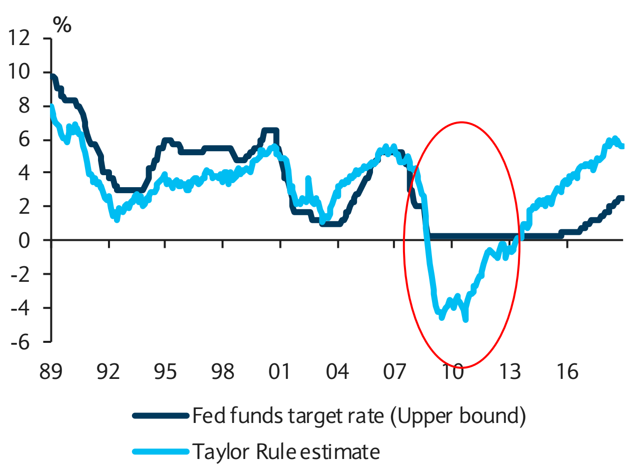
The same is not true in a world where inflation and r* are both very low. Given limitations on how low the nominal interest rate can be set, the policy rate is limited by the so-called effective lower bound (ELB), whereas the real interest rate can move well into negative territory. Thus, if expectations are for very low inflation or even deflation, even a policy rate at zero may not be low enough to push the real rate sufficiently below r* to re-stimulate growth and inflation. For example, in the wake of the GFC, Taylor Rule estimates of the appropriate nominal Fed funds rate were as low as -4.6%, yet the Fed stopped at zero (Figure 5).

Estimates of the neutral rate have fallen, forcing central banks to consider new tools

Today, policy makers face a world of very low estimates for r*, combined with low inflation expectations. Thus, even by lowering the nominal policy rate to zero, real interest rates may not go low enough to push inflation back to target. This fundamental challenge to the orthodox IT framework has forced central banks to consider what tools they could employ beyond the traditional policy interest rate.

FIGURE 5

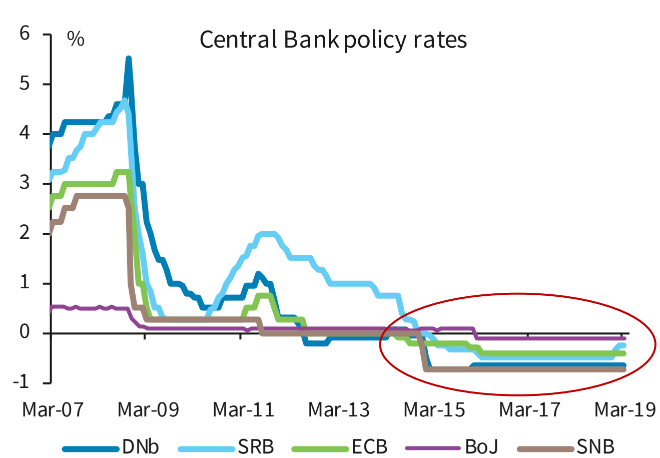
The Fed stopped at zero, but r* estimates were much lower



Source: FRB, Haver Analytics, Barclays Research

FIGURE 6

European central banks followed the ECB into NIRP



Source: DNb, SRB, ECB, BoJ, SNB, Haver Analytics, Barclays Research

Box 1: Why are neutral interest rates so low?

Global decline in r* driven by lower growth, demographics and technology

The question of which interest rate is consistent with a stable macroeconomic performance is a crucial one in modern, developed economies. Even though such neutral or equilibrium real interest rates (r*) are unobservable, an understanding of them is fundamental to setting appropriate monetary policy. A policy rate above r* should tend to suppress activity and thus inflationary pressure, while a rate below r* would have the opposite effect.

Over the past four decades, long-term (real) interest rates have declined across economies and asset classes. This suggests neutral real rates have fallen. Model-generated estimates of r* show declines as well — often even suggesting a negative r* in the wake of the GFC. Given the close conceptual link between r* and trend growth, the deceleration in trend across developed economies has likely played a key role in pushing r* down. In turn, this deceleration is mainly explained by demographic factors and slowing productivity growth. Population growth in advanced economies has fallen in the past decades from 1.4% p.a. in the 1970s to less than 0.4% today, while measures of both labour and total factor productivity (TFP) have largely declined in parallel.[4]

Alongside lower trend growth, global shifts in desired saving and investment are also related to the long-term decline of r*. Again, demographics play a crucial role, as population growth, ageing, and choices about length of retirement affect the prevailing balance of saving and investment, and hence equilibrium interest rates. This imbalance has likely been exacerbated by a glut of precautionary saving by emerging markets and by the drag on spending from widening income inequality, which driven overall savings higher. Meanwhile, slower technological progress and lower public investment have put downward pressures on global investment.

Estimations by the BoE for the global r* suggest a total 450bp decline over the past 40 years, of which 400bp are explained by the combination of lower trend growth (100bp) and shifts in the balance of desired savings and investment (300bp), with an additional savings element driven by demographics (90bp). Although these estimates come with large uncertainties and depend on a number of assumptions, they do provide a good impression of the different factors and orders of magnitude at play. Importantly, most of these forces are expected to persist or intensify (such as population ageing).

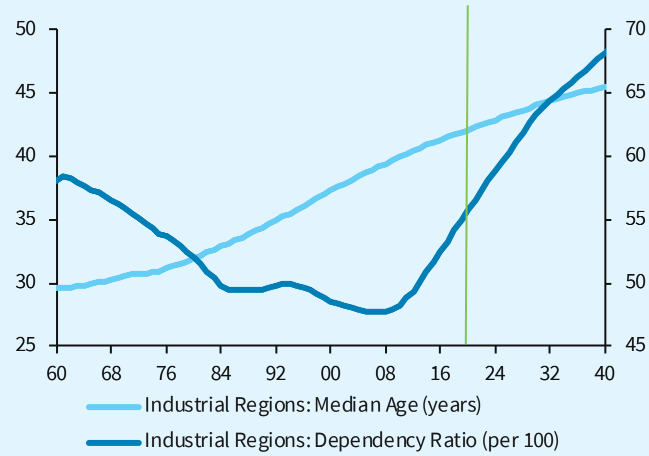
Diminishing Inflation Expectations

Nominal rates along the curve are also being pushed down by low expectations for inflation. With inflation having trended down for several decades and falling further in the aftermath of the GFC, inflation expectations — which IT regimes had earlier managed to anchor around their targets — have started to shift down as well. Both inflation-linked assets and broad consumer surveys show evidence of this: as priced by the market, 5y5y breakeven inflation rates from US TIPS and nominal US Treasuries and 5y5y US CPI swaps have both been 60-80bp lower, on average, in 2015-19 than in 2010-H1 14. 5y5y HICPx swaps indicate that market-based inflation expectations have dropped in Europe as well. The measure of 5-10y inflation expectations from the University of Michigan Survey and the 3y ahead inflation expectation measure from the NY Fed's Survey also confirm that consumer inflation expectations have fallen over the past several years.

[4] L. Rachel and T.D. Smith (2015): *Secular drivers of the global real interest rate*; Bank of England; L. Rachel and L.H. Summers (2019) On falling neutral rate, fiscal policy, and the risk of secular stagnation; Brooking Papers; *Equity Guilt Study, Chapter 2, (2016): When absolute zero isn't low enough*; Barclays Research

FIGURE 7

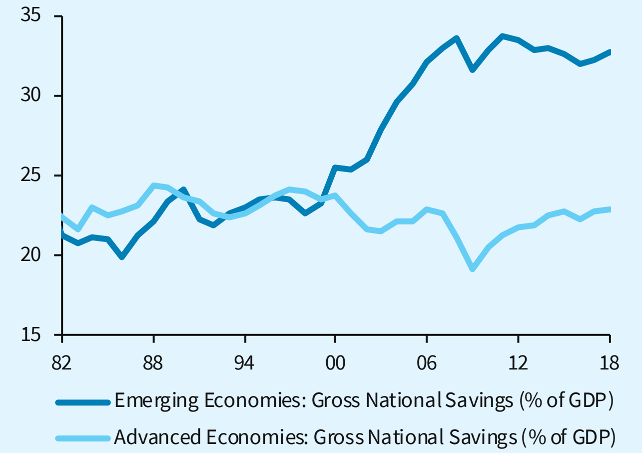
Demographic shifts due to lower birth rates and longevity…



Source: UN, Haver Analytics, Barclays Research

FIGURE 8

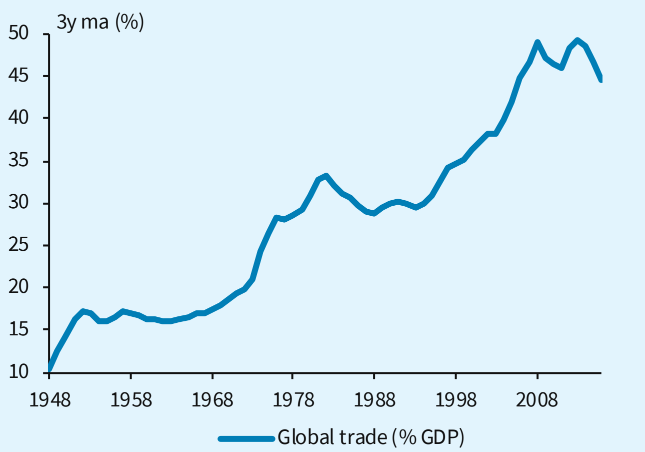
…increases in EM economies' savings ratios…



Source: IMF, Haver Analytics, Barclays Research

FIGURE 9

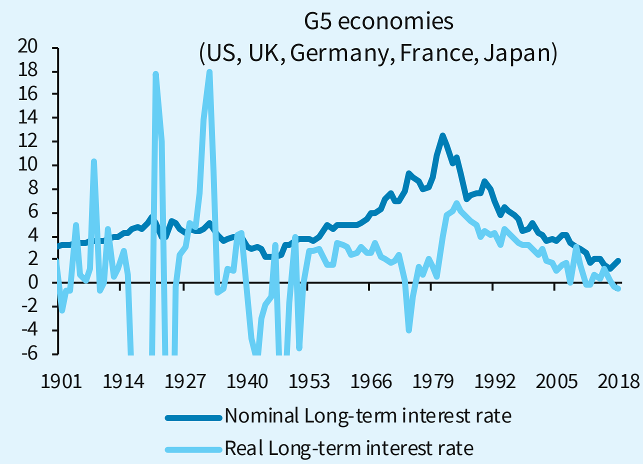
…and globalisation of commerce and labor markets …



Source: IMF, Barclays Research

FIGURE 10

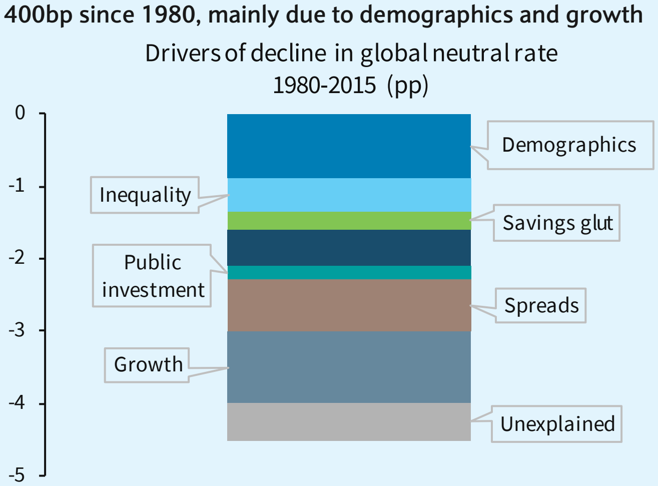
… all contributed to lower nominal and real interest rates



Source: Jordà-Schularick-Taylor Macrohistory Database, Haver Analytics, Barclays Research

FIGURE 11

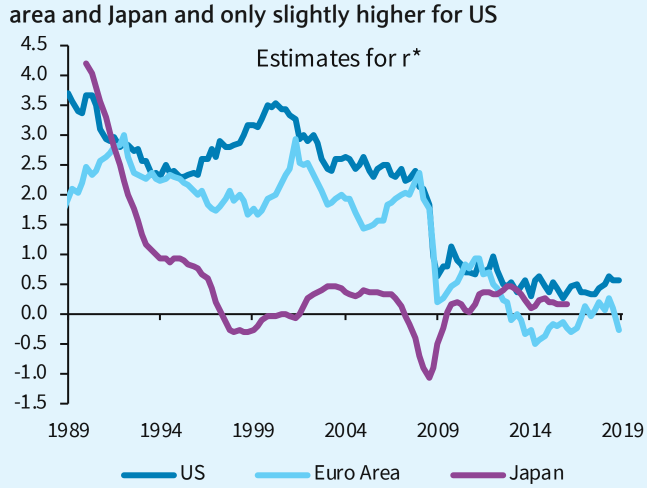
The global neutral rate is estimated to have declined by over 400bp since 1980, mainly due to demographics and growth



Source: Bank of England, L Rachel and T.D. Smith (2015)

FIGURE 12

Estimated neutral rates (r*) hover around zero for the euro area and Japan and only slightly higher for US



Source: Federal Reserve Bank of New York, *Measuring the Natural Rate of Interest*, BoJ, Barclays Research

Initial crisis response: bringing out new tools

Quantitative Easing (QE)

Quantitative easing is a tool by which a central bank expands the monetary base by buying assets in the secondary market. There are generally a few channels through which QE is thought to affect activity: increasing bank credit extension, lowering longer-term borrowing rates in the capital market, supporting asset prices (also known as the portfolio-rebalance channel as investors are pushed out the risk spectrum) and as a signalling mechanism. While there is a fine line between QE and debt monetisation, the distinction is that central banks could reverse QE by secondary market sales.

Central banks expanded the monetary base by buying assets in the secondary market

Long before the GFC, the Bank of Japan was deploying QE from 2001 as it increased the monetary base after a zero-interest-rate policy (ZIRP) introduced in 1999 failed to eliminate deflation. Initially focused on buying JGBs, it expanded the program to equity purchases in autumn 2002. The Fed followed in December 2008 with it its own long-term asset purchase program, later known as QE1, which focused on mortgage purchases. It would go on to QE2, which focused on US Treasury purchases, then Operation Twist (which technically was not QE because it sterilized purchases with sales of shorter-maturity Treasuries), and QE3, which included both Treasury and mortgage purchases. The BoE began its program in March 2009 with a concentration in UK gilts. The ECB launched its own version in late 2014, when they bought asset-backed securities and covered bonds and later expanded the program significantly in early 2015 to include bonds issued by euro-area governments, agencies and European institutions.

Forward Guidance (FG)

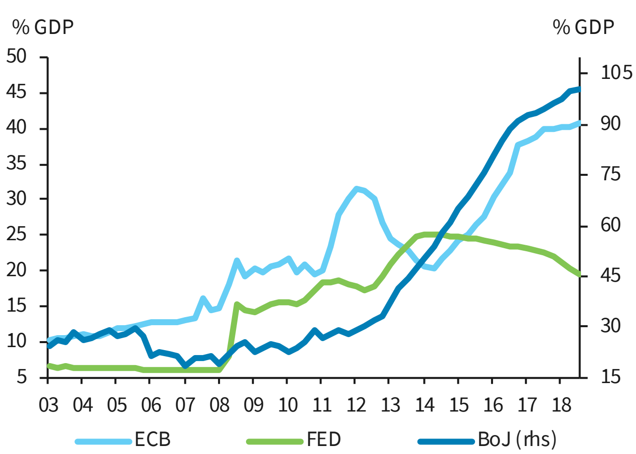
Forward guidance seeks to commit the central bank to future policy actions

Another tool central banks have used to stimulate growth is pre-committing to easy policy through FG. It can be an effective tool when clearly communicated, provided that the central bank has credibility. The implementation of FG can be put into three broad categories: qualitative, time contingent and threshold-based.

The BoJ was also a pioneer in providing the market with some certainty through FG. When it introduced the ZIRP in 1999, the Bank explicitly committed to continuing it "until deflationary concern is dispelled." The Bank of Canada, the Fed and the Riksbank all implemented FG shortly after the onset of the recession, with the BoC and Riksbank both providing time-contingent guidance in April 2009. The ECB and BoE joined others in mid-2013, with the BoE basing its low-rate policy in part on the unemployment rate. At its

FIGURE 13

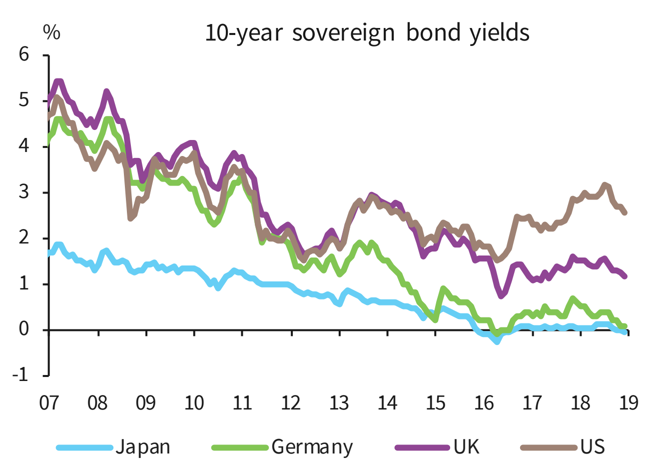
Central banks' QE expanded their balance sheets…



Source: FRB, ECB, BoJ, Haver Analytics, Barclays Research

FIGURE 14

…bringing down longer-term interest rates



Source: US Treasury, MoFJ, Bbk, BoE, Haver Analytics, Barclays Research

March 2019 meeting, the ECB updated its FG by stating that it expects its key interest rates to "remain at their present levels at least through the end of 2019."

Negative interest rates (NIRP)

The effective lower bound on the policy rate can be negative because it is costly to store cash

While the low neutral-rate problem facing policy makers in a downturn is often attributed to a zero-lower bound on nominal rates, several central banks have shown that nominal policy rates can be pushed into negative territory and held there to provide further stimulus. Most have found that there is a limit to how low negative rates can be set; after all, one would only pay to park money when the risk-adjusted cost is lower than an alternative storage facility. The primary concern with NIRP has been the potential effect on bank profitability, which can weigh on the bank credit channel of monetary policy.

Switzerland used NIRP in the 1970s in an attempt to deter a flood of foreign investment and control the currency. Following the financial crisis, first Sweden (2009), then the Dankse Bank (2012), ECB (2014), Swiss National Bank (SNB, 2015) and BoJ (2016) all pushed some policy rates below zero. Many have implemented NIRP with a tiered or partial approach. For example, the SNB only applies negative interest rates to the portion of deposits that exceeds a given exemption threshold. Similarly, when the BoJ adopted NIRP, it implemented a three-tier system where a 0.1% rate was applied for a member bank's "basic balance," a 0% rate for a "macro add-on balance," and a -0.1% rate for holdings in excess of these two balances. While the Fed has not ruled out using NIRP in the next downturn, there remains considerable debate as to whether it would work in the US.

Yield Curve Control (YCC)

While traditional short-term interest-rate focused monetary policy attempts to influence longer rates through the expectations channel and QE works, in part, through its influence on term premia, yield-curve control takes it one step further by setting targets for both short and longer interest rates. It is essentially QE where instead of announcing a fixed notional amount of assets to be purchased, the central bank commits to purchase whatever amount is needed to cap rates at some portion of the yield curve. This approach leads to more control over the term structure of interest rates – so long as that commitment can be fulfilled. This is subject to some risks, as it is possible that the central bank is unable to purchase enough bonds to fulfil its commitment or that central bank buying becomes so dominant that the market ceases to function effectively.

Currently only used by the BoJ, yield curve control could become an option for other banks as well

YCC was first implemented by the Fed during WWII in the early 1940s, with an implicit commitment to cap long rates at 2.5%, mainly to help the Treasury finance the war, though it was rarely binding. In September 2016, after QE and NIRP failed to push up inflation to a desired level, the BoJ committed to purchasing longer bonds in a flexible manner such that 10y JGB yields "will remain around zero percent." While other central banks have not followed the BoJ, the Fed's Richard Clarida recently noted that the Fed "can send some solid long-term signals with this (yield curve control) and that would help in a future downturn." Thus, it appears that it might be a regular tool in central banks' toolkits.

Non-standard tools have become standard…

One broad conclusion regarding the new tools central banks have employed since the GFC seems increasingly accepted: the non-standard has become the standard. What were initially regarded as extraordinary emergency measures have been incorporated into the regular policy toolbox. There is no indication that central banks' balance sheets will decline back to their pre-GFC crisis levels and, in case of significant deteriorations of the current macro environment, QE would likely be reactivated, with YCC being an additional variation. Similarly, now that some central banks have shown that it is possible to set negative policy rates, to a certain degree, it seems likely that this option will be considered more widely. Indeed, ongoing efforts to reduce some of NIRP's negative side-effects on banks (eg, tiering of reserves) suggest that the option of negative policy rates is here to stay.

…but even that seems insufficient to credibly attain inflation targets

That said, these new tools have still not allowed central banks to deliver satisfactorily on their inflation targets. Even in the US, where the Fed's preferred core PCE inflation measure has reached around 2%, it has occurred only late in the cycle and with a very low unemployment rate that usually would be associated with stronger inflationary pressures. Hence, while in Japan and Europe the 2% target remains out of reach, the risk of not sustainably delivering 2% also remains high in the US. This could damage the credibility of these target, raising risks that inflation expectations become anchored at rates below 2%. Moreover, with QE programs implemented to date having already pushed down term premiums, future programs could plausibly have less traction on longer-term borrowing rates. Thus, with the logic of the 2% target being questioned, it is not surprising that central banks have started to consider potential changes to the IT framework itself. The Fed's ongoing strategy review, which is expected to be complete by mid-2020, is an important example.

Beyond the crisis: different *targets* for a new normal?

Some considerations for evaluating the options

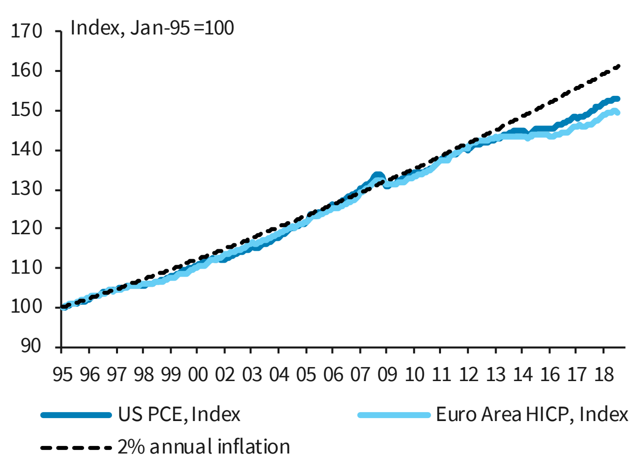
Having conceded that additional policy tools such as QE, FG, YCC are imperfect substitutes for the conventional policy rate instrument, discussion around modifying or replacing IT is typically motivated by the increased likelihood that policy rates could regularly hit the ELB in a low neutral rate environment. In theory, many of the proposals being discussed – such as targeting a higher level of inflation, price *levels*, or *nominal GDP* – could bolster FG in ways that help address this issue. But this narrow focus will not suffice, as policymakers will need to weigh the costs (both temporary and permanent) and other practical shortcomings of these proposals.

Any new target needs to be credible to shape expectations

One crucial issue when weighing these alternatives is the formation and management of expectations by market participants. Although an idea may sound promising in theory, its effectiveness in practice will depend on whether policy can influence market *expectations* in the intended way. In other words, will the proposed 'target' be a credible commitment device for guiding expectations? This is not assured, because today's commitments may not be *time consistent* (in economics jargon), meaning that even well-intentioned policymakers will have strong incentives that will prevent them from following through on a commitment. In particular, a commitment to eventually allow inflation to run above or below some long-run desired level may prove exceedingly costly in the event, and therefore may not influence expectations as intended.

FIGURE 15

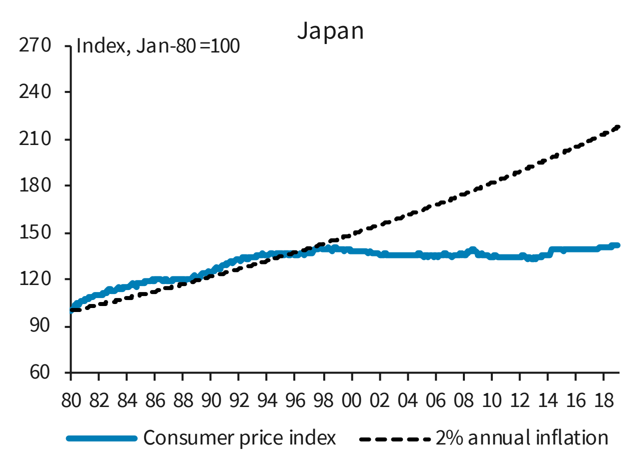
Price level targeting could require…



Source: Eurostat, BEA, Haver Analytics, Barclays Research

FIGURE 16

…significant catch-up, in particular for Japan



Source: MIC, Haver Analytics, Barclays Research

Alternative targets come with costs

There are other meaningful costs to consider, some of which are transitory, and others more lasting. For instance, many of the new frameworks discussed below aim to meaningfully increase inflationary expectations. To the extent that such efforts are successful, the outcome would clearly benefit some market participants (such as borrowers) at the expense of others (lenders), implying substantial re-distributional consequences during the transition. Even after the transition, higher inflation would likely prove costlier for some groups (including those who are inadequately hedged for inflation) than others. While re-distributional consequences are unavoidable for any policy change, there may be considerable reluctance to shift away from a framework that for two decades, by and large, has delivered notable improvements relative to previous approaches.

Setting a higher inflation target

A higher inflation target would create more space for rate cuts

Perhaps the simplest alternative under discussion is to permanently raise the inflation target (such as from 2% to 4%). By essentially maintaining the IT framework, this approach would inherit many benefits, including the flexibility for policymakers to let bygones be bygones when supply shocks occur. To the extent that the higher target is credible, the added benefit would be higher inflation expectations and nominal interest rates. With greater scope to reduce the policy rate in a downturn, central banks would be less likely to hit the ELB. Higher inflation expectations would also bolster stimulus once the ELB has been reached, since anticipated real rates of interest would be lower. With less time seemingly spent at the ELB, recessions would be less costly and average economic activity would be higher.

Can a 4% target be credible when even 2% has not been achieved?

But, as with all alternatives, these benefits come with costs. The most obvious is that economic participants would have to live with higher expected and realized inflation rates. This is meaningful because inflation is not costless: a choice to hold cash would come with a greater sacrifice of purchasing power, and actions to avoid these costs – such as economizing on cash holdings and inflation hedging – involve deadweight losses for the economy. Arguably, these costs would fall disproportionately on those who lack access to cash substitutes, such as lower-income households. At the same time, these same households may benefit disproportionately from spending less time at the ELB.

Higher inflation means losses for some

Boosting inflation targets would also involve substantial transition costs. As mentioned earlier, higher inflation expectations tend to transfer wealth from existing lenders to existing borrowers. To provide a ballpark sense of the magnitudes at play, the US Federal Government has sold to the public about $8.2 trillion of longer-term nominal debt securities.[5] Given the average duration of these securities (6.2 years), a credible commitment to permanently raise the inflation target by 1 percentage point would raise yields by about the same amount, thereby transferring about $500 billion of wealth from bondholders to the US Federal government.[6] Of course, this is only a fraction of nominal debt contracts outstanding, so the overall wealth transfer would be much larger.[7]

[5] The $8.2 trillion total excludes treasury bills, inflation-indexed bonds, and bonds held by the Federal Reserve.
[6] This magnitude is calculated as the change in the aggregate market value of these debt holdings, approximated using the formula: Change in value of securities = duration x value of securities x change in yields.
[7] The political reality of these redistributions is perhaps part of the reason that Federal Reserve Chair Jay Powell has stated during Congressional testimony that the FOMC has ruled out this alternative. See Powell, J.H.,, February 27, 2018, "*Semimanual Monetary Policy Report to the Congress*", Before the Committee on Financial Services, U.S. House of Representatives, Washington, D.C.,

FIGURE 17

The costs and benefits of alternative frameworks differ

Alternative		Lower probability of ELB?	Enhance policy at ELB?	Accommodate supply shocks?	Main drawbacks
Higher inflation target		Yes	Yes	Yes	• may lack credibility • wealth redistribution
Price level target	temporary	Possibly	Yes	Yes/No	• may lack credibility
	permanent	Yes	Yes	No	• may lack credibility • potentially destabilizing with supply shocks • challenging to calibrate, ex ante
Average inflation target		Yes	Yes	Yes	• may lack credibility • challenging to calibrate, ex ante • heightened risk of political interference
Nominal GDP target	growth rate	Possibly	No	Yes	• somewhat counterproductive at ELB • misleading supply signals may constrain policy • unstable inflation expectations
	level	Yes	Yes	No	• may lack credibility • misleading supply signals may constrain policy • challenging to calibrate, ex ante

Source: Barclays Research

Price level targeting

Price level targeting (PLT) has been advocated since the late 1990s, when it was proposed by a number of prominent economists to help Japan emerge from its ongoing liquidity trap.[8] With this approach, central banks target a trajectory of the price level, commonly one in which prices rise at a pre-specified rate – which, for illustration, we assume is 2% y/y.

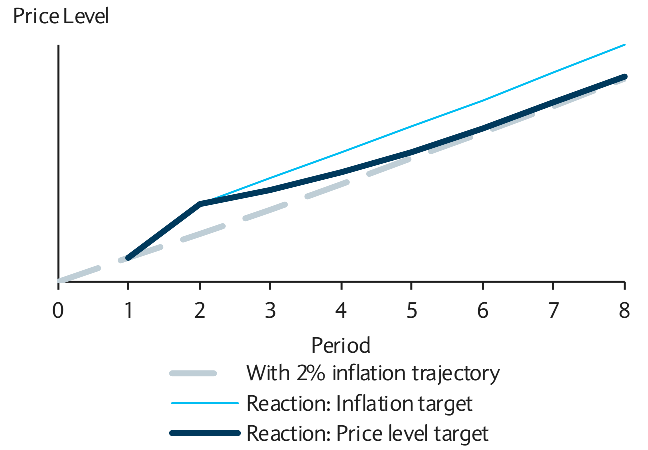
Making up for the years of below-target inflation with years of above target inflation

The main benefit of PLT relative to IT is to bolster the credibility of FG at the ELB. In such a scenario, inflation would generally be running well below 2%, and, to eliminate the shortfall, the central bank would eventually need to let the economy run hot so that inflation exceeds 2% for a time. If financial markets view this as credible, they would factor in expectations of lower policy rates when the economy emerges from the ELB, which would stimulate activity immediately by forcing down longer-term borrowing rates. In turn, this would provide central banks with more ammunition to avoid reaching the ELB: with the economy expected to spend less time at the bound when it is reached, markets would presumably boost inflation expectations to around 2%, thereby raising nominal interest rates. Of course, these benefits depend critically on the credibility of the commitment to keep rates lower for longer after emerging from a liquidity trap.

[8] For instance, see "*Price Level Targeting vs. Inflation Targeting: A Free Lunch*," by Lars Svensson, *Journal of Money, Credit and Banking*, Vol 31, 1999 and *NBER Working Paper No. 5719*.

FIGURE 18

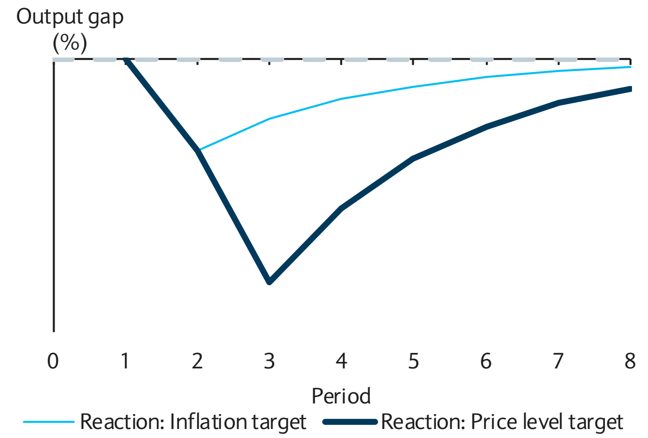
A price-level target would require the central bank to reverse supply shocks…



Source: Barclays Research

FIGURE 19

…which would tend to destabilise activity



Source: Barclays Research

However, credibility issues with PLT are more acute than demonstrating a willingness to tolerate inflation after reaching the ELB: meaningful tensions will also arise in the event of adverse supply shocks (or "price level shocks"), when the virtues of PLT can rapidly become a vice. This is illustrated in Figures 18 and 19, which compare the response of prices (left panel) and the output gap (right panel) to a persistent adverse supply shock – such as an increase in the price of oil. With both a forward-looking IT regime (the light blue lines) and a PLT regime (the dark blue lines), the shock initially raises consumer prices and leads to a slight contraction in real activity. With IT, the central bank lets bygones be bygones, allowing the shock to temporarily raise inflation in the short run and the output gap to gradually close. However, with PLT, the central bank seemingly does not have the luxury of prioritising economic stability ahead of defending the target. Policy would need to be tightened in order to undo the inflationary impulse from the shock, leading to a costly period of foregone activity. Since shocks are quite common, policy may need to engineer many such reversals to secure the credibility needed to reap the benefits of PLT at the ELB.

But should central bank really suppress inflation below target after a period of overshoot?

PLT also raises subtle, but important, issues with implementation. For example, once a target has been established, adverse demand shocks may well occur after a period when the economy has been running above potential, with prices pushed above the target. Figure 21 depicts such a situation, using the experience of the US in the run-up to the GFC as an example. The lines in the figure show accumulated gaps between PCE prices and core PCE prices and a plausibly calibrated target.[9] With this calibration, both prices had ascended well above their targets (in part due to an ill-timed energy price shock) so that the FOMC would have entered the crisis with an intention to keep its policy stance *tighter* than otherwise to unwind these overruns. Even if the Fed had fully anticipated the magnitude of the impending crisis at the time, its commitment to the target would have seemingly undermined its ability to respond.

Although targets can surely be recalibrated to support FG in cases where levels are clearly misaligned with the public interest, the possibility of doing so speaks to its credibility as a commitment device. If a central bank can opportunistically boost its target when the economy is operating below full employment, it can just as easily reduce it when the time comes to reflate the economy following a bout at the ELB.

[9] We assume each target rises at 2% y/y, and normalise each so that the initial gap is zero in Q2 2005 – the last quarter prior to the GFC when the US unemployment rate gap was closed.

These various shortcomings are part of the reason that former Federal Reserve Chairman Ben Bernanke has proposed a *temporary* PLT approach.[10] In this alternative framework, the central bank would only commit to the PLT when the policy rate is at or near the ELB, with an eye to boosting the credibility of FG to keep rates lower for longer. Although this alternative seemingly helps address some of the shortcomings of a permanent PLT discussed above, it may still lack credibility, as policymakers can always renege on the commitment when the time comes to follow through with high inflation.

Average inflation targeting

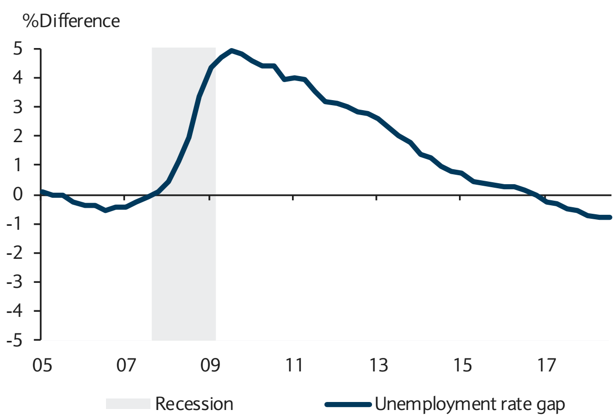
John Williams, the current head of the New York Federal Reserve branch and vice-chair of the FOMC, has proposed the idea of average inflation targeting (AIT).[11] With this approach the central bank would vary its inflation target over time, committing to intentionally set to targets somewhat above 2% – such as 2.25% – in periods when the economy is running in the vicinity of full employment and a somewhat lower target – such as 2.0% – otherwise.

Targeting an average inflation rate over time may be a workable alternative

AIT can be thought of as a hybrid that seeks to extract the most useful features of IT and PLT. The main idea is to bolster inflation expectations to levels closer to 2%, acknowledging the strong likelihood that inflation will tend to run well below the target for extended periods when the policy rate is trapped at the ELB. On paper, the commitment to adjust the target at a later date, as necessary, to balance out low-inflation outcomes would work much like PLT, reinforcing FG at the ELB by assuring markets that the policy rates will be kept lower for longer when the ELB no longer binds. As with PLT, this could also help provide more ammunition for central banks to avoid ELB outcomes, by raising expected inflation and neutral interest rates when the economy's output is closer to potential.

FIGURE 20

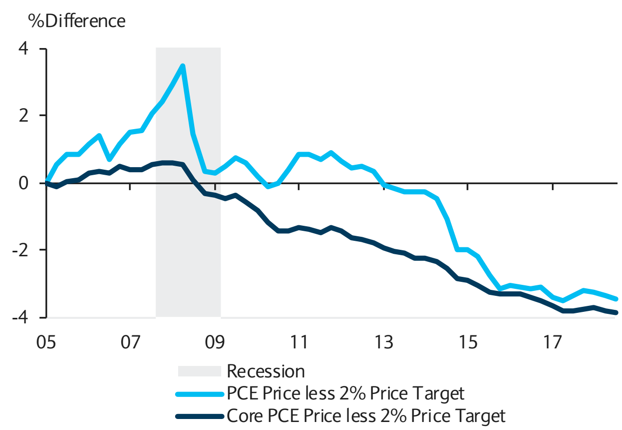
The Fed's full employment mandate clearly called for an accommodative policy stance in the GFC…



Note: Target is normalized to Q2 2005, when the unemployment rate gap is closed according to the CBO. Source: Congressional Budget Office, Bureau of Economic Analysis, Barclays Research.

FIGURE 21

… but a price level target may have undermined its ability to respond



Note: Target is normalized to Q2 2005, when the unemployment rate gap was closed according to the CBO. Source: Congressional Budget Office, Bureau of Economic Analysis, Barclays Research

[10] "*Monetary Policy in a New Era*" by Ben S. Bernanke, paper prepared for conference on Rethinking Monetary Policy, Peterson Institute, Washington DC, October 2, 2017.

[11] Williams has outlined this approach in a number of speeches, including recently with "*Monetary Policy Strategies in a Low-Neutral-Interest-Rate World*", presented at the Plenary Meeting of the Group of Thirty, Federal Reserve Bank of New York, November 30, 2018.

However, AIT resembles IT in the sense that it provides scope to temporarily prioritise economic stability above defending the target when the economy is hit by supply shocks. This is because the target within each regime can be treated much as in a flexible IT framework, with a forward-looking view that de-emphasizes the need to reverse supply shocks. With this shift in emphasis, it would be considerably easier for the central bank to demonstrate the credibility of its commitment to an AIT framework. Another potential benefit is that AIT may be more intuitive to the public than PLT, which could also help reinforce credibility.

Enhanced flexibility could come at the expense of lower credibility

But this enhanced flexibility potentially comes at the cost of undermining credibility, and may also expose central banks to heightened political pressures. By construction, an adjustable target may lack credibility because it is subject to future adjustment. As with PLT, markets will also be aware that policymakers will eventually need to grapple with the costs imposed by a commitment to let the economy run hot, and may not view this commitment to be credible. Policymakers also would not know the duration of an upcoming expansion, which would leave open to debate the appropriate adjustment to the target. Among other things, this would provide scope for political interference, as a given political administration, once in power, will have incentives to pressure the central bank to set the higher target – thereby reaping the benefits of a strong economy while leaving the central bank to sort through any hangover effects on inflation and financial stability.

Nominal GDP targeting

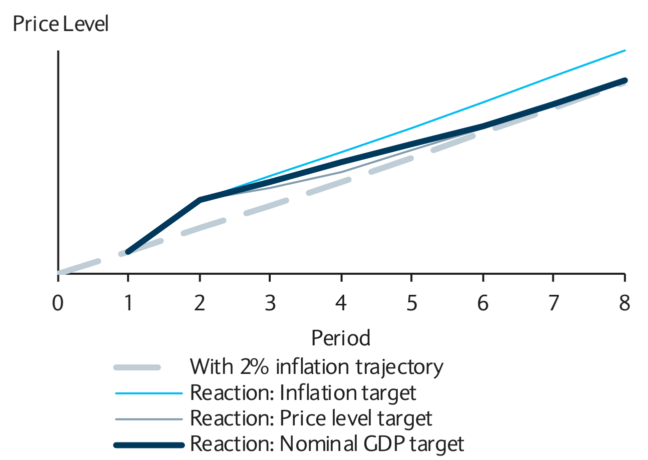
A key theme of the forgoing discussion is that frameworks based solely on a price stability objective, such as IT or PLT, can sometimes be at odds with full employment. Nominal GDP targeting (NGT) is a framework that attempts to achieve a more consistent balance between these two considerations, using a single target that weights both goals.

Targeting nominal GDP is an elegant solution in theory …

NGT has two main variants. In the first, the central bank would target a specific *growth rate* – such as 4.5% q/q saar – at some horizon, much as it targets consumer inflation with IT. Since nominal GDP growth is (approximately) the sum of GDP price inflation and real GDP growth, the target would place equal weight on the gaps between (a) the growth rates of output and potential, and (b) GDP price inflation and an inflation target (set implicitly, as the nominal GDP target less potential GDP growth). As with IT, policymakers would receive an unambiguous signal to make policy rates more accommodative if both gaps are expected to run negative, and the converse if both gaps will run positive. Hence, the framework would direct

FIGURE 22

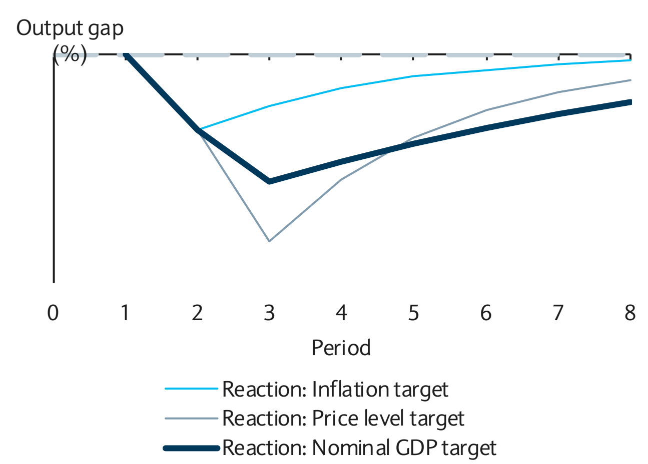
With a nominal GDP target, the central bank would be react more gradually to supply shocks than with a price target…



Source: Barclays Research

FIGURE 23

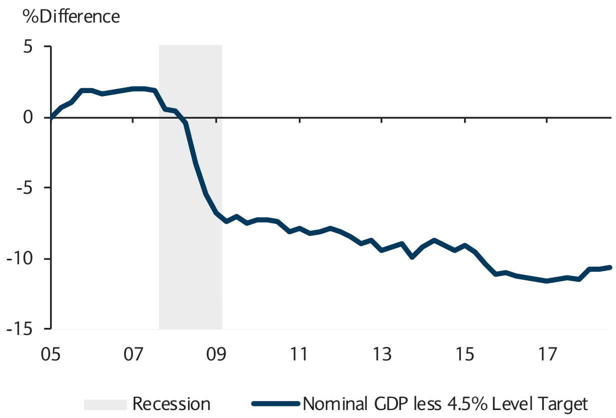
…which would be less destabilizing for activity



Source: Barclays Research

FIGURE 24

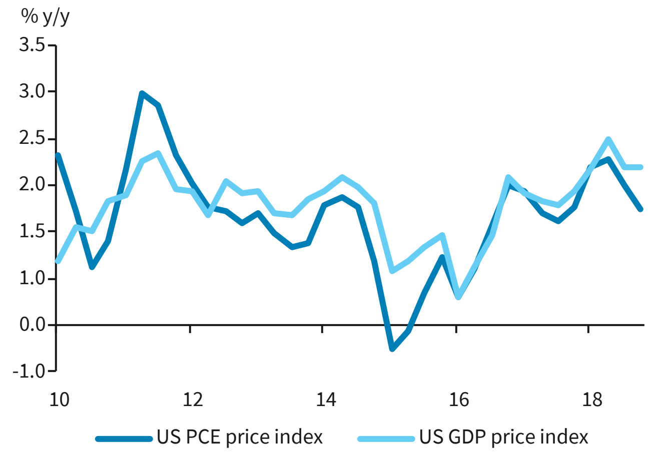
At the onset of the GFC, a nominal GDP level target may have slowed the Fed's policy response



Note: Target is normalized to Q2 2005, when the unemployment rate gap is closed according to the CBO. Source: Congressional Budget Office, Bureau of Economic Analysis, Barclays Research

FIGURE 25

Nominal GDP targeting ignores the distinction between GDP and PCE prices



Source: BEA, Haver Analytics, Barclays Research

policymakers to lean against demand shocks as with IT, automatically steering the economy toward full employment. [12] When supply disturbances hit, the two gaps would send mixed signals, and any dilemma about which gap to prioritise would be resolved by weighting them equally. This would tend to split the burden of adjustment between activity and prices in the short run.

A key shortcoming of NGT is that it may not effectively reinforce FG when policy rates are constrained by the ELB. As discussed, a pledge to keep rates lower for longer will only be effective if policymakers can credibly commit to future outcomes where the economy is allowed to run "hot" to generate expectations of higher inflation. But such outcomes almost surely require a sustained period of rapid nominal GDP growth, which would violate the NGT when the time comes to follow through on the pledge.

…especially when targeting a nominal GDP level rather than growth rates…

The second variant helps address this shortcoming by having the central bank adopt a *level* nominal GDP target (NGLT) that grows each year at a specified growth rate. Much like a PLT, this approach would counsel policymakers to take an accommodative stance when nominal GDP is persistently falling short of its target, and a restrictive stance when the opposite is the case. Among other virtuous aspects, this would reinforce forward policy guidance at the ELB, by committing policymakers to run the economy hot until the NGLT is reached. Indeed, this commitment may be more credible with PLT or AIT, because the nominal GDP benchmark automatically directs policymakers to make trade-offs between inflation and unemployment that might otherwise lack credibility. With more effective FG, ELB episodes would tend to be shorter in duration, which would typically raise inflation expectations and interest rates on balance, once again providing the central bank with more ammunition to avoid ELB outcomes. A NGLT would also not be as much of a straightjacket as PLT when the economy is hit with adverse supply shocks, with the burden of adjustment split between activity and prices.

Another key benefit of NGLT is that it seemingly de-emphasizes the need to assess unobserved supply variables. With central banks calibrating policy to a readily observed

[12] Indeed, some proponents of nominal GDP targeting propose that the central banks calibrate its monetary policy stance using a futures market for the level of nominal GDP. Specifically, policymakers would loosen policy if the futures market pointed to nominal GDP growth below the target, and would tighten policy if the futures market pointed to growth above the target.

nominal GDP benchmark, policymakers need not go to such pains to assess economic slack. This might help make policy more transparent and predictable, as decisions need not be tied to judgmental assessments of unobserved variables and the weights placed on inflation and unemployment.

But these virtues would be accompanied by meaningful disadvantages. The first is that a NGLT does not let bygones be bygones. As with PLT, this would be most apparent when the economy is hit by a supply shock when it is operating near full employment. As shown in Figures 22 and 23, the framework would tend to direct policymakers to reverse adverse supply shocks; otherwise the level of nominal GDP would exceed the target when output returns to potential. The balanced priorities of NGLT merely provides flexibility for policymakers to smooth costs in terms of foregone activity, likely implying a more prolonged adjustment than with a price level target.

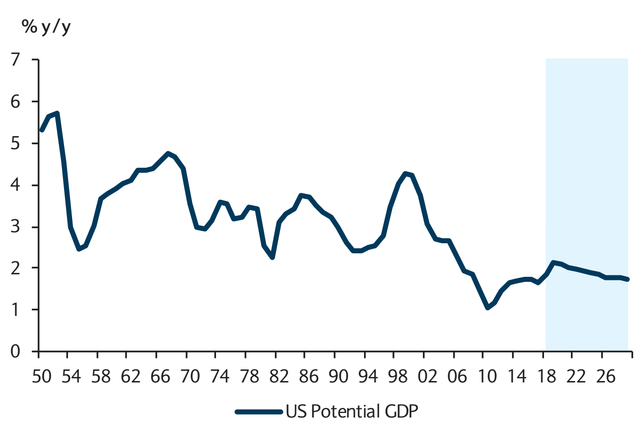
A second disadvantage is that policymakers would sacrifice some nimbleness. As with a PLT, policymakers in each period inherit some accumulated gap between GDP and the target. Given the cyclical tendencies of the economy, downturns will tend to hit at times when cyclical forces have been pushing nominal GDP above its target. With policymakers generally adopting a restrictive stance in such cases, it is reasonable to think that they will be more reluctant to respond to signs of an economic downturn than they would be with a target that lets bygones be bygones. As shown in Figure 24, this may well have been the case in the United States in the early stages of the GFC, when nominal GDP had generally been growing at rates exceeding plausible nominal GDP targets.[13]

But nominal GDP targeting comes with a number of conceptual as well as practical challenges

Beyond these disadvantages, NGT and NGLT are subject to a number of meaningful conceptual issues. First, NGLT may not do enough to stabilize prices that matter for consumers. Conceptually, the price index reflected in nominal GDP captures prices of domestically produced goods that may not be important to consumers, and is not the same as consumer price benchmarks that measure changes in households' living costs. Indeed, the rate of inflation in GDP prices can often differ substantially from rates based on PCE prices (see Figure 25), especially in countries with a high import content. Second,

FIGURE 26

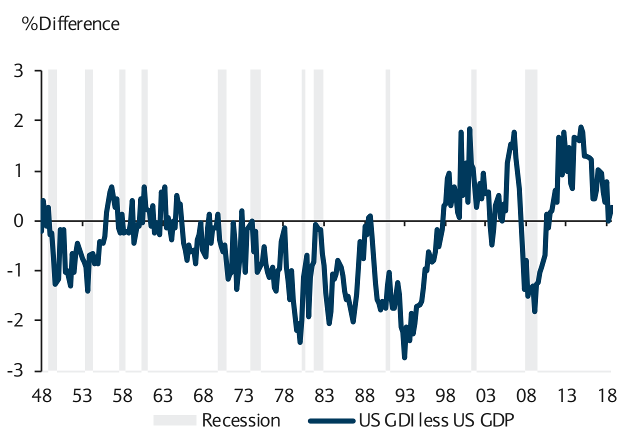
The ongoing deceleration of potential GDP poses problems for nominal GDP targeting



Source: Congressional Budget Office, Barclays Research

FIGURE 27

Nominal GDP is subject to substantial measurement errors



Source: Haver Analytics

[13] One reasonable target, given the rate of potential GDP growth (about 2.5% y/y, according to current estimates from the US Congressional Budget Office) that prevailed in the mid-2000s and the Fed's preference of inflation around 2%, would have been 4.5% y/y.

policymakers would need to grapple with how changes in potential GDP growth will interact with inflationary outcomes. In most developed countries, potential GDP has been gradually decelerating for decades due to population demographics and other influences (Figure 26) – and this trend is expected to continue. The consequence of this deceleration, with a fixed NGT, would be gradual upward creep in inflation.[14] Lastly, nominal GDP is subject to numerous measurement difficulties that would complicate monetary policy. This is apparent from Figure 27, which shows discrepancies in the US between nominal GDP and GDI (which are conceptually equivalent but are measured using different approaches). Reflecting these measurement difficulties, real-time measures of nominal GDP growth are prone to substantial revisions over time as statistical agencies periodically revisit their estimates to incorporate better source data and alter measurement conventions.[15] With such revisions often occurring within months of initial estimates, policymakers would often receive misleading signals about the appropriate stance of policy, which would pose issues for communication and implementation.

More radical conceptual changes

As part of the Fed's strategy review, the above alternatives to the current IT framework are transitioning from the pure academic sphere to that of policy practitioners. The future of monetary policy frameworks has entered the discussion in other central banks as well, even if merely for debate.[16] In academia, more radical concepts are being discussed, many of which seek a break from long-standing policy and social conventions. They may be far from being seriously considered today, but if the past decade has shown anything, it is how quickly the unorthodox can become orthodoxy.

Abolishing cash

Without cash holdings as an alternative, negative interest rates would be fully effective

One proposal is for central banks to fully eliminate (cash) currency, as to overcome the ELB.[17] By removing the arbitrage opportunity of escaping negative interest rates through substituting deposits for cash, the asymmetry of interest rate policy can be overcome: policy rates can, in principle, be moved both above and below zero without boundaries. Freed from the ELB, monetary policy would have regained interest rates as its core instrument with ample room for counter cyclical downturns. In addition, proponents argue that the full digitization of money would create savings by reducing the costs associated with the physical storage and transport of cash, while also hampering some illegal activities and promoting transparency.

A cashless society would bring more transparency at the cost of diminished anonymity…

There are a number of drawbacks, however. Transacting and storing value in cash has survived throughout the centuries. For example, ECB surveys find that 80% of transactions in the euro area at the point of sale are still in cash. Furthermore, while full digitization might reduce illegal cash transactions, it may also open the door for new type of criminal activities. Indeed, even law-abiding citizens may have a preference for cash and could perceive its abolition as an assault on their freedom and their right of anonymity. Likewise, savers may view the abolition of cash, coupled with a negative nominal interest rate on deposits, as a

[14] To be sure, this upward creep may offer some advantages, such as helping to offset the effect of slowing potential on the nominal neutral rate of interest.

[15] For instance, the US BEA expanded the scope of GDP in 2013, when it added a number of categories of intangibles – such as R&D expenditures – to its estimates of business fixed investment. These changes affected the entire history of GDP estimates back to 1929, with the various definitional changes boosting the level of nominal GDP in 2012 by more than $0.5 trillion (3.4%).

[16] See, for example, Constâncio, V., 25 May 2017, "*The future of monetary policy frameworks*", Instituto superior de Economia e Gestao, Lisbon,

[17] See Buiter, W.H. (2009), "*Negative Nominal Interest Rates: Three ways to overcome the Zero lower Bound*", NBER Working Paper 15118; Rogoff, K.S. and Reinhart, C.M (2014), "*Recovery from Financial Crises: Evidence from 100 Episodes*", NBER Working Paper No. 19823; Goodfriend, M. (2016), "*The case for Unencumbering Interest Rate policy at the Zero Bound*", Federal Reserve Bank of Kansas City, Jackson Hole, Wyoming.

form of unfair wealth tax. That said, such attitudes can change and some societies outside the euro area are becoming increasingly cashless (eg, China and Sweden).

… breaking with long-standing social convention

In sum, the proposal to abolish cash is radical as it would break with long-standing social convention, depriving economic agents of the ability to hold and deal with cash. Its economic logic, in contrast, follows conventional reasoning regarding the limitations of interest rate policy due to the ELB. From this perspective, it would be a radical new tool, rather than a new conceptual approach to monetary policy. Given this radical nature, , an important final concern about eliminating cash would be financial stability. Many argue that interest rates close to zero have significantly driven up prices for real assets, raising concerns about asset price bubbles and excessive leverage. The ability to maintain very negative interest rates for extended periods would only deepen these concerns.

Accepting low inflation — reassessing the threat of deflation

Whether proposing new tools, adjustment in targets or even abolishing cash, all these attempts aim ultimately at reviving inflation. Having inflation rates back at around 2% is part of a superior economic outcome, as it helps to achieve employment mandates and reduces the threat of deflation. It assumes that the negative side effects of the measures taken to reach the 2% level again can be contained through prudential policies.

Aggressively pursuing an unattainable 2% target could fuel financial bubbles…

However, this assumption that these side effects can be contained is open to challenge. Concerns about the potential influence of persistently accommodative monetary policy on financial cycles and stability are behind a fundamentally different school of thought which advocates that central banks accept the reality of low inflation.

Underlying inflation appears to be gradually trending lower over recent decades – arguably reflecting many of the same structural influences that are weighing on neutral interest rates: demographics, globalisation and technology. These structural influences are largely beyond the influence of monetary policy. If trend inflation rate is, in fact, below 2%, persistent attempts to reach 2% inflation targets may require monetary policy to continuously adopt an accommodative stance to stimulate demand. Such accommodation could fuel financial cycles, driving unsustainable increases in credit and asset prices. Although prudential regulations can lean against these pressures, they may be unable to prevent them. If and when asset price bubbles burst, the deflationary impact could be significant, likely stronger than the disinflation that would occur during periods of slow growth and/or supply-driven price reductions.[18]

… and bursting asset bubbles could create worse deflation scenarios…

In other words, stubbornly aiming at an unattainable inflation target could ultimately result in what the policy is aiming to avoid: deflation. Deflation is feared because of its adverse effect on economic activity, even though this link may vary over time, depending on circumstances. In principle, deflation undermines the economy's ability to adjust to adverse demand disturbances because of various *nominal rigidities*: the key ones are the ELB, nominal wage rigidities, and the possibility of debt deflation. When these rigidities are present, inflation can help ease adjustments to adverse economic shocks. For example, if nominal wages cannot be reduced, letting inflation erode wages' real value can hasten the process of labor market adjustment, while unexpected inflation can reduce the real burden of debt servicing. The presence of such rigidities poses an asymmetric risk to economic stability. In an extreme case, an economy could become stuck in a 'deflationary trap', where the ELB prevents real interest rates from falling enough to push the economy back to full employment, and the deflationary impetus from nominally denominated debt and other nominal distortions becomes self-reinforcing.

[18] See "*Monetary policy in the grip of a pincer movement*", Claudio Borio *et al*., BIS Working Papers, No. 706, March 2018.

Box 2: Lessons from Japan's experience

Bursting asset bubble ends in deflation

In a number of ways Japan lends itself as a reference to the broader situation across advanced economies today. Following a boom period from 1986-1991, during which real estate and stock market prices soared massively, Japan's asset price bubble burst in 1992 and the country entered into what many dubbed the 'Lost Decade' of economic stagnation. Non-performing assets accumulated, productivity growth slowed, and, notably, consumer price inflation started to steadily decline. Japan's potential growth rate is estimated to have declined from around 4 percent in the early 1990s to around 1 percent in the late 1990s. the CPI finally slid into deflation in the late 1990s, where, with brief exceptions, it stayed for 15 years. The BoJ's response to this deflation dynamic has been an issue of debate. Critics argue that the BoJ's hesitance to ease monetary conditions more decisively, and its premature exit from such measures after it finally acted, contributed to the dynamic, largely by allowing for inflation expectations to permanently shift downward.

Central bank commitments must be credible to shape expectations

With core inflation dropping into negative territory, in 1999, the BoJ introduced the zero interest rate policy (ZIRP), in which the uncollateralized overnight call rate was guided to virtually 0 percent. In 2001, QE was introduced, increasing the monetary base. While these steps no longer appear extraordinary in today's context, they were path-breaking policy steps at the time. Importantly, the BoJ took them isolation rather than in the wake of a global phenomenon like the GFC, where central banks pretty much all moved together into 'unorthodoxy.' Indeed, the idiosyncratic nature of these actions may also have caused the BoJ to act too hesitantly, failing to convey the strong commitment needed to give its policies necessary credibility. Paul Krugman opined in 1999 "while the Bank of Japan has actually been engaging in some quite unconventional monetary operations…, it is doing so in a surreptitious, almost shamefaced manner, and therefore not creating the sort of 'credible promise to be irresponsible' that I argued was necessary."

Indeed, after entering ZIRP in February 1999 the BoJ withdrew from the policy in August 2000, when inflation was still negative. At the time, the BoJ stated that, "the downward pressure on prices stemming from weak demand has markedly receded". Instead of considering whether the exit was premature, BoJ communication almost apologetically tried to explain why it had maintained ZIRPs for so long. Sure enough, deflationary pressures soon returned and just six months later the BoJ reversed course and returned to ZIRP in Q1 2001. This was also the first instance the BoJ embarked on a course of QE, with the official objective to "continue until the consumer price index… registers stably a zero percent or an increase year on year." The initial asset-purchase program was later expanded and the BoJ also engaged in unsterilized FX intervention. However, in March 2006, when inflation had recorded just four consecutive months of non-negative readings QE was ended. Soon after, in July 2006, the BoJ raised the policy rate above zero. Subsequently, inflation did climb to over 2% in Q4 08, but by Q2 09 it had slumped back into negative territory.

The withdrawal from QE in 2006 may be more difficult to qualify as a 'policy mistake', given that the BoJ was certainly not alone in not foreseeing the events of 2008/9, which also drove Japan back into deflation. However, the story of Japan's monetary policy response reiterates how crucial it is for any commitment to be credible, which requires persistent policy actions. Indeed, the ECB seemingly committed similar mistakes in 2008 and 2011, when it prematurely hiked rates, which it corrected subsequently through forceful policy measures and communication. Another lesson from Japan is how difficult it is to significantly raise inflation expectations once economic agents have experienced deflation for a prolonged period.

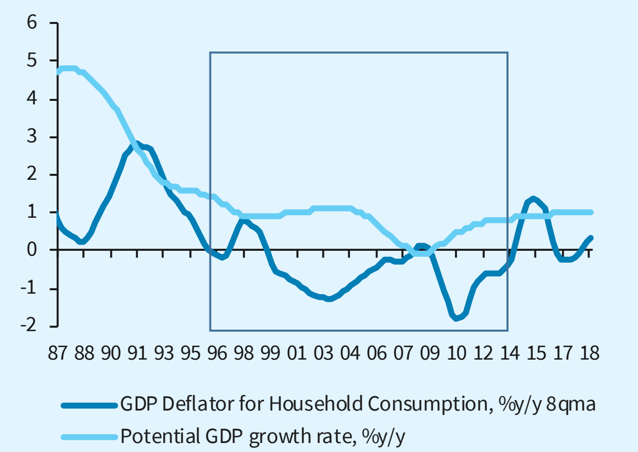
Demography matters and no inflation does not have to mean no growth

That said, it would also be misleading to explain Japan's experience as pure consequence of a monetary policy mistake. Important other factors played a role, notably Japan's demographic situation. Japan's population decline and aging is progressing at a faster pace than in other major economies. The effect of such demographic shifts on macroeconomic variables such as in potential growth, r*, and inflation has been well documented in research, and it should therefore be no surprise that Japan has been particularly affected.

However, Japan may still also serve as a lesson that periods of low inflation and/or mild deflation may not necessarily result in economic misery. In spite of continued below-target inflation over the past ten years, Japan's economy is experiencing its longest post-war expansion, unemployment has dropped to record lows, and, importantly, per capital GDP growth has been stronger than in the US, the euro area, UK and Canada. Looking back over the last 30 years, Japan's average per capita GDP growth rate was in line with that of the other advanced economies: it was much higher than others in its pre-deflationary period (ie, pre-1997), much below others during the period when deflation took hold (ie, post-1997), but has again outperformed others since the GFC. This could lend support to the argument that highly advanced but rapidly ageing economies may be just fine with below 2% inflation, as long as conditions do not descend into a deflationary trap.

FIGURE 28

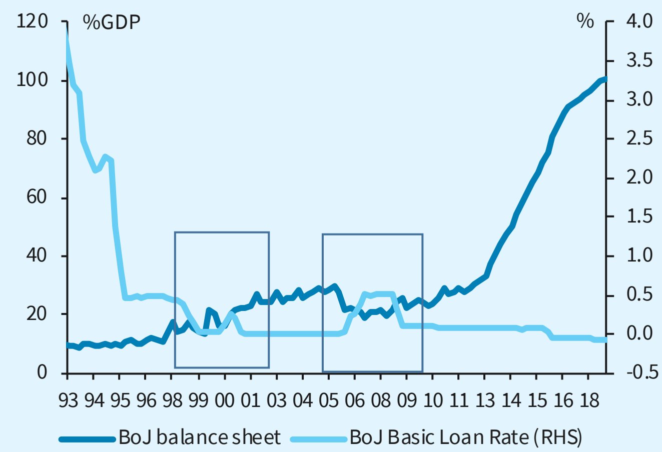
After the crisis, growth slowed and deflation followed



Source: CAO, Haver Analytics, Barclays Research

FIGURE 29

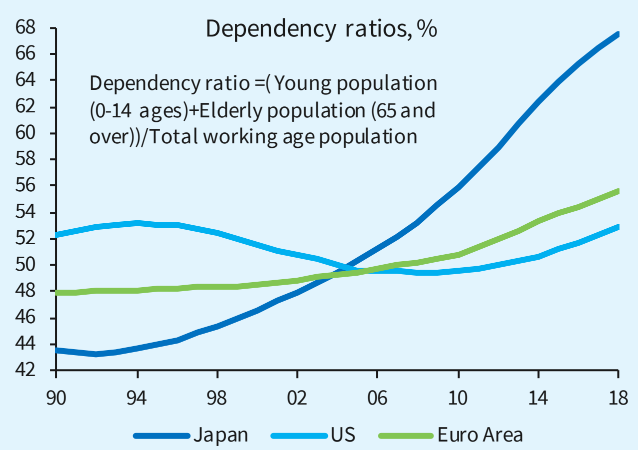
The BoJ acted, but at times hesitated and exited prematurely



Source: BoJ, Haver Analytics, Barclays Research

FIGURE 30

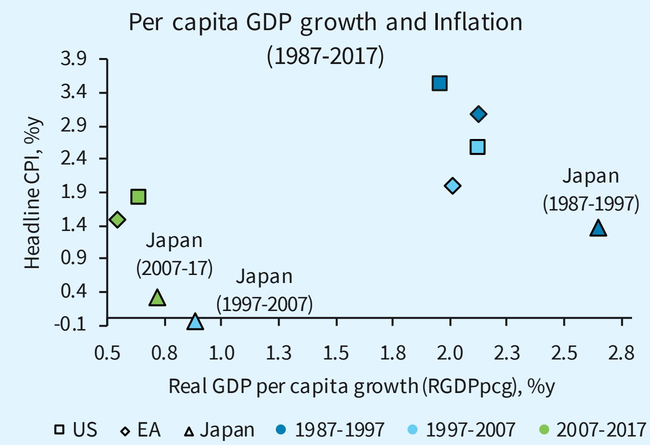
Japan's demographic transition is extremer than elsewhere



Source: UN, Haver Analytics, Barclays Research

FIGURE 31

Japan's per capita growth has not underperformed



Source: World Bank, BLS, EABCN, MIC, OECD, Haver Analytics, Barclays Research

… than a mild deflation during a downturn in a low-growth environment

While this is a well-established argument, some of its assumptions may hold less weight today. For example, labour markets seem to have become more flexible, with wage-price Phillips curves not only flatter but also allowing nominal wage growth to fall below zero. Moreover, there is a case to be made that deflation is less disruptive if driven by positive supply side shocks (eg, productivity improvements) in an environment of constrained demand, rather than by adverse demand shocks. Indeed, empirical work on inflationary periods during history and across countries suggests that many deflationary episodes have been rather benign, with temporary and relatively mild price declines.[19] In fact, one could point out that Japan — despite being commonly cited as an example of dysfunctional monetary policy, with CPI inflation having persistently run at (often negative) rates well

[19] See "*Back to the future? Assessing the deflation record*", Claudio Borio and Andrew J. Filardo, BIS Working Papers, No. 152, March 2004.

below those of the US since the mid-1990s — has still managed to achieve the same per capita real GDP growth as the US over the past 30 years.

In sum, these arguments challenge the increased 'policy activism' of other proposals, advocating that central banks simply accept lower inflation rather than fight against it. In practical terms, this could imply tolerating a wider band of inflation outcomes (eg, between 1-3%) or simply a de facto negligence of the 2% target. Even though this would likely imply hitting the ELB with greater frequency, this would be gauged against the threat of potentially more destructive scenarios from pursuing an unattainably high inflation target, such as financial instability and self-reinforcing deflationary spirals.

Debt monetization — 'Modern Monetary Theory' and 'helicopter money'

While conventional theory suggests fiscal policy should complement monetary policy…

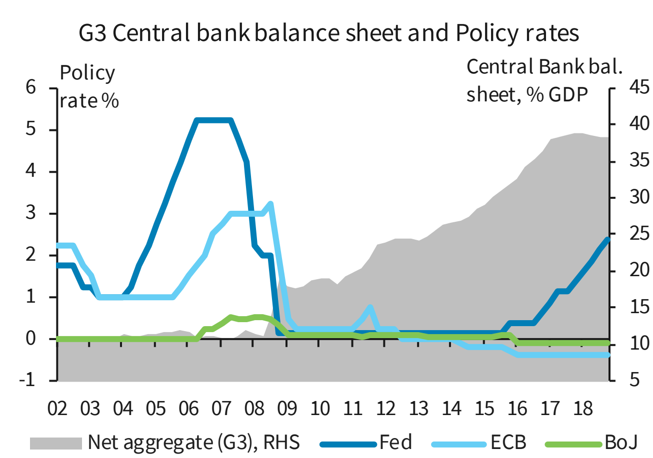
Other concepts agree with the limited effectiveness of monetary policy, but are less concerned over financial stability concerns. Instead, they point to the need for more active fiscal policy in combination with monetary easing. At first sight, this does not seem new, as monetary policymakers have long argued for fiscal policy to share more of the burden of stabilizing the economy. In particular, when policy rates are pinned at the lower bound, theory suggests that fiscal expansion should be especially effective at boosting growth and employment.[20] Demanding a policy mix with active counter-cyclical fiscal policy seems therefore uncontroversial. However, the approach advocated by Modern Monetary Theory (MMT) is more radical, arguing that central banks should defer economic stabilisation fully to fiscal policy, eschewing other objectives apart from funding the government.

…monetization of debt has historically led to out-of-control inflation

More specifically, MMT essentially argues that governments should take an active role in manipulating fiscal policy to keep macroeconomic activity near potential levels. This fiscal policy would exploit a wide range of policy levers that influence overall demand, including spending, taxation, credit policy, and regulations. The unorthodox twist is that the government would actively use *debt monetization* as its primary funding source, thereby delegating taxation to a secondary role. One way to envision how this would work is to think of a case where the central bank monetises government debt beyond the point where financial markets are in a liquidity trap, with nominal interest rates pinned near zero.

FIGURE 32

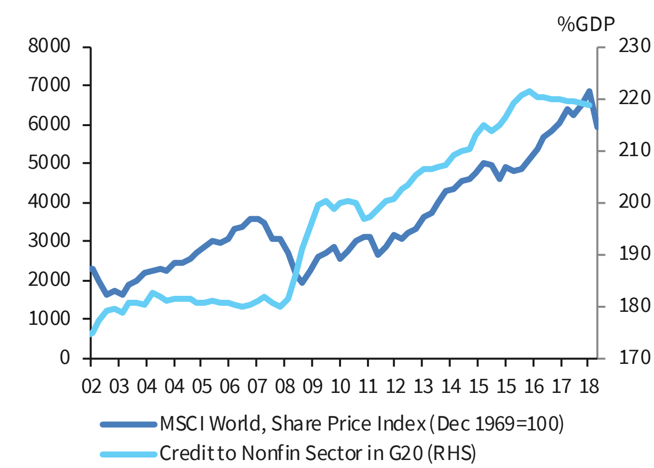
Aggressive monetary easing in core economies…



Source: BoJ, FRB, ECB, Haver Analytics, Barclays Research

FIGURE 33

… boosts credit growth and asset prices globally



Source: MSCI, BIS, Haver Analytics, Barclays Research

[20] Lots to cite here, including various Bernanke speeches from 2012/2013, IMF articles, etc.

Could central banks just print money to finance governments, while fiscal policy manages demand?

In one aspect, this mechanism is already exploited though QE, where the central bank purchases government securities to expand its balance sheet, and, while it holds these bonds, returns profits to the government. The difference is, however, that the QE debt on the bank's balance sheet is not rolled over but has to be repaid by the government when it matures. Hence, the debt is only temporarily 'monetized'. In contrast, MMT represents permanent monetization, with the central bank effectively rolling over its bond holdings in perpetuity. From this perspective, 'helicopter money' could be seen as a special case of MMT. Different from mere QE, the government debt would actually be monetized, but the monetization by helicopter would be a one-off measure to escape a liquidity trap.

The pivotal question is whether monetizing debt in this way would be inflationary. Under ordinary conditions, this would not be controversial. Following the standard chain of macroeconomic logic, expanding the balance sheet would tend to boost the money supply, which, under normal conditions, would reduce real interest rates below neutral levels, thereby contributing to an overshoot of aggregate demand relative to potential output that feeds through to higher inflation. Indeed, history is replete with episodes that seemingly establish the inflationary nature of debt monetization, including Germany's experience of hyperinflation in the aftermath of WWI, the experience of Zimbabwe in the late 1990s, and Venezuela's recent experience with runaway inflation.

Helicopter money could work…

In the case of 'helicopter money', proponents would argue that such inflationary risks are limited due to the one-off nature of the measure, as the helicopter would 'land' and the printing press stop as soon as the liquidity trap is overcome. In contrast, MMT aims to sever the link between debt monetization and inflation through a very active fiscal policy, which would keep activity at a maximum, non-inflationary level. When private demand is weak, stabilizers would kick in automatically: eg, MMT proponents suggest a government commitment to temporarily hire unemployed workers (at a low reservation wage) to provide public goods. Equally, when output is set to run above potential, the government would have to withdraw demand though countercyclical discretionary measures, such as raising taxes and reducing spending.

… but would the helicopter land again in time?

Although perhaps possible in theory, MMT's implementation raises a host of doubts: first, governments simply do not seem well equipped to enact timely countercyclical measures that would be needed to forestall inflationary pressures. They would not only need to have extremely good forward looking models of the economy, but also extremely efficient administrative processes, to implement the appropriate countercyclical fiscal measures in time. Even proponents would concede that governments have a poor track record in fine-tuning demand in this way.

Political economy concerns paramount

Importantly, the *political economy* dimension of countercyclical fiscal policy also raises concerns over *time inconsistency*: With the burden of funding constraints seemingly lifted, governments would likely find it politically difficult to enact countercyclical policies when the economy is booming. Such concerns weigh very heavily against MMT, as the theory rests on the government's ability and willingness to effectively carry out not only fiscal loosening but also tightening when the private economy is running hot. If it fails in the latter, the ongoing debt monetization could radically unmoor inflation, leading to large and abrupt jumps in expectations. In the case of 'helicopter money' proposals, the concerns may be reduced somewhat by its intended one-off nature, but the political economy concerns would still apply.

Expectations could adjust very abruptly and drastically

One could see MMT and the special case of 'helicopter money' as opportunistic responses to the various conditions that have proved so challenging to monetary policy: (1) the very shallow Phillips curve, with relatively well-anchored inflation expectations; (2) low neutral interest rates; and (3) the elevated probability of ELB outcomes. All of these conditions seemingly challenge the chain of logic linking debt monetization with inflation. Even though central banks have dramatically expanded their balance sheets since the GFC, effects on standard measures of the money supply (such as M1 or M2) have not been proportionate. This is because private banks have substantially increased reserve holdings for a variety of reasons, including new regulations that encourage liquid reserves, the shift to paying interest on excess reserves, and the close substitutability between currency and interest-bearing assets at the ELB. Even though the increased money supply has helped to push down interest rates at various horizons, this has often proven insufficient to generate inflationary conditions given weakness in demand from other structural influences. Finally, in the few cases when aggregate demand has been boosted to levels in excess of potential — as in the US — the inflationary response has been subdued.

In sum, if disinflationary pressures persist in spite of the dramatic bank balance expansion of the past, fears that various forms of debt monetization will rekindle inflation could start to fade. Radical conceptual changes as proposed by MMT still seem very unlikely to be seriously considered. However, more limited proposals such 'helicopter money', as one-off policy measures to overcome a liquidity trap episode, may no longer be as remote as they would have seemed in the past.

Conclusion: Not the 'end of history'

IT has reached the life-span of previous dominant regimes …

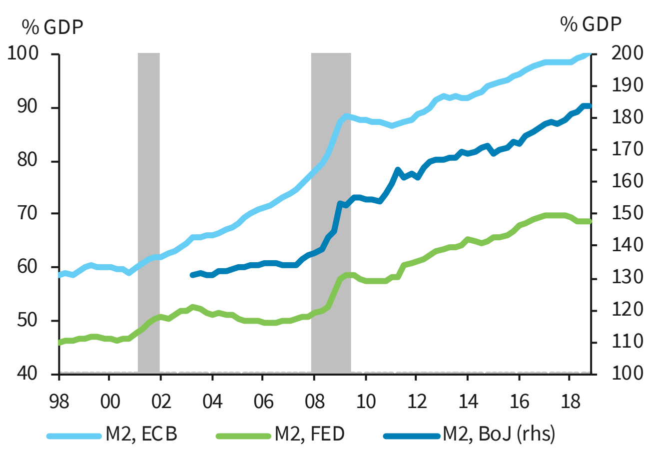
Monetary policy has undergone many changes in history. Even if IT's sophistication and great initial success created the sense of an "end of history" moment for monetary policy, the framework is coming increasingly under pressure as it approaches its 30th birthday. Coincidentally, this has been roughly the life-span of previous monetary regimes that dominated a certain period: the Gold Standard (1870s-1914) and the Bretton Woods fixed exchange rate system (1948-1973). In between such periods, monetary policy typically became more experimental and more diverse. Once again, we may have entered such a new phase in monetary policy.

… which were typically followed by more experimental and volatile periods

The challenge for monetary policy has turned from the need to reduce high inflation to preventing inflation from becoming too low in the face of secular trends that are weighing on inflation and neutral interest rates. The unorthodox policy tools with their many acronyms — QE, NIRP, FG, YCC — introduced in response to the GFC are well on their way to becoming orthodox. But as IT regimes struggle to meet inflation targets, alternative goals — higher inflation, price levels or average inflation, nominal GDP — have started to be discussed. None seems necessarily superior when weighing their pros and cons, especially

FIGURE 34

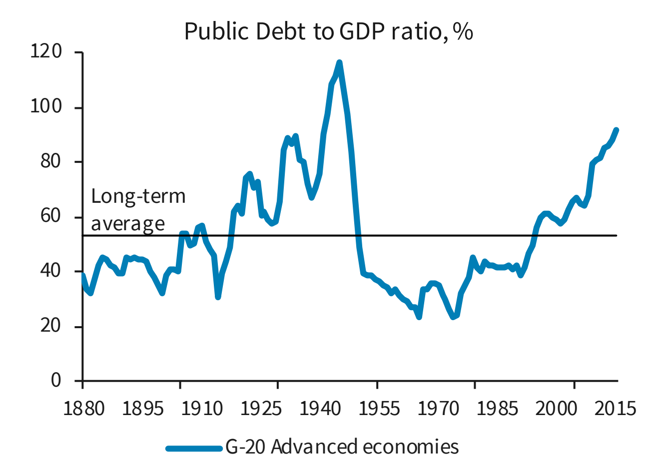
QE's effect on the money supply has been muted



Source: FRB, ECB, BoJ, Haver Analytics, Barclays Research

FIGURE 35

High public debt raise concerns about more fiscal expansion



Source: FRB, ECB, BoJ, Haver Analytics, Barclays Research when considering the additional obstacles of their implementation in practice. It seems likely that rather than formally moving away from IT strategies, central banks will either become more tolerant of inflation that stays below target (BoJ, ECB) or adopt frameworks along the lines of average inflation targeting, seeking to achieve more symmetric outcomes. Hence, policymakers would at least aim for inflation somewhat above 2% (Fed) after long periods of undershooting.

'Unorthodox' policy tools must now be considered standard

However, when the next economic downturn inevitably arrives, simply re-engaging existing non-traditional tools (such as QE) could no longer be enough, and fiscal stimulus may well have to play a larger role. Concerns about public-debt sustainability, combined with the fact that past QE has generally been unable to lift inflation rates back to targets, could increase demands to consider monetising fiscal expansions.

Move towards average inflation targets could be next

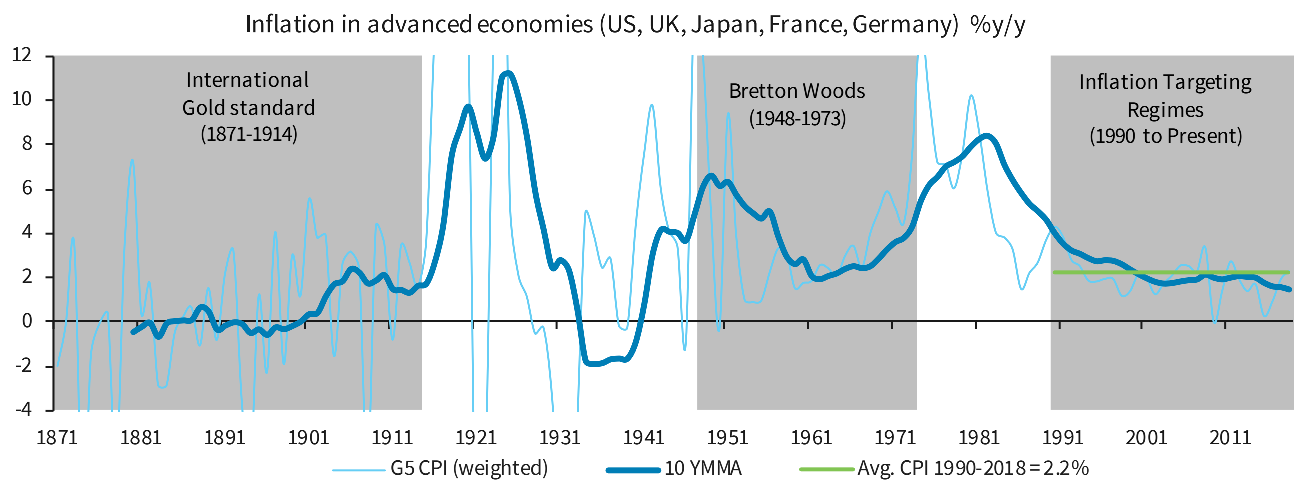
While the radical ideas of Modern Monetary Theory seem very unrealistic, some forms of helicopter money could eventually be considered. The true challenge to these concepts are not theoretical flaws in the effectiveness of their mechanisms but rather human nature: once initiated, it is not hard to imagine how such seemingly "free" spending power could become addictive to political decision takers. Thus there are risks that when "liquidity traps" are eventually overcome and the link between monetary expansion and inflation re-established, expectations could become unanchored.

But a more pronounced downturn could bring more radical concepts to the fore

For investors, in particular those buying debt, this creates a future with fatter tails. While inactive monetary policy creates the risk of deflationary scenarios with ever increasing nominal debt burdens, aggressive experiments that blur the boundaries of fiscal and monetary policy could eventually result in sudden and sharp upward adjustments in inflationary expectations, with related swings in risk premia, and exchange rates.

FIGURE 36

Inflation targeting is unlikely the end of monetary history. Notably, periods of dominant policy regimes were typically followed by periods when monetary policy became more diverse and experimental—and typically also higher inflation.



Source: Jordà-Schularick-Taylor Macrohistory Database, Haver Analytics, Barclays Research

INFLATION THEMES

Finding relative value

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We discuss our approach in finding micro relative value using our daily forwards and TIPS relative value reports, along with the analytics.

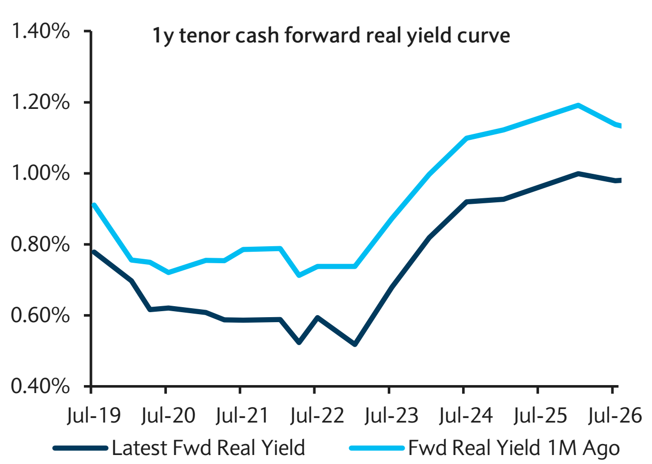
The framework

When evaluating TIPS, we look at fundamentals for asset class selection (TIPS versus nominals, portfolio diversification), tactical value (supply, demand) and micro relative value. Once we have decided on TIPS valuations from a macro perspective and a particular sector to invest in along the TIPS curve, we think investors can further add alpha by exploring micro relative value. We look at many tools when evaluating rich/cheap along the curve including our *TIPS Pricing Report*, *Inflation-Linked Daily* and various analytical tools on Barclays Live. No one evaluation method drives our views and, instead, we look for a consistent signal from different approaches.

Example of finding micro relative value using the inflation forwards report

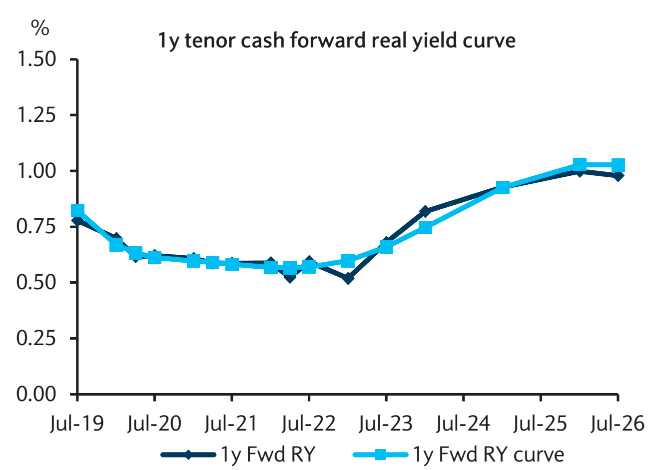
The *Inflation-Linked Daily* displays a number of charts, including the path of forward real yields, breakevens, CPI swaps, and longer forwards (5y5y and 10y20y). The longer forwards can be used for relative sector richness or cheapness. The path of forward 1y real yields (Figure 1) can be used to find micro value. We have added z-score information on our forward 1y real and breakeven curves in order to further aid us in finding value. We use z-scores above 0.5 to identify cheap forwards, while we use a z-score of less than -0.5 to identify rich forwards. In addition, we use consecutive pairs (ie, Jan20-Jan21, Jan21-Jan22, Jan22-Jan23) to confirm whether a security is trading rich/cheap. For example, as of 25 February 2019, the Jan24-Jan25 (low coupon) forward real yield pair looks cheap (Figure 1 and Figure 2) in the 1y apart forwards real yield curve. If one can trade forwards and had a view that real rates were trading cheap in this sector, we would recommend putting on a cash-neutral forward real-rate trade of buying Jan25s versus Jan24s. This cheap Jan24-Jan25 forward rate, however, does not tell us whether Jan24s are trading rich and/or whether Jan25s are trading cheap. To further dissect what is happening in this sector, we look at several consecutive pairs of forwards. The prior pair, Jan23-Jan24, has a z-score of -0.8, indicating the Jan23-Jan24 pair is rich. The Jan24-Jan25 pair has a z-score of 0.7, marking

FIGURE 1
Jan24-Jan25 forward real yield standing out as cheap



Source: Barclays Research

FIGURE 2
Jan24-Jan25 forward real yield looks cheap on a forward spline z-score basis as well



Source: Barclays Research

the pair as cheap, as expected. Last, the Jan25-Jan26 forward pair has a z-score at 0.3, which marks Jan25-Jan26 as neutral. So we combine this information to formulate a view on Jan24s and Jan25s. In our forward real curve z-score grading scheme, the following consecutive pairs' status filters are applied to determine a security's status, ie, assuming two statuses are derived for a security from consecutive pairs:

1. Neutral + Rich = Rich,
2. Neutral + Cheap = Cheap,
3. Rich + Cheap = Neutral,
4. Rich + Rich = Rich,
5. Cheap + Cheap = Cheap.

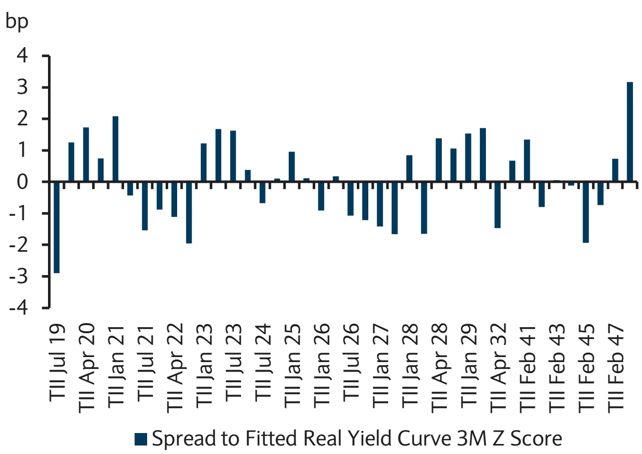
In this case, Jan24s are neutral because of rich + cheap status via two consecutive pairs (Jan23-Jan24, which are rich; Jan24-Jan25 fwd, which are cheap), while Jan25s are trading cheap (Jan24-Jan25 pair is cheap, while Jan25-Jan26 pair is neutral). We go through this exercise for each security and identify rich/cheap securities versus the forwards. One thing to keep in mind is that forward rate trades have a curve level risk; ie, if the broad level of real yields moves up, this forward rate trade can get hurt.

For the second measure, we look at the *TIPS Pricing Report* (Figure 3). Here we look at TIPS securities versus a fitted real curve to determine rich/cheap on a 3m z-score basis of the current bond real yield versus the matched-maturity curve real yield. As of 25 February 2019 the Jan24s in this relative value sheet have a 3m z-score of 0.4 indicating that Jan24s are trading neutral versus the fitted real curve (absolute value of the spread is less than 0.5bp). Jan25s have a z-score of 0.1, also indicating they are neutral. Given that Jan24s are showing up as neutral in both the forwards report and against the TIPS fitted real curve, we mark this security as neutral with a total score of 0. The Jan25s have appeared cheap on the forwards report and neutral on the fitted real curve, indicating that the security is cheap with a total score of 1.

Lastly (Figure 4), we look at the z-spread ASWs curve; visual inspection versus the fitted spline z-spread ASWs curve shows that Jan24s are trading rich (spread at -2.1bp; we use an absolute 1bp threshold) but Jan25s are trading neutral (-0.6bp spread) versus the z-spread ASWs curve.

FIGURE 3

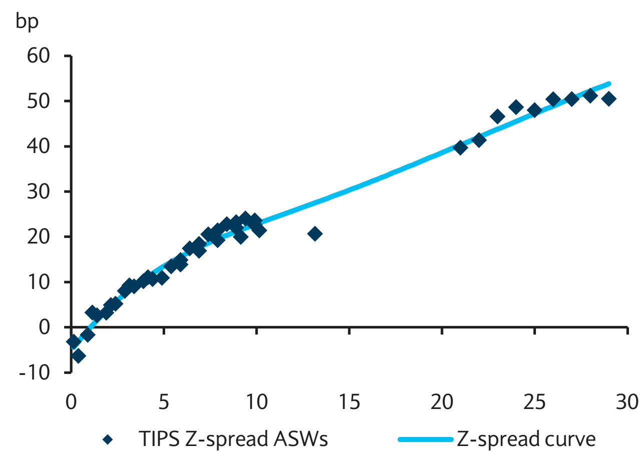
TIPS real yield spread (versus fitted real curve) 3m z-score shows Jan24s and Jan25s as neutral



Source: Barclays Research

FIGURE 4

TIPS z-spread ASWs curve shows Jan24s are rich



Source: Barclays Research

So, in total, Jan24s appear rich on one measure (z-spread ASWs) and neutral on the other two (forward real curve, z-score versus a fitted real curve). We assign this security a total TIPScore of -1 (in rich territory). Meanwhile, Jan25s appear cheap one measure (forward real curve) and neutral on the other two (z-spread ASWs and z-score versus a fitted real curve); hence, this security has a total TIPScore of 1.

A historical backtest of such a micro-relative value approach indicates a successful indication in identifying rich/cheap securities. See the "*TIPScores*" article for back-tested results of such an approach.

Strategic Indicator

The three metrics above provide a starting point for tactical relative value. To complement this analysis, we also wish to identify bonds that stand out on a longer-term structural basis. To this end, we have added a strategic indicator that highlights rich/cheap bonds based on a seasonally and option adjusted fitted real curve measure, since removing these two technical factors that affect all TIPS issues leaves us with a 'cleaner' measure of absolute value (see "Fitting an (adjusted) real yield curve" in this guide for more details). To adjust for seasonality across issues, we adjust all real cash flows on a particular date by an index ratio for that date derived from a CPI curve; first using an unadjusted CPI swap curve, then one adjusted by the latest BLS seasonality vector. Discounting these cash flows and subtracting the two resulting prices, produces a measure of seasonality adjustment. We add this residual to the bond's real clean price to get a seasonally adjusted clean price. We then convert this price to a seasonally adjusted YTM. From this seasonally adjusted YTM, we add back the par floor value (in yield terms) of each issue to adjust for the exceptional richness of particular issues. In particular, we use a Black log-normal model on the forward index ratio to price floors. With this final seasonal and floor adjusted real yield in hand, we convert back to a final clean price for each bond. We then build a cubic spline through these new adjusted real yields. We compare the new adjusted real yield to the fitted yields for each issue to assess strategic relative value. Issues 0.5-1bp cheap to this spline receive a '+' Strategic Indicator value, 1-2bp, a '++', and >2bp, a '+++'. Similar logic follows for rich issues (replaced with '-'s).

The fitted real curve tactical measure above does not adjust for seasonality or optionality. However, by valuing rich/cheapness using a 3m z-score, we remove any persistent effects from seasonality and/or par floor values. Otherwise, July maturity issues would nearly always appear rich and April maturity issues cheap. On the other hand, since the new strategic metric does make these adjustments, no z-score metric is needed, as the value of the spread to spline alone provides an absolute level of long-term structural relative value.

Figure 5, shows the rich/cheap TIPScore card (including the Strategic Indicator) across all issues as of February 25, 2019.

FIGURE 5

Rich/Cheap Scorecard as of February 25, 2019

Bond	Maturity	3m Z-Score	3m z-score vs TIPS real spline	Z-Spread ASWs curve	Fwd 1y real curve z-score	Total Score	Strategic Indicator
TII 0.125% Apr 20	4/15/2020	1.7	Cheap	Cheap	Neutral	2	+++
TII 0.750% Jul 28	7/15/2028	1.1	Cheap	Cheap	Neutral	2	+
TII 1.375% Jan 20	1/15/2020	1.2	Cheap	Rich	Cheap	1	
TII 1.250% Jul 20	7/15/2020	0.7	Cheap	Neutral	Neutral	1	++
TII 1.125% Jan 21	1/15/2021	2.1	Cheap	Neutral	Neutral	1	
TII 0.625% Apr 23	4/15/2023	1.7	Cheap	Neutral	Neutral	1	+
TII 0.375% Jul 23	7/15/2023	1.6	Cheap	Rich	Cheap	1	
TII 0.250% Jan 25	1/15/2025	0.1	Neutral	Neutral	Cheap	1	
TII 1.750% Jan 28	1/15/2028	0.8	Cheap	Neutral	Neutral	1	
TII 2.500% Jan 29	1/15/2029	1.5	Cheap	Neutral	Neutral	1	++
TII 2.125% Feb 40	2/15/2040	0.7	Cheap	Neutral	Neutral	1	
TII 2.125% Feb 41	2/15/2041	1.3	Cheap	Neutral	Neutral	1	
TII 0.625% Feb 43	2/15/2043	0.1	Neutral	Cheap	Neutral	1	
TII 0.875% Feb 47	2/15/2047	0.7	Cheap	Neutral	Neutral	1	
TII 0.125% Apr 19	4/15/2019		Neutral	Neutral	Neutral	0	
TII 0.125% Jan 23	1/15/2023	1.2	Cheap	Neutral	Rich	0	
TII 2.375% Jan 25	1/15/2025	1.0	Cheap	Rich	Neutral	0	
TII 0.375% Jul 25	7/15/2025	0.1	Neutral	Neutral	Neutral	0	++
TII 2.000% Jan 26	1/15/2026	0.2	Neutral	Neutral	Neutral	0	
TII 0.375% Jan 27	1/15/2027	-1.4	Rich	Cheap	Neutral	0	--
TII 0.500% Jan 28	1/15/2028	-1.6	Rich	Cheap	Neutral	0	
TII 3.625% Apr 28	4/15/2028	1.4	Cheap	Rich	Neutral	0	
TII 3.875% Apr 29	4/15/2029	1.7	Cheap	Rich	Neutral	0	++
TII 0.750% Feb 42	2/15/2042	-0.8	Rich	Cheap	Neutral	0	
TII 1.375% Feb 44	2/15/2044	-0.1	Neutral	Neutral	Neutral	0	
TII 0.750% Feb 45	2/15/2045	-1.9	Rich	Cheap	Neutral	0	
TII 1.000% Feb 48	2/15/2048	3.2	Cheap	Rich	Neutral	0	
TII 0.125% Apr 21	4/15/2021	-0.4	Neutral	Neutral	Rich	-1	+
TII 0.625% Jul 21	7/15/2021	-1.5	Rich	Neutral	Neutral	-1	---
TII 0.125% Apr 22	4/15/2022	-1.1	Rich	Cheap	Rich	-1	+
TII 0.125% Jul 22	7/15/2022	-2.0	Rich	Neutral	Neutral	-1	--
TII 0.625% Jan 24	1/15/2024	0.4	Neutral	Rich	Neutral	-1	--
TII 0.125% Jul 24	7/15/2024	-0.7	Rich	Neutral	Neutral	-1	
TII 0.625% Jan 26	1/15/2026	-0.9	Rich	Neutral	Neutral	-1	
TII 0.125% Jul 26	7/15/2026	-1.1	Rich	Cheap	Rich	-1	
TII 2.375% Jan 27	1/15/2027	-1.2	Rich	Neutral	Neutral	-1	--
TII 0.375% Jul 27	7/15/2027	-1.7	Rich	Cheap	Rich	-1	-
TII 1.000% Feb 46	2/15/2046	-0.7	Rich	Neutral	Neutral	-1	
TII 0.125% Jan 22	1/15/2022	-0.9	Rich	Neutral	Rich	-2	-
TII 3.375% Apr 32	4/15/2032	-1.5	Rich	Rich	Neutral	-2	--
TII 1.875% Jul 19	7/15/2019	-2.9	Rich	Rich	Rich	-3	

Source: Barclays Research

Relative value in European linkers

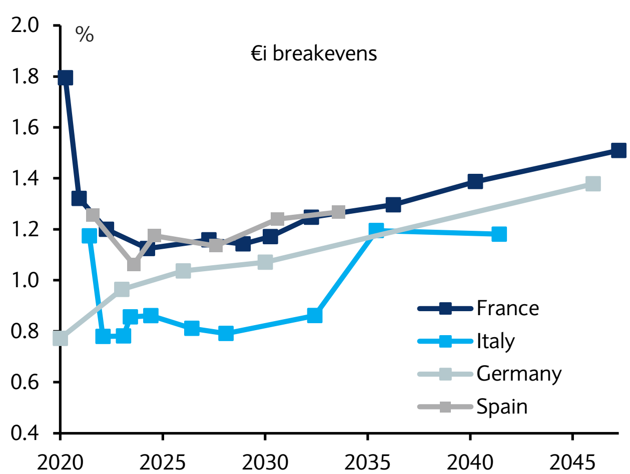
Identifying relative value in European linkers requires the isolation of country risk, which has become an increasingly important driver of valuations since the onset of the euro sovereign debt crisis. A comprehensive assessment of relative value opportunities across euro linkers can sometimes appear a cumbersome task. The multi-issuer aspect of the market, with each segment referencing different points on the seasonality curve, clouds relative valuations between bonds. Furthermore, the euro linker market has been battered during the crisis years, more so than any other developed market, in our opinion. In that context, reduced dealer balance sheets and various sources of distortions (eg, exclusion of BTP€is from SMP) triggered bond-specific moves that stood out as relative value opportunities but for which did not see any corrective momentum in the short term. As a result, to maximise the relevance of a signal as a tradable opportunity, relative value in euro linkers should be assessed using several indicators and preferably those that are commonly used in practice by market participants to identify opportunities.

Adjusting for seasonality

The starting point for relative valuations in the euro linker market is finding a comparable breakeven measure that adjusts for the fact that bonds from the three sovereign issuers mature in different months. This difference means that real yields and breakevens between issuers are not directly comparable because the headline measures for each issuer will be biased differently by inflation seasonality. In the *Seasonality: Estimation and Adjustment* chapter, we explain how to correct valuations for this seasonality bias. The output from such calculations will be subjective, as the seasonals used will be user-dependent. However, we believe this is not a major issue because there is now sufficient consensus on monthly seasonality magnitudes across market participants. Figure 6 shows that headline breakevens on German linkers are notably lower than on their French counterparts, even though they reference the same price index. Adjusting for seasonals shows that their breakevens are, in fact, higher in the sub-10y. We note that BTP€i breakevens remain notably lower than for Germany and France even after seasonal adjustments. This highlights that valuation discrepancies can be large for other reasons. Here, for instance, one of the possible explanations for the relatively low BTP€i breakeven valuations is the fact that Italian linkers tend to have a narrower investor base than their core counterparts. SPGB€i valuations also used to have a significant discount versus core, but this has been eroded by asset swap demand.

FIGURE 6

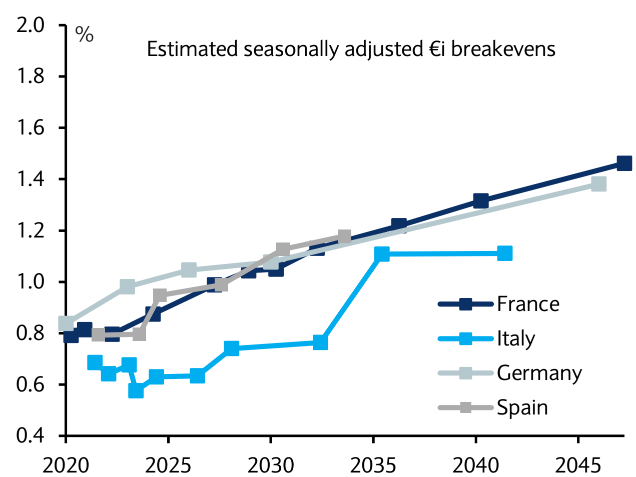
Headline German breakevens appear cheap to OAT€is…



Source: Barclays Research (26 March 2019 close)

FIGURE 7

… but relatively close once adjusting for seasonality



Source: ECB data, Barclays Research (26 March 2019 close)

Incremental forward real yields and breakevens

When looking at relative value on the curve of a single issuer, more micro considerations come into play. One standard analysis here is to look at incremental forward curves of breakevens and real yields – ie, the forwards implied between a bond and the next bond shorter on the curve. Building the structure of forwards implicitly corrects the valuation of each bond for whatever the market is pricing in shorter maturities. What is calculated isolates micro relative value but nevertheless incorporates the directional element in valuations.

While forward curves tend to be relatively well behaved in real yield, they tend to be all over the place in breakevens. This can be due to bond- or sector-specific distortions on the nominal curve, which are then reflected in breakevens and amplified on the forward curve. To smooth out such distortions, we can try maturity-matched nominal yields from a fitted curve.

Refining asset swap measures – the S-spread

The most commonly used measures of relative value in linkers are related to asset swaps. Asset swaps are more comprehensive indicators of relative value because they integrate valuations versus the inflation swaps curve. Also, being spreads versus a nominal curve (versus Euribor for instance), asset swaps should be less directional (at least theoretically), and therefore are more appropriate to capture relative value. We typically use the z-spread asset swap. It is a purely theoretical analytical tool, but it circumvents many of the distortions inherent to tradable formats of asset swaps, such as par/par and proceeds asset swaps. Z-spreads on linkers can also compared with those of nominals and, by construction, this relative z-spread is an expression of the relative valuation between the bond's breakeven and the corresponding inflation swaps curve. However, the z-spread is calculated as a flat spread versus the Euribor curve and, as such, does not properly account for the credit component factored into the nominal curve. The relative z-spread can therefore be distorted by credit considerations. As a result, to gauge the static richness or cheapens of bond breakeven versus inflation swaps, we use the S-spread. For an explanation of asset swap calculations, including z-spreads and S-spreads, please see *Linker Asset Swaps* earlier in this publication.

A systematic approach to relative value

FIGURE 8

3m z-scores for relative value metrics, ranked cheap to rich

	S-spread 66D z-score	Fwd RY 66D z-score	Fwd BE 66D z-score	Z-spread 66D z-score	Average z-score	
OATei 1.1% Jul 22	0.80	-0.19	2.12	0.37	0.77	Cheap
OATei 0.10% Mar 21	-0.66	0.80	1.53	-1.05	0.16	
OATei 0.25% Jul 24	0.32	-1.49	1.80	-0.66	-0.01	
OATei 1.8% Jul 40	-0.77	-0.03	1.22	-0.71	-0.07	
OATei 3.15% Jul 32	-0.84	-0.63	2.21	-1.60	-0.21	
OATei 2.25% Jul 20	-0.23			-0.36	-0.29	
OATei 1.85% Jul 27	0.08	-2.28	2.01	-1.58	-0.45	
OATei 0.1% Jul 36	-0.61	-2.67	2.10	-0.79	-0.49	
OATei 0.1% Jul 47	-0.95	-2.60	2.19	-0.69	-0.51	
OATei 0.7% Jul 30	-0.50	-2.96	0.80	-1.97	-1.16	Rich
DBRei 1.75% Apr 20	1.37			1.25	1.31	Cheap
DBRei 0.1% Apr 23	0.11	0.15	2.41	0.72	0.85	
DBRei 0.1% Apr 26	-0.10	-1.68	1.64	0.72	0.15	
DBRei 0.1% Apr 46	-1.31	-2.35	2.39	0.72	-0.14	
DBRei 0.5% Apr 30	-0.73	-2.88	1.41	0.32	-0.47	Rich
BTPei 1.3% May 28	1.35	0.66	3.09	0.03	1.28	Cheap
BTPei 2.55% Sep 41	-0.58	0.75	2.04	0.60	0.70	
BTPei 0.1% May 22	-0.16	0.95	1.78	-0.97	0.40	
BTPei 2.35% Sep 24	0.54	-0.01	1.42	-0.66	0.32	
BTPei 3.1% Sep 26	0.49	-1.35	0.62	-0.46	-0.18	
BTPei 1.25% Sep 32	-0.08	-0.88	-0.08	0.28	-0.19	
BTPei 2.6% Sep 23	-0.66	-0.70	0.77	-1.03	-0.41	
BTPei 0.1% May 23	-0.56	-1.32	1.26	-1.02	-0.41	
BTPei 2.35% Sep 35	-1.29	-1.18	0.45	0.21	-0.45	Rich
SPGBei 0.15% Nov 23	0.60	-0.63	3.15	-0.94	0.55	Cheap
SPGBei 0.3% Nov 21	-0.24	-0.69	1.92	-1.95	-0.24	
SPGBei 1.80% Nov 24	0.38	-1.78	1.04	-0.97	-0.33	
SPGBei 0.70% Nov 33	-1.46	-1.27	1.57	-0.73	-0.47	
SPGBei 0.65% Nov 27	-0.67	-1.87	1.13	-1.33	-0.69	
SPGBei 1.00% Nov 30	-1.34	-1.78	0.65	-1.15	-0.91	Rich
OATi 3.4% Jul 29	-0.44	1.09	1.94	-1.99	0.15	Cheap
OATi 2.1% Jul 23	-0.68	-1.32	1.48	-1.19	-0.43	
OATi 0.1% Jul 21	-0.90	-0.91		-1.13	-0.98	
OATi 0.1% Mar 28	-1.67	-2.57	1.08	-2.24	-1.35	
OATi 0.1% Mar 25	-2.03	-2.23	-0.28	-2.07	-1.65	Rich

Note: Bonds of residual maturity <1y are excluded from this framework

Rich	Cheap

Source: Barclays Research (26 March 2019 close)

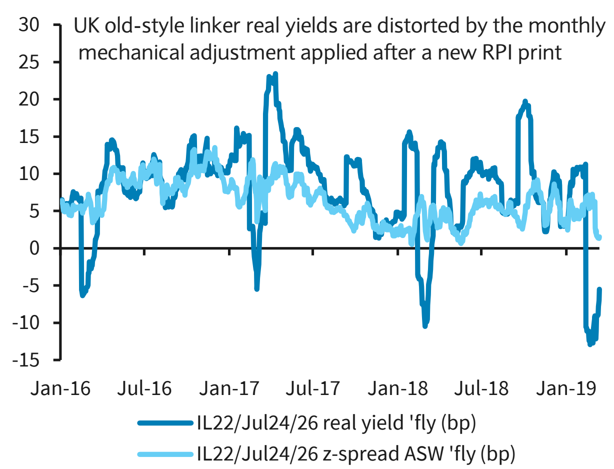
We can aggregate the metrics discussed above to have a systematic relative value framework, but we also move beyond a static approach by taking their 3m z-scores. We retain the incremental forward real yields and breakevens, the z-spread asset swap and the S-spread measures. For each bond, we sum up the z-scores and use the averages to rank the different issues. We can weight the relative importance of the different metrics differently, but we feel that each is relevant enough for equal weightings (however, for the shortest bonds, incremental forwards are not available, and the importance of the asset swap measures is therefore doubled).

Relative value in UK linkers

Assessing relative value in UK linkers is perhaps the least straightforward of the three major inflation markets. The different indexation models underpinning old-style 8m linkers and new-style 3m linkers mean that comparing the real yield spread of the various issues is a poor guide to relative value. Old-style linker real yields are adjusted at each RPI print to account for the difference between actual inflation accretion and the 3% linear assumption embedded in the pricing formula for the bonds. New-style linkers by contrast follow the internationally standard Canadian model for indexation. UK linkers do not have a deflation floor, so this complication is avoided when valuing linkers. New-style linkers are issued with both November and March maturities creating a seasonal differential between the two issues. This means that when constructing forward real yields, best practice is to compare old-style issues with old-style and for new-styles forwards between Nov/Nov and Mar/Mar issues to avoid distortions. Our preferred relative value metric for UK linkers is the z-spread asset swap, which is calculated via an iterative process. The measure is calculated by projecting the real bond flows into nominal space and then determining the parallel shift that needs to be applied to the nominal curve to equate the discounted value of the cash flows and the bond's dirty price (the full settlement price of the bond including accrued interest and inflation uplift).

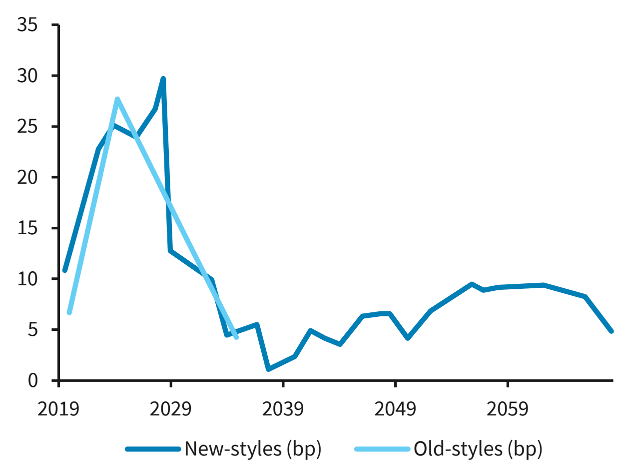
Figure 9 shows a chart of the old-style ILJul24 plotted against a real yield barbell of the new-style IL22+26. As can be seen, the real yields significantly exaggerate the moves, whereas the z-spread measure is more stable and not subject to as many discrete jumps. When assessing micro relative value, we tend to always compare real yield, breakeven and z-spread flies to come to a clear conclusion. Forward real yields can be an important element of assessing value in the UK linker market, for indexed investors. Long-dated linker supply results in benchmark indices extending, and as such active managers face being taken short duration versus their benchmarks. Unlike passive managers, actives have a choice as to which longer-dated bonds to buy and which shorter bonds to sell. Forward real

FIGURE 9
What you see is not what you get with old-style UK linkers



Source: Barclays Research

FIGURE 10
UK relative z-spread asset swap curve



Source: Barclays Research

yields offer a guide as to which bonds offer the best value for a cash-for-cash extension trade; generally it is advantageous to sell and buy the two bonds between which the implied forward yield is cheapest (ie, highest). Relative z-spread asset swaps (iotas) are also often closely scrutinised to assess the relative value between cash breakevens and RPI swaps.

Moving towards a relative value framework

Figure 11 shows a range of 3m z-scores ([Spot Level – 3m Avg]/3m STDEV) for various linker metrics. We then sum up these z-scores, and divide these by the number of available metrics and subsequently use this to rank the various linkers on the curve in order of cheapness. Cheap issues appear first in the table, and rich issues at the bottom.

FIGURE 11

3m z-scores for various UK linker relative value metrics, ranked cheap to rich (Dark blue implies rich, Grey cheap)

		Z-spread 3m z-score	Fwd RY 3m z-score	Z-spd fly 3m z-score	Weighted sum of z-scores	Fly structure
IL48	3m Aug	0.02	-1.80	3.91	0.71	*IL46/IL48/IL50*
IL37	3m Nov	-0.15	0.92	1.21	0.66	*IL32/IL37/IL42*
IL22	3m Nov	1.33	-0.47	1.11	0.66	*IL20/IL22/ILMar24*
IL19	3m Nov	0.38			0.38	
IL47	3m Nov	-0.15	0.50	0.64	0.33	*IL42/IL47/IL55*
IL34	3m Mar	-0.26	-1.88	1.94	-0.07	*IL29/IL34/IL40*
IL42	3m Nov	-0.22	-0.70	0.54	-0.13	*IL40/IL42/IL44*
IL36	3m Nov	0.10	-2.25	1.29	-0.28	*IL34/IL36/IL40*
ILMar24	3m Mar	0.45	-1.78	0.28	-0.35	*IL22/ILMar24/IL26*
IL62	3m Mar	-0.16	-2.29	1.31	-0.38	*IL58/IL62/IL68*
IL55	3m Nov	-0.21	-1.26	-0.09	-0.52	*IL40/IL55/IL62*
IL52	3m Mar	-0.16	-2.52	0.54	-0.71	*IL44/IL52/IL62*
IL46	3m Mar	-0.17	-2.17	0.15	-0.73	*IL42/IL46/IL50*
IL32	3m Nov	-0.55	-2.03	0.29	-0.77	*IL27/IL32/IL37*
IL58	3m Mar	-0.17	-2.12	-0.22	-0.84	*IL52/IL58/IL62*
IL44	3m Mar	-0.23	-2.34	-0.10	-0.89	*IL40/IL44/IL50*
IL28	3m Aug	-1.02	-2.73	1.08	-0.89	*IL27/IL28/IL29*
IL65	3m Nov	-0.27	-2.50	-0.03	-0.93	*IL62/IL65/IL68*
IL56	3m Nov	-0.19	-2.47	-0.20	-0.95	*IL55/IL56/IL62*
IL41	3m Aug	-0.28	-2.53	-0.32	-1.04	*IL40/IL41/IL42*
IL40	3m Mar	-0.28	-2.13	-0.74	-1.05	*IL37/IL40/IL42*
IL50	3m Mar	-0.16	-3.65	0.36	-1.15	*IL47/IL50/IL55*
IL68	3m Mar	-0.37	-2.54		-1.45	
IL26	3m Mar	-0.92	-2.69	-1.12	-1.57	*ILMar24/IL26/IL29*
IL29	3m Mar	-1.17	-2.17	-2.62	-1.99	*ILMar24/IL29/IL34*
IL27	3m Nov	-1.08	-2.78	-2.24	-2.03	*IL22/IL27/IL32*
Old-style Bonds						
IL24	8m	0.50	-0.96	1.26	0.27	*IL20/IL24/IL27*
IL35	8m	0.16	-1.92	2.42	0.22	*IL30/IL35/IL37*
IL20	8m	-0.37		-1.32	-0.85	*IL19/IL20/IL22*
IL30	8m	-0.73	-2.88	-3.18	-2.26	*IL24/IL30/IL35*

Source: Barclays Research. Market data as of close 26 March 2019

Z-spread asset swap is the cleanest measure of RV

We show the z-spread asset swap as a measure of outright richness/cheapness. This strips out distortions between old- and new-style linkers, and also seasonality. The z-spread asset swap is defined as the bp shift by which the nominal swap curve needs to be bumped in order to make the discounted value of the inflation-uplifted linker cash flows (determined by the current RPI swap curve) equal to the bond's dirty price. This provides a consistent measure for comparing different linkers. The z-score of the outright z-spread also provides an indication as to the relative performance of various parts of the curve. For analysing RV, the z-scores of the incremental forward real yields are useful for identifying which parts of the curve have underperformed. Given the issues we described earlier with using a fitted curve, we instead have constructed a series of butterfly structures. We aim to use relatively nearby bonds for each linker, but also minimise the residual duration of the butterfly structure to avoid directional bias. At the ultra-long end of the curve, this means that the butterflies we analyse use notably shorter bonds given the very high duration of the IL62 and IL68. We believe these combinations of bonds to be relatively frequently traded, potentially having the advantage of easily transforming relative value indicators into trade ideas. However, systematic relative value indicators should not be used blindly, and indeed just because a bond has cheapened over a 3m horizon does not make it structurally cheap. Instead, we think the advantage of our UK linker relative value framework is that it provides a quick screen of moves across UK linkers from a number of different standpoints but that it is merely a starting point for guiding analysis.

INFLATION THEMES

The drivers of the CPI/PCE inflation gap

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The gap between core CPI and core PCE is currently 30bp, significantly lower than it was two years ago and also below the 40bp average of the past two decades. This narrowing of the gap is not unprecedented; between 2012 and 2014 it was even lower, dropping from 80bps to an average of 13bps. Nevertheless, we have noticed a significant change from 2015/16 when the gap between the two measures was elevated and in this report we investigate the reasons behind the recent trend.

Historically, three main categories have influenced the gap between core CPI and core PCE: shelter, medical and food inflation. Shelter carries a much larger weight in CPI and we find that the difference continues to drive the CPI/PCE gap. Regulatory-driven changes in healthcare costs have in the past widened the gap, but we find the effect in recent years has been muted and has contributed to the narrowing of the CPI/PCE gap. The effect from food services inflation has also diminished recently.

A narrower core CPI/PCE inflation gap

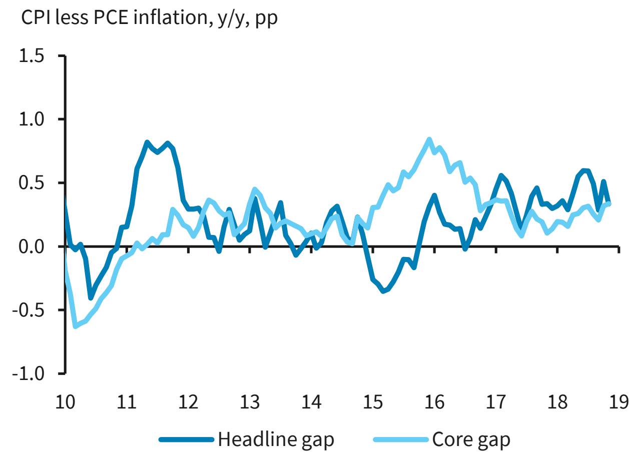
The differences in the measures of yearly rates of core and headline inflation have averaged about 40bp for both over the past two decades. During 2015 and 2016 the gap between core inflation rates increased, but the difference between the headline rates of inflation fell because declines in energy prices weighed more heavily on CPI. However, since 2017 the difference between CPI and PCE measures of inflation has narrowed and has been more stable than recent history (Figure 1). Below, we examine a few of the drivers of the CPI/PCE gap. We focus primarily on CPI data when forecasting US inflation because principal and interest payments on TIPS are indexed to the NSA CPI-U. However, the Federal Reserve prefers to communicate its policy mandate in terms of the PCE because it views it as a broader measure of inflation. As a result, understanding the drivers of the gap between the two measures is important for monetary policy considerations.

The Bureau of Economic Analysis (BEA) publishes a reconciliation table that breaks down the differences between the two price measures into three categories:

- **Formula effect:** The CPI and the PCE price indices are constructed using different formulas. The CPI is based on a modified Laspeyres formula, while the PCE price index is based on a Fisher-Ideal formula. In general, the formula effect leads to a slight downward bias in PCE compared with CPI.[1]
- **Weight effect:** The weights for each item in the CPI and PCE price indices are different (Figure 2). The CPI weights are based mainly on household surveys, while those used in the PCE price index are based on business surveys. The three main differences lie within shelter, medical care and food.
- **Scope effect:** The CPI measures the out-of-pocket expenditures of all urban households, while the PCE price index measures expenditures of households and nonprofit institutions serving households as defined in the NIPAs (National income and product accounts). As a result, some of the items in the PCE are not included in the CPI price index and vice versa.

[1] The fundamental difference between the formulas involves the degree to which each method allows for consumer substitution among items as relative prices change. Both permit some substitution effect over time, with the Fisher-Ideal formula more fully reflecting substitution patterns. See McCully, Moyer and Stewart (September 2007), “A Reconciliation between the Consumer Price Index and the Personal Consumption Expenditures Price Index.” Available at *http://www.bea.gov/papers/pdf/cpi_pce.pdf*

FIGURE 1
CPI and PCE inflation differ at both headline and core levels



Source: BLS, BEA, Haver Analytics, Barclays Research

FIGURE 2
Differences in PCE and CPI weights

	CPI	PCE
Food	13.3	7.1
Energy	7.7	4.3
Core (all items ex food, energy)	79.1	88.6
Core services	59.5	67.1
Rent	7.9	4.4
OER	23.9	11.5
Medical care services	6.9	17.0
Other core services	20.8	34.2
Core goods	19.2	21.6
Apparel	3.1	2.9
New vehicles	3.7	2.1
Other core goods	12.3	16.6

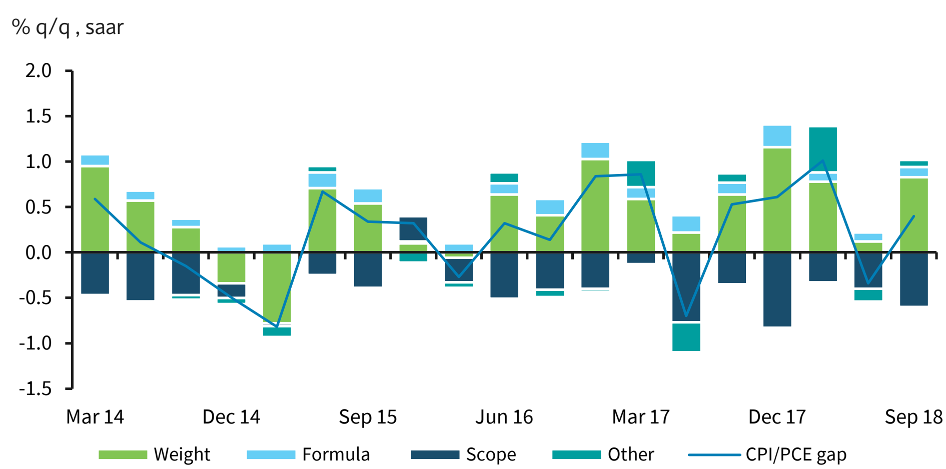
Source: BLS, BEA, Haver Analytics, Barclays Research

As Figure 3 shows, weight and scope effects have accounted for most of the headline CPI/PCE gap over the past few years. Since these effects tend to pull in different directions they have often had an offsetting impact. For instance, smoothing over the quarter-to-quarter volatility, the weight effect has widened the CPI/PCE gap by 60bp on average during 2017 and 2018. Over the same periods, the scope effect has offset some of this bias by decreasing the difference by 50bp. The CPI/PCE gap during this period has averaged 30bps as the formula effect and other, more idiosyncratic factors have pushed the gap higher. For example, in Q1 2018 there was an unusually large contribution from the “other” category of about 50bp (Figure 3). Upon closer inspection of some of the less prominent drivers of the CPI/PCE gap, it seems the difference came from seasonal adjustment and price effect discrepancies between the two measures. (in particular air transportation prices). Since the start of 2018, the contribution from idiosyncratic factors has fallen dramatically and the more traditional drivers of the CPI/PCE gap are leading more recent changes.

What’s driving the gap?

A large portion of the gap between CPI and PCE inflation is driven by shelter inflation and owners’ equivalent rent (OER) in particular (Figure 4). Although the BLS and BEA use the

FIGURE 3
Weight and scope effects drive the gap between headline CPI and PCE inflation



Note: Positive values reflect periods when headline CPI exceeds headline PCE.
Source: Bureau of Economic Analysis, Barclays Research

same source data to measure these imputed rents, the relative weight of OER differs substantially in the computation of the two indexes. OER is the most heavily weighted single item in CPI, at 23.9%. Its weight in PCE is less than half that. The CPI weight is benchmarked against a specific question in the semi-annual Consumer Expenditure Survey that asks homeowners to estimate the monthly rental value of their property. Given OER inflation of 3.2% y/y, it currently implies PCE would be 51bp lower than CPI based on this factor alone, but of course other offsetting effects mean that the actual gap is smaller.

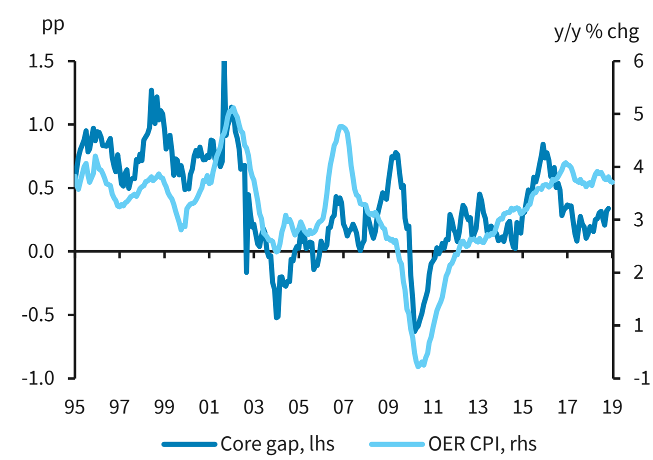
Trends in medical care services inflation are another important driver behind the CPI/PCE gap. In the CPI, the cost of medical care services is estimated on an out-of-pocket basis, meaning that any medical costs covered by health insurance are not incorporated into CPI. Conversely, PCE incorporates all consumption expenditures on behalf of households and, therefore, includes price changes that are paid by insurance companies on behalf of consumers. In practice, the PCE price index primarily uses producer prices as source data. Producer prices capture the net output of various medical services providers.

We noticed a significant divergence between CPI and PCE medical care services inflation between 2015 and 2016, which we think was a result of cost-shifting within the health care industry (Figure 5). Initially, the Budget Control Act of 2011 forced cuts in Medicare reimbursement rates that went into effect in mid-2013. Research from the Federal Reserve Bank of San Francisco has shown that this decline in public-sector pricing effectively spilled over into the private sector with a lag.[2] This public-to-private spillover was initially blamed for the softness in overall medical care inflation that began in 2013. Since then, PCE measures of medical care services inflation significantly underperformed those of CPI until Q4 2017, when the divergence between the two measures all but closed (Figure 5).

In addition, some of that divergence was attributed to the cost burden of medical care shifting toward consumers, while total prices declined as health insurance coverage increased. Following the ACA implementation more widespread health insurance coverage resulted in lower output prices for medical services providers because insurers typically pay a lower pre-negotiated rate to service providers than self-paying consumers. Hence, as health insurance coverage grew, effective selling prices for medical services fell. At the same time, health insurance companies shifted a larger share of the overall cost burden toward consumers in the form of higher insurance premiums and out-of-pocket costs. This incremental cost shift pushed CPI medical care services inflation higher, while the decline in

FIGURE 4

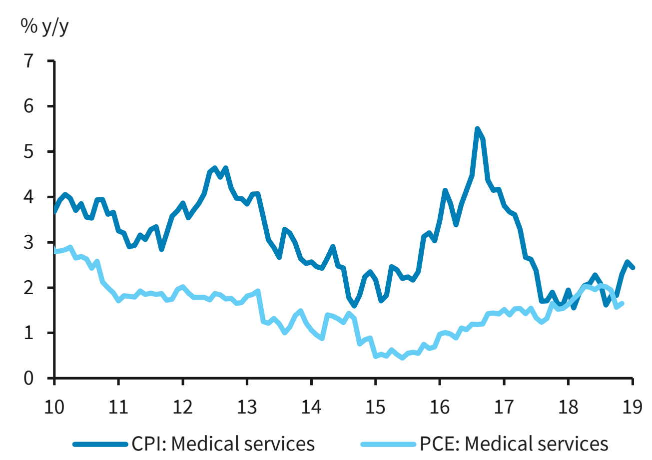
Shelter is the dominant force driving the CPI/PCE gap



Source: BLS, BEA, Haver Analytics, Barclays Research

FIGURE 5

Changes in healthcare have narrowed the gap lately



Source: BLS, BEA, Haver Analytics, Barclays Research

[2] See Clemens, Gottlieb and Shapiro (September 2014), "How Much Do Medicare Cuts Reduce Inflation?" Economic Letter, Federal Reserve Bank of San Francisco. Available here: *http://www.frbsf.org/economic-research/publications/economic-letter/2014/september/medicare-cuts-reduce-inflation-budget-control-act/*

total output prices resulted in lower PCE prices. This dynamic seems to have stabilized in recent years as aggregate pricing behavior has largely adjusted to the regulatory changes in the healthcare industry.

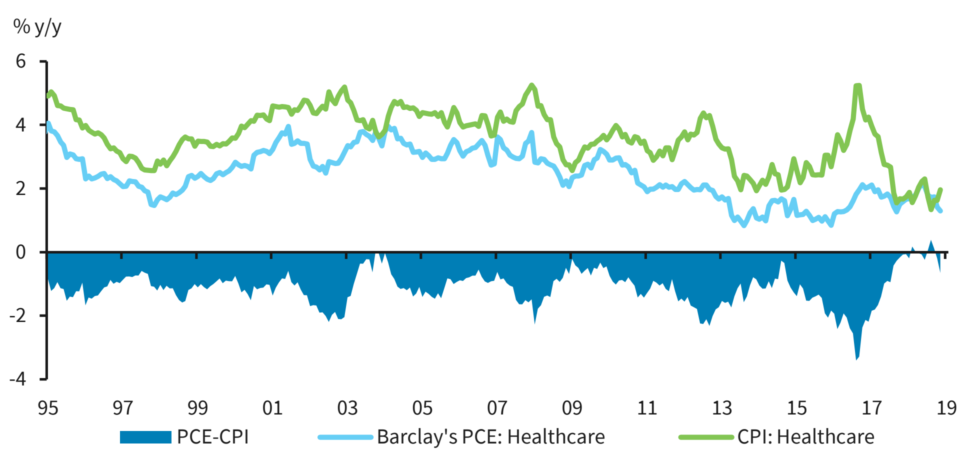
To further monitor the divergence in the trends between CPI and PCE, we have constructed a PCE medical inflation index to size up this gap. It includes the PCE components for durable and nondurable medical goods as well as services, making it comparable to the CPI measure of the Bureau of Labor Statistics. We use a Fisher ideal formula to construct our series, replicating the same methodology employed by the Bureau of Economic Analysis (BEA). Figure 6 shows these results. Medical CPI inflation currently stand just shy of 2.0%, compared with 1.6% for the Barclays constructed measure of healthcare PCE, resulting in a modest 38bp gap between the two. During 2018 this gap averaged about zero, reaching its lowest in the post-inflation targeting period. This compares with a 240bp gap during 2016 - its widest since the early 1960s.

Uncertainty regarding medical care policy also spills over into uncertainty about the evolution of prices for medical care goods and services. Based on industry pressures to increase price transparency and market consolidation through mergers, we can expect the broad trend to be one of measured inflation pressure. For instance, increased scrutiny on pharmaceutical industry price practices combined with ongoing patent expirations have led to muted price pressures for medicinal drugs. In addition, some of the strong increase in CPI medical care inflation was being induced by policy changes as well as higher demand for medical services from increased coverage of a pool of less healthy patients - but those factors are not creating renewed upward price pressures currently. As a result, the rate of medical inflation in both PCE and CPI has stabilized around 2.0% and we expect it to trend sideways over the next year. We would expect the gap between the two to remain modest in the near to medium term, absent a major policy or idiosyncratic industry shock.

Another important discrepancy between CPI and PCE lies with the food category, which has about double the weight in the CPI as it does in PCE price index. This is due to a methodological difference: while CPI includes food eaten on premises (ie, at restaurants) within the broader food category, PCE groups this line item within services. When excluding food from core inflation, CPI therefore removes restaurant food prices, while PCE does not. Food services account for about 5.6% of total PCE, most of the difference in food weights. Since food services inflation typically exceeds core PCE inflation, the inclusion of food services in the core tends to boost core PCE inflation modestly relative to core CPI. This difference alone has boosted annual core PCE inflation by an average of 7bp per month over

FIGURE 6

The gap between healthcare CPI and PCE has been at historical lows in recent years



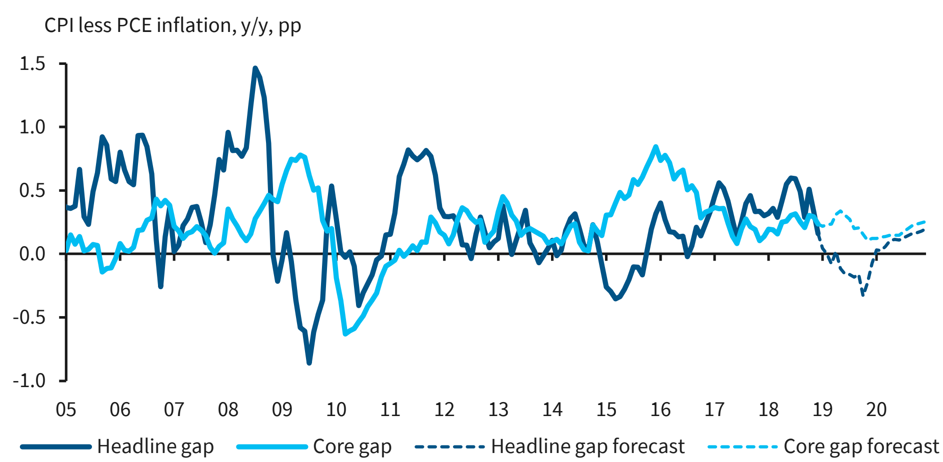
Source: BEA, BLS, Haver Analytics, Barclays Research the past decade. The difference only affects core PCE versus core CPI, though, as food services are ultimately included in the headline total for both consumption baskets.

Looking ahead

It is difficult to forecast the idiosyncratic differences that often drive the near-term dynamics of the CPI/PCE gap. Sharp declines in oil prices weigh more heavily on CPI inflation than PCE. This dynamic, combined with a larger energy weight in CPI, led the CPI/PCE gap to reverse in 2015, with annualized CPI inflation below PCE inflation. That gap in headline rates has now normalized, with CPI inflation once again outpacing PCE inflation. However, we expect this gap to become negative again later this year, as the energy drag on headline CPI gathers momentum, and to then return to its historical norm in 2020. We believe the trend in shelter inflation is likely keep core CPI slightly above core PCE for some time. As a result, we expect the CPI/PCE gap at the core level to be between 20bp and 30bp throughout 2019 and 2020.

FIGURE 7

The CPI/PCE gap has closed in recent years and is likely to continue at current levels



Source: BEA, BLS, Haver Analytics, Barclays Research

Forecasting inflation: Top down, bottom up

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The significant volatility in energy prices and the foreign exchange value of the dollar in recent years has placed a premium on understanding core inflation as a guide to underlying price pressures in the United States. We attempt to overcome these difficulties in predicting underlying inflation pressures by using a hybrid approach that evaluates near-term inflation using a bottom-up method and allows our forecast to be influenced by the relationship between inflation and the unemployment rate, economic slack and inflation expectations in the longer run. We believe that a combination of views on inflation – top down, bottom up and the very near term – provides a broad understanding of underlying inflation dynamics and hence the likely near- and medium-term evolution of inflation.

We believe using a full suite of models and approaches to forecast inflation substantially improves forecast performance

Our top-down approach takes a Phillips curve view of the world, in which the overall state of the economy drives the evolution of inflation over the long term. We find that although the relationship between inflation and activity is weaker that it was, the relationship continues to hold; the Phillips curve is flatter but still a useful framework for understanding inflation dynamics. We augment that macro view with periodic examinations of individual price series (eg, shelter, core goods and non-shelter services). At this level of detail, inflation dynamics are often driven by idiosyncratic shocks or special factors. Understanding how these shocks are likely to resolve can yield more consistent micro level forecasts and can improve the performance of the overall inflation forecast.

Inflation over the medium term: the Phillips curve

Our view on inflation over the long-term is derived from an inflation-expectations-augmented Phillips curve

Medium-term movements in inflation are hard to predict, and forecast accuracy of different models varies over time. As a result, using a number of regressions to forecast inflation can help improve accuracy. Some such as Atkeson and Ohanian[1] have argued that univariate models, which assume a high degree of persistence in inflation, often outperform Phillips curve forecasts at least at the four-quarter horizon. However, the Phillips curve remains a significant part of the inflation forecasting framework for many central banks, including the Federal Reserve, and it is a useful tool for understanding the interaction between labour market slack and inflation. For example, Stock and Watson[2] argue that basic univariate inflation models can be augmented by including macroeconomic variables that measure the degree of economic slack, especially at turning points for the economy. In our estimate of the long-term Phillips curve (Figure 1), we conclude that the Phillip's Curve is indeed flat and the behaviour of US inflation has changed in the past few two decades. IMF research found similar results in a panel study for several developed economies.[3]

In our view, although the Phillips curve is much flatter than it used to be, it still provides a useful guideline for medium-term inflation pressures. Below we describe how we come up with our view on inflation over the long term using an inflation-expectations-augmented Phillips curve. We begin with a model of inflation based on the one used by former Federal Reserve Chair Yellen (see *Inflation dynamics and monetary policy*, 24 September, 2015)[4]. Our framework in this approach assumes that inflation is influenced by inflation expectations, past inflation, resource utilization (as proxied by the unemployment rate relative to NAIRU or by a measure of the output gap) and the relative price of imports. We

[1] Atkeson, A. and L. Ohanian (2001) Are Phillips Curves Useful for Forecasting Inflation? Quarterly Review, Federal Reserve Bank of Minneapolis.
[2] Stock, J. and M. Watson (2008) Phillips Curve Inflation Forecasts. NBEER working paper 14322.
[3] 2013 World Economic Outlook, Chapter 3.The Dog that Didn't Bark: Has inflation been muzzled or was it just sleeping?
[4] For a full explanation of our approach and for implementation details please see *Target 4.0% unemployment to achieve 2.0% inflation* (November 30, 2015) and *Some unpleasant dual mandate arithmetic* (October 8, 2015).

aim to use this approach to understand pressures likely to push inflation over longer periods of time. Hence, we enhance our Phillips curve forecast with our forecast for the evolution of unemployment, import prices and wages, all of which are likely to impact inflation.

In one of our models below, we follow the Fed's lead and apply our efforts to PCE. This approach keeps us close to the Fed's views of inflation and helps us understand how it is likely to view inflation pressures in the economy and hence how likely these are to accelerate or slow the pace of interest rate hikes. The main disadvantage of the approach above is that it does not speak directly to CPI inflation. As a result, we then extend this approach to the CPI inflation measure as well as a measure of domestic price pressures that excluded predominantly core goods components which are more readily influenced by international prices rather than the building up of domestic price pressures. The differences between the various measures of inflation do not greatly change our view about longer-term inflation trends; more generally, we believe this combined approach prevents us from fixating on any one definition of inflation as we try to determine the true underlying inflation trends.

Our price model

Using this framework, we specify a number of different Phillips curve models as shown in Figure 1. The first column shows the coefficients from Chair Yellen's inflation-expectations-augmented Phillips curve. The specification uses a measure of inflation expectations (currently at 2%), two lags of the dependent variable, a measure of the changes and relative importance of import prices, and the gap between the unemployment rate and the CBO's estimate of the long run NAIRU[5] (Figure 2). The coefficient on the last element (UR-NAIRU) is the Phillips curve slope; numbers closer to zero indicate a flatter curve and, all else equal, mean a larger change in unemployment is needed to move inflation. We extend the Phillips curve finding to a core CPI-based model, a domestic inflation index such as that of core services which more accurately reflects the underlying price pressures of the economy. And finally we replicate these results, dropping our control for relative changes and importance of import prices. The flatness of the Phillips curve is evident across specification although the response of domestic inflation (core services) to labour market slack is significantly higher than for overall core inflation, as one would expect. The Phillips curve coefficient on

FIGURE 1

Although the Phillips curve is relatively flat…

	Chair Yellen	Barclays			
	PCE	PCE	CPI	Domestic	PCE no imp
Inflation Expectations	0.41	0.45	0.47	1.01	0.39
Lag(-1)	0.36	0.43	0.27	0.22	0.49
Lag(-2)	0.23	0.11	0.32	0.10	0.13
Rel. Import Price	0.57	0.26	0.25	0.11	N/A
UR - NAIRU	-0.08	-0.07	-0.10	-0.18	-0.06

Model estimated with data from 1990 Q1 to 2018 Q4

Source: Barclays Research

[5] The core inflation forecasting equation is:

$$\pi_t^c = \pi_t^e + \pi_{t-1}^c + \pi_{t-2}^c + SLACK_t + RPIM_t + \epsilon_t,$$

where core inflation (π_t^c) is modeled on long-term inflation expectations (π_t^e), lags of core inflation, economic slack ($SLACK$) in terms of the U3 unemployment rate against the CBO's measure of long-run unemployment, and the relative price of core imported goods ($RPIM$) as described in the paper.

domestic inflation is about double of that on core PCE or CPI (-0.18 versus -0.07 and -0.10).

The estimation of the different Phillips curves specified with a domestic measure of inflation highlight the implications of continued tightness in labour markets and of running an economy hot. Running the economy hot, or creating a *high-pressure* economy, can help increase the overall level of inflation and increase the dispersion of inflation in the economy between the domestic and tradable sectors. Domestic inflation, closest in practice to services inflation, would accelerate significantly more in response to high capacity utilization than would core goods, which can be influenced more by international demand and the evolution of exchange rates.

FIGURE 2

… a falling unemployment rate still boosts inflation.

Source: BLS, CBO, Haver Analytics, Barclays Research

Globalization and protectionism leave an imprint on inflation

The steady increase in global political and economic cooperation since the end of World War II (WWII) led to a sharp acceleration in international trade flows in what can be characterized as a period of hyper-globalization. But international integration has experienced cycles through history and we now seem to be going through another turning point where global trade flows and openness is declining. Globalization has been credited with boosting output and productivity growth, as well as containing inflation, because it has led to increased global competition and lower import prices. It is, therefore, natural to wonder whether its reversal could have the opposite effect and generate negative repercussions for those economic parameters.

If globalization has peaked and trade openness is set to decline in the years ahead, what does that mean for inflation dynamics? We have become accustomed to the familiar dichotomy of core good inflation running significantly below core services inflation. This has kept inflation close to the Federal Reserve’s 2.0% target, even as services inflation has risen by 2.8% y/y on average over the past two decades. The question we want to answer is whether the era of low goods inflation is over and if it is likely to become structurally firmer in a way that will make it more likely for the Fed to overshoot its inflation target.

To answer our questions, we turn to our preferred hybrid approach for understanding inflation. From the top down, we start with a reduced-form equation that explains movements in inflation (eg, the Phillips curve) and ask how the historical relationship rooted in this equation has been affected by several decades of increased trade openness. Based on this outcome, we ask whether a reversal in openness could have the opposite effect. Once the top-down macro picture is identified, we look at a panel of manufacturing industries for which import competition has been more prevalent, and test the hypothesis that globalization has affected inflation directly via cheaper imports and indirectly by increasing competition for domestic firms. We discuss the industry level results in the next section.

Empirically, we find that trade has increased the sensitivity of US inflation to external factors directly (import price fluctuations) and indirectly (global competition). The results of our analysis are shown in Figure 3. This relationship is significant statistically, but modest in practice. Most of the variation in core PCE is still driven by domestic factors, such as inflation expectations (a proxy for central bank credibility) and labour market slack. In Figure 4, we estimate that, on average, external factors have lowered core PCE by 0.1-0.3pp per year since the early 1990s. Most external drag is from the direct effect of lower import prices, while trade openness is responsible for about a third of the drag. Over the same period, we estimate cyclical factors such as inflation persistence and the unemployment gap have pushed inflation higher by 0.5-1.0pp, a significantly larger driver of inflation trends in the US, second only to the role of central bank credibility as proxied by the anchoring of inflation expectations which have contributed 1.3-2.0pp to core inflation.

Although the average effect of external factors on inflation is fairly modest, at least the upper limit of this range is not negligible either. If outside factors have consistently been a drag on inflation since the early 1990s, a reversal could make the difference between being below the inflation target for the Fed and just hitting it. Our model suggests that trade openness has made a positive contribution to PCE inflation since 2016, reversing an almost three-decade long trend (Figure 4). This is worth elaborating further. Our model tells a story whereby the slowdown in globalization in recent years as depicted has already started to affect inflation, albeit its net effect is only modest. As a result, we think that a sustained decline in trade openness could prove more of a tailwind to higher inflation than the hurdle it has been, although, the magnitude of that effect is likely to be modest.

FIGURE 3

A Phillips curve equation that controls for imported inflation and trade openness

Inflation = α*Inflation Expectations + β*Inflation Lag(-1) + (1-α-β)*Inflation Lag(-2) + γ*Labor Market Slack + δ* Relative Import Price*Trade Openness + μ*ΔTrade Openness

Model	(1)	(2)	(3)
Inflation expectations	0.39***	0.59***	0.62***
Inflation Lag(-1)	0.48***	0.31***	0.30***
Inflation Lag(-2)	0.13	0.09	0.08
Labour Market Slack	-0.07**	-0.07**	-0.06**
Relative import price	…	0.28***	0.27***
Trade openness	…	…	-0.70*
Adjusted R2	0.50	0.59	0.60
Observations	115	115	115

Note: Using data from 1990 to the present, we estimate the q/q annualized change in core PCE inflation on inflation expectations, two lags of inflation, a proxy of labor market slack based on the c the CBO's estimate of the natural rate, the relative price of imports interacted with our measure of trade openness, and trade openness. For inflation expectations, we use the Survey of Professional Forecasters series on long-term inflation expectations. Our measure of trade openness is total US exports and imports as a share of domestic output. We exclude trade in petroleum.

Source: Barclays Research

One likely reason that changes in trade openness have a modest influence on inflation is because trade intensiveness changes slowly. Globalization is a gradual process and the ratio of trade to GDP changes only slowly. For instance, our measure of trade openness rose from 17% of GDP in 1990 to 27% of GDP by the end of 2015. We estimate that over this 25-year period, globalization lowered core PCE inflation by 0.1-0.3pp per year through lower import prices and increased competition. If we reverse the 1990s openness and trade flows fell from 26% to 15% of GDP and if this process occurred at a slow pace over 20-30 years, it would boost inflation by 0.1-0.2pp per year.

A more rapid deglobalization process that reverses everything we have achieved in the past 30 years over a third of that time would have a more significant effect on inflation, boosting it by almost 0.5pp per year. Even in this more dramatic scenario, we would expect inflation over a 10-year period to be about 5% higher than it would have otherwise been. However, rapid shifts in globalization may also yield growth effects that could limit the overall amount of pass-through.

Using the model

We do not take the results of the price model directly into our inflation forecast. Rather, the results of the model inform our view on the underlying inflation pressures which may (or may not) be building in the economy. Our broad macroeconomic framework always yields a concrete view on the rate at which core inflation is likely to firm, the likely pace at which wages will rise, and a long-term view on import price inflation. We use this output to judge the extent to which core inflation, as an aggregate, is likely to rise. We apply the resulting tilt across individual CPI series, from which we build our forecast.

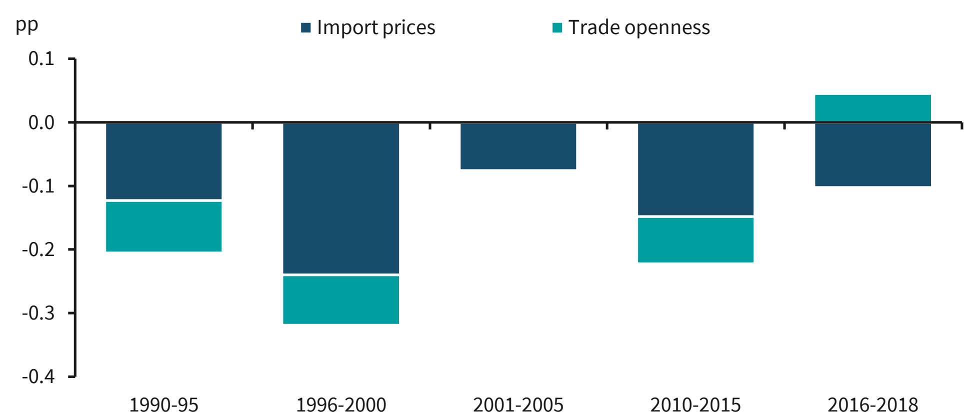
Micro foundations: One series at a time

The Phillips curve formulation cannot be used to forecast inflation in isolation. Each item in the CPI is likely to be influenced by factors beyond the amount of slack in the economy and therefore individual series' forecasts are often quite different to what would be implied from aggregate inflation pressures. The evolution of individual series is often determined by idiosyncratic economic or structural factors in specific markets that influence inflation. In these circumstances, understanding the movements in those particular series has the potential to substantially improve the performance of the overall inflation forecast.

For example, after a period of rapid exchange rate appreciation, the inflation rate on goods

FIGURE 4

Our model suggests external factors have been a small headwind to core inflation



Note: Average contribution to the y/y rate of PCE inflation from external factors divided between import prices and trade openness. It is based on the results of the model specification described in Figure 4. Source: Barclays Research with high import content is likely to substantially underperform inflation in other prices for some time. Failing to anticipate that idiosyncratic influence on inflation could lead to a substantial overshooting of the inflation forecast, especially if the forecast assumes that prices of imported goods follow the same relationship with the amount of slack in the economy as do other goods in the economy[6].

To provide context and increase understanding of our approach, we include a few specific examples of the micro-data explorations we have published over the past year. However, these are just examples; we consistently examine our assumptions on individual series to identify series with anomalous behaviour and that may be subject to temporary idiosyncratic pressures. Once these are identified we use a combination of judgement, statistical models and anecdotal evidence to inform our view on the near- and medium-term evolution of those series.

Shelter

Shelter has a large weight in PCE inflation and an even larger weight in CPI. In our piece *US Inflation – Don't expect shelter to accelerate* 26 February 2019, we examined the drivers of shelter-specific inflation. The price of rent, which underpins rent of primary residence directly and owners' equivalent rent indirectly, is fundamentally determined by the supply and demand of rental units which can be encapsulated in rental vacancy rates. We started by examining the indicators of housing demand and supply that inform our forecast for vacancy rates, which is a main input into our outlook for rent and owners' equivalent rent.

We believe the evolution of rental demand over the past decade is fully consistent with labour-market developments during the recovery and the deterioration in home affordability. Early in the recovery there was pent-up demand for rental units given the depressed rate of household formation – more young adults were forced to stay at home or live in shared housing following the broad weakness in the labour markets. Subsequent labour-market improvements – strong employment increases and the gradual pick-up in wages – are consistent with stronger household formation and the surge in demand for rentals as the first step toward more independent living arrangements.

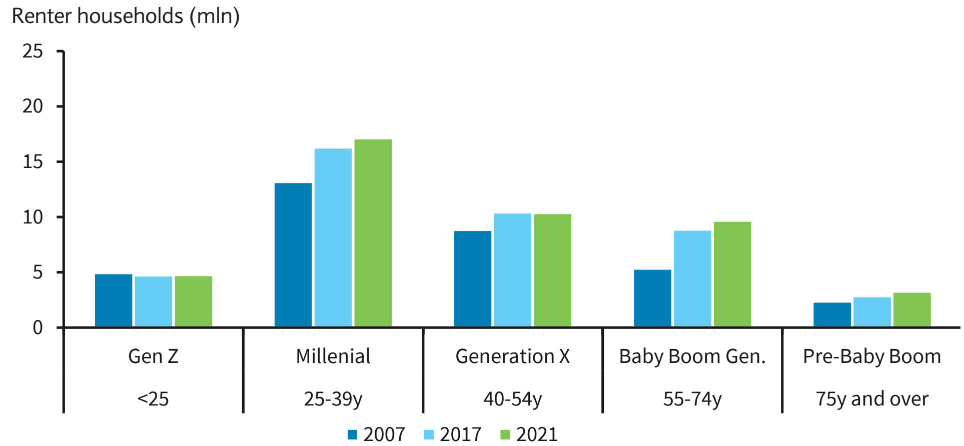
The continued labour-market improvements have likely pushed some households out of the rental market and into home ownership. The shift from renting to owning this late in the business cycle does represent some downside risks to demand for shelter. But in the current climate of poor home affordability, higher mortgage interest rates and more stringent mortgage lending requirements, risks to shelter emanating from households shifting to owning versus renting should not be overplayed.

In all, demographic data point to three broad factors still providing some tail winds to demand for rental units. First are members of Generation X who are renting for longer, pushing up rental demand from 40-54 year olds. The fall in the homeownership rate among these households during the financial crisis and their shift to renting has been an important driver of rental demand. Second, the population of millenials (23-39 years of age) is sizeable and boosting the number of adults in the prime age for renting. Finally, the baby boom generation (55-74) is transitioning into retirement. We think that some of the growth in rental households will come from older homeowners making the transition to rental housing to accommodate their changing needs (eg, downsizing). For instance, over 2005-2017, baby boomers added 4mn new households to the rental market.

[6] Our price model, described above, incorporates import prices; however, it applies the generic influence of import prices to all items in core inflation.

FIGURE 5

The rise in renter households to be driven by the millennial and baby boom generations



Source: Census, Haver Analytics, Barclays Research

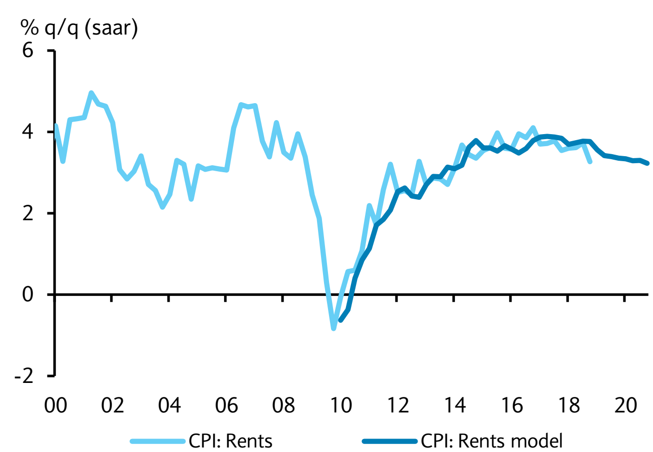
As a result, we see more balanced risks to shelter now than at any point in the recovery. Slower rental household creation represents a headwind to demand for shelter and, in turn, to inflation. Some of the downside demand side risks will likely be offset by the demographic factors mentioned above. In addition, construction of new rental units has slowed, thereby preventing prices from correcting sharply. In our view, the quick supply adjustment that normally occurs when demand has slowed will likely prevent shelter from slowing appreciably. We do not believe further acceleration in rent inflation is likely this year or next, but we expect that overall shelter inflation should remain stable around its current level. According to our model, and based on our assumption that supply and demand factors will push the vacancy rate slightly higher over the next two years, we forecast overall shelter inflation of 3.2% this year and 3.1% next year (Figures 5&6).

Domestic and tradable inflation

The sharp appreciation of the dollar between mid-2104 and mid-2015 combined with fundamentally weak economic conditions in most the emerging-market trading partners of the US economy led to considerable import price deflation. To better differentiate between the influence of domestic and tradable prices, we constructed an inflation index weighted

FIGURE 6

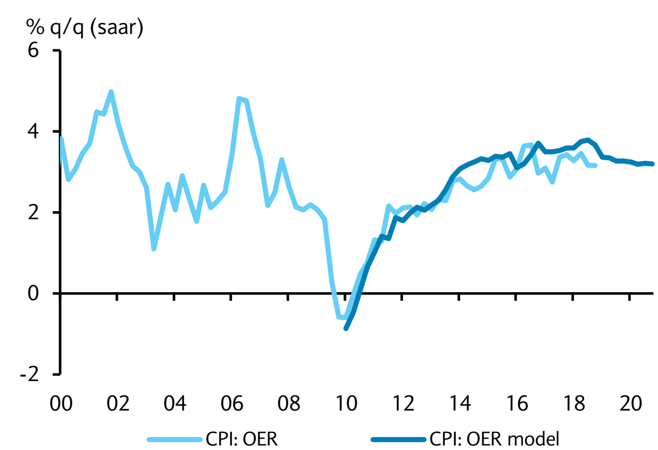
Our models suggest that rent and OER inflation should …



Source: BLS, Haver Analytics, Barclays Research

FIGURE 7

… gradually slow after a strong rally



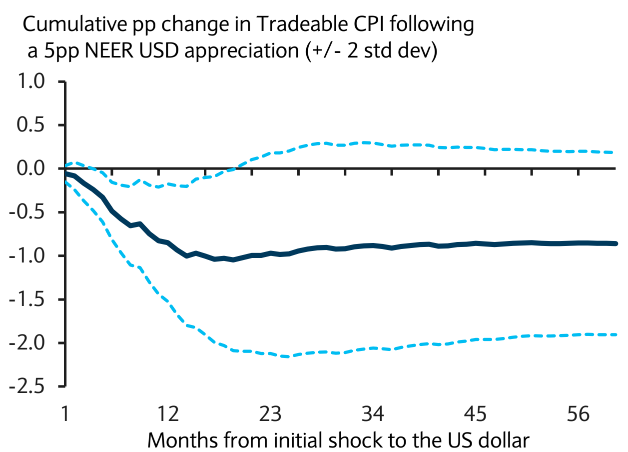
Source: BLS, Haver Analytics, Barclays Research toward expenditure items with a high level of domestic value added – Domestic CPI (see *Creating domestic inflation*, 17 August 2015). This allows us to better differentiate the portion of inflation driven by domestic supply and demand versus that driven by the evolution of supply and demand abroad. As a by-product, we created a tradable CPI measure.

Domestic CPI helps us identify sources of inflation or deflation pressures in the US. In addition, because prices determined primarily in domestic markets tend to evolve slower than tradable inflation (akin to the Atlanta Fed's sticky price measure[7]), Domestic CPI is especially useful for understanding underlying trend inflation. In addition, the index allows us to more closely follow the net influence of external shocks on overall US inflation. In other words, we can more directly measure the effect of such moves on US prices beyond their direct effect on imported goods prices.

We find two features of these series especially useful for forecasting. First, according to our statistical models, only Tradable CPI is measurably influenced by changes in the value of the US dollar (exchange rate fluctuations). A 5pp appreciation of the US dollar leads to a roughly 1pp decline in Tradable CPI (Figure 8). In contrast, the same appreciation leaves the level of Domestic CPI largely unchanged. This implies that assumptions on foreign exchange movements need only influence the path of our tradable index rather than aggregate inflation. Likewise, we find that US economic slack has a relatively large influence on domestic prices and almost no effect on tradable prices. Indeed, we find that the slope of the Phillips curve when applied to domestic prices alone is considerably more stable than the traditionally measured Phillips curve, such as the one used in our price equations.

FIGURE 8

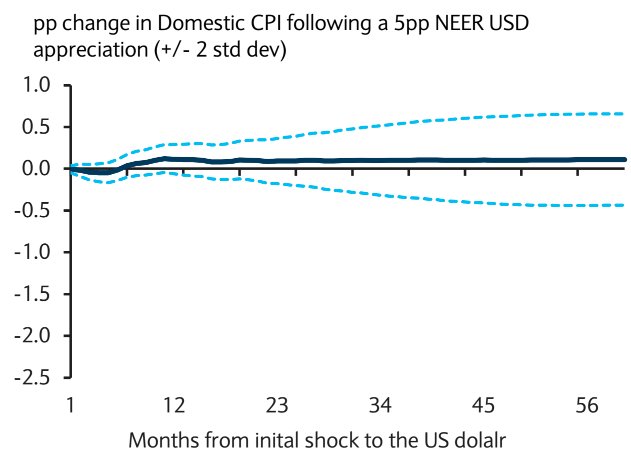
Dollar appreciation leads to lower Tradable CPI



Source: Barclays Research

FIGURE 9

While Domestic CPI remains largely unchanged



Source: Barclays Research

[7] *Atlanta Fed's sticky prices measure*

Tradable goods prices to get a boost from regime shift in trade openness

As discussed earlier, we find the top-down approach useful for estimating the aggregate effect of trade openness on price dynamics; however, it has its flaws, and is likely to mask distributional issues. The share of imports to GDP in the US economy has risen dramatically over the past three decades, and this has occurred almost entirely in the goods sector; services trade as a share of GDP is little changed. Here we focus on developments in the manufacturing sector, which has been the most exposed to trade. We have created an industry-specific measure of import penetration (IPR) using data on imports, exports and shipments. Figure 10 illustrates the increased depth and diversity of trade that has taken place at the industry level. Close to 90% of US industries had an IPR of 20% or lower in the early 1980s, but the share of industries with such a small import exposure fell to 60% by the mid-1990s and to under 40% in recent years. On the other extreme of the distribution, no industries had an IPR above 80% in the early years of our sample, but 14% of the sample had a high degree of trade exposure in 2016.

We test the *global competition hypothesis* at the industry level, i.e., the predicted negative relationship between trade openness and industry level inflation. It stipulates that more competition from cheaper foreign goods can limit the ability of domestic producers to raise prices. We look at a panel of 20 three-digit NAICS manufacturing industries and analyze the relationship of producer prices, import prices and IPR. First, we investigate whether producer price changes are positively correlated with changes in industry-imported inflation. We then assume that the pass-through of imported inflation will depend not only on swings in international prices, but also on a sector's exposure to foreign competition (IPR). See *Protectionism to intensify cost pressures in tradable goods sectors, December 10 2018* for a more detailed discussion of the theoretical framework used.

We find a strong statistically significant relationship between domestic PPI and import prices by industry. On average, 20% of import price changes are passed to domestic producer prices directly. The interaction variable has a positive sign and confirms the hypothesis that sensitivity to import prices increases with greater import competition. While the coefficient in front of the interaction variable is small in absolute terms, the total effect of external factors in our regression is captured by the sum of the effect from import prices, as well as the effect from increased international competition. Once the interaction between import prices and import penetration is taken into account, this pass-through can vary between 20% to almost 60% (Figure 11). Manufacturing industries such as food, printing, and paper are at the lower end of the spectrum for pass-through and apparel, leather and electrical equipment at the higher end.

FIGURE 10

Import penetration of manufacturing has increased dramatically since the 1950s

	Import Penetration Ratio (IPR)as percent of total							
	1958	1970	1980	1990	1996	2002	2010	2016
	SIC classification					NAICS classification		
0 ≤ IPR ≤20	96	94	87	68	60	52	40	37
20 < IPR ≤ 40	2	5	9	19	24	37	31	25
40< IPR ≤ 60	0	2	3	8	9	2	14	17
60< IPR ≤ 80	0	0	0	3	5	4	4	6
80< IPR ≤ 100	0	0	0	2	4	5	10	14

Note: IPR=[imports/(imports + shipments - exports)]. Figures prior to 2002 are from Gamber and Hung (2001) based on the SIC and include 431 three digit industries. Figures after 2002 are based on the NAICS and include 80 three-digit industries.

Source: Gamber and Hung (2001), Census, Haver Analytics, Barclays Research

Our analysis points to the industries on the left hand of Figure 11 as the ones to have been historically less open to trade and, as a result, domestic producer prices in these sectors are less sensitive to import price changes. All told, changes in import prices will still have an effect on these sectors, but the pass-through to producer prices is likely to be significantly smaller than in other manufacturing sectors. If import price pressures increase because of trade protectionism, the effect on these sectors should be smaller by comparison.

Sectors on the right hand of Figure 11 are the most open to international competition and rising import prices following a reversal of trade openness could have a more significant effect on producer prices pressures. Higher import prices, by lowering competitive pressures on import-competing goods, can induce profit-maximizing firms to raise the strategic mark-up over marginal cost to exploit the decline in market completion. This can lead to an increase in the prices of domestic goods. For instance, we estimate that if the cost of import inputs were to increase by 1pp, more than 50% of that increase would be passed through to domestic producer prices of the sectors in the right hand side.

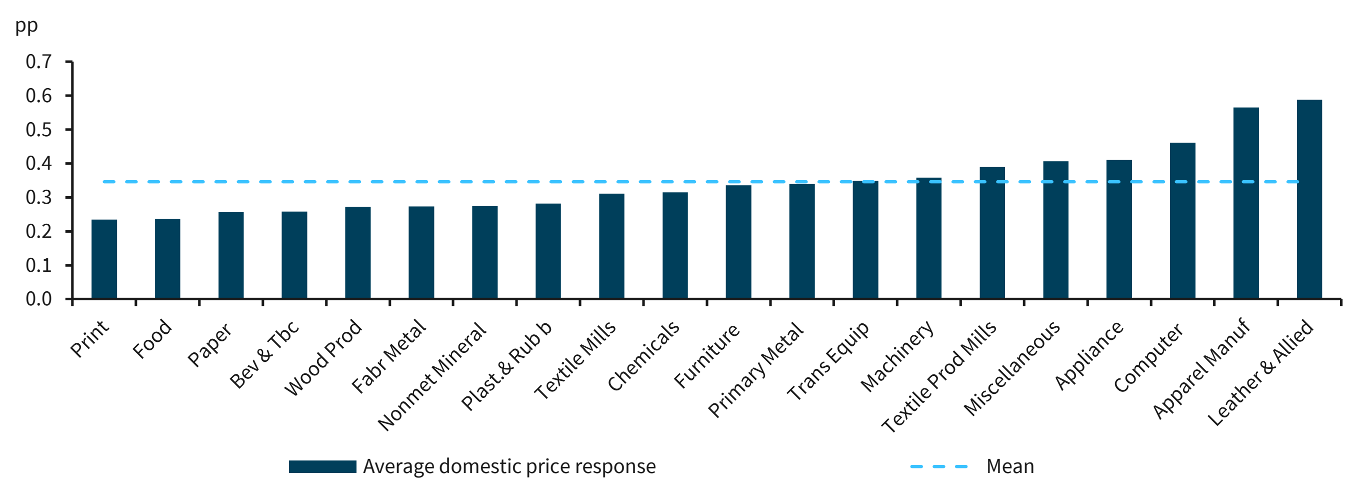
Our findings at the industry level are the same as trends in goods' consumer prices for goods during the hyper-globalization period when the rate of inflation for goods such as apparel, computers and transport equipment has been lower than for printed materials, beverages, tobacco and food. We expect industries on the right hand side of Figure 11 to generate a modest inflationary impulse from reduced trade openness at the aggregate level. Our analyses at the industry level match our conclusions from a top-down view on inflation that globalization has affected inflation dynamics through international competition. In addition, the intensity of competition and its effect on prices vary significantly by industry and manufacturing, which has been historically more open to trade, and affected the most.

Forecasting core inflation in the very near term

We acknowledge that in the very near term, the Phillips curve influence is likely to have very little influence on the evolution of prices, and the particular micro idiosyncrasies only apply to a small subset of goods. Therefore, for a near-term forecast (two to three months) we rely on an adaptive forecasting model to estimate near-term inflationary pressures. There is a wide body of research arguing that univariate models, which assume a high degree of persistence in inflation, often outperform Phillips curve forecasts (at least at the four-quarter horizon). The Atkeson and Ohanian 2001 paper provides a solid foundation for this

FIGURE 11

The pass-through from import prices and increased competition on domestic producer prices



Source: Barclays Research

view of the world[8]. We also find support for this approach, but with the main caveat that at turning points in economic activity or when structural shocks hit particular sectors, forecasting performance can be improved by using slack based models of inflation and/or a micro foundation approach to forecasting respectively.

Nevertheless, in forecasting, we put considerable weight on these univariate adaptive forecasting approaches. Unlike regression-type models that use fixed coefficients, this method adjusts the forecast based on the distant and recent history of forecast errors. Using component exponential smoothing in this manner is effective for predicting short-term inflation, as it helps filter out noise and extract the underlying trend. We use the Holt-Winters procedure.[9]

Forecasting energy

We take a different approach to forecasting energy. We believe that energy prices are determined in the global market and are thus not especially sensitive to changes in US activity. In addition, we believe that any special factors for energy are likely to be reflected in market prices. Therefore, for our near-term forecast, we use oil and gasoline futures contracts. These futures contracts are especially useful for forecasting the NSA series as they reflect market prices of deliverable energy on that date rather than seasonally adjusted data. Over the medium term, as futures contracts become less liquid, we use Barclays forecast for oil prices in the energy portion of our inflation forecast.

Pulling it together

We construct our actual forecast of inflation from the bottom up. We take a view, as described above, on each individual series and then aggregate the series to find our forecast of headline inflation. In this manner, incorporating our various approaches into a consistent view on inflation is straightforward. Any changes in view, whether stemming from, say, idiosyncratic changes in health care laws or a shift in our view on the state of the economy, are automatically incorporated into our inflation forecast. Our bottom-up aggregation approach allows us to seamlessly incorporate specific idiosyncrasies and the broader macro outlook into our inflation forecast. We believe that this combination is key to a well-founded view on inflation.

[8] Atkeson, A. and L. Ohanian (2001) *Are Phillips Curves Useful for Forecasting Inflation?* Quarterly Review, Federal Reserve Bank of Minneapolis.

[9] For a discussion on the various exponential smoothing procedures we suggest consulting Yar and Chatfield *Prediction intervals for the Holt-Winters forecasting procedure* (1990), Eviews User's Guide among other resources

INFLATION THEMES

Barclays Live: Inflation market analytics

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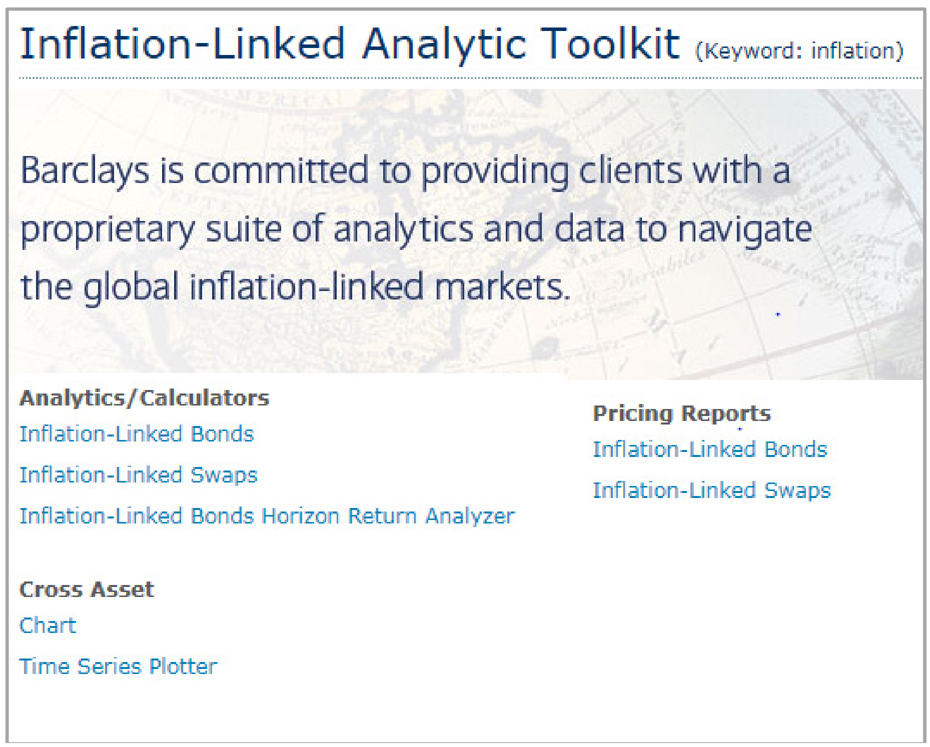
**The listed individual is a member of Barclays Live Sales and is not a research analyst.*

Barclays Live offers a proprietary suite of inflation-linked analytical tools and market data to identify relative value in the global inflation markets and against other asset classes. In addition, all inflation-linked research is available on Barclays Live in real time and can be received automatically via email or read anywhere from the Barclays Live app.

Inflation-Linked Analytic Toolkit *(Keyword: Inflation)*

The Inflation-Linked Analytics Toolkit provides a suite of tools and quantitative models to analyse the global inflation linked markets. Features include:

- Calculators to estimate projected total returns, yields, carry and breakevens.
- Relative value tools to view historical data, regressions, correlations and curves.
- Daily pricing reports that display market data and highlight statistical value across issues and tenors.

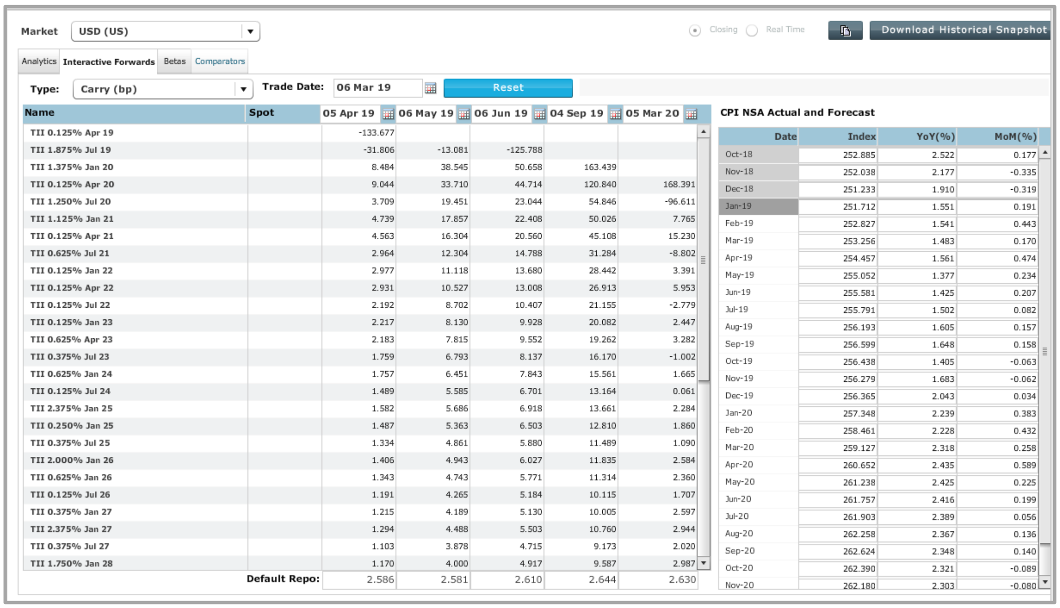


Calculators

Inflation-Linked Bonds *(*Keyword*: ILBond)*

Global inflation bond analysis, including forward carry and breakeven calculations, as well as beta and returns data. Users can:

- Monitor inflation-linked market data by currency and view historical data for linkers or spreads.
- Input user-defined inflation and repo assumptions to calculate forward carry, real yields, breakeven inflation, and breakeven protection for inflation-linked bonds.
- Adjust spot rates to see the effect on forwards at multiple horizons.
- Customise CPI forecasts by index or percentage.
- View yield and returns beta calculations, as well as daily, monthly, and year-to-date total returns.



Name	Spot	05 Apr 19	06 May 19	06 Jun 19	04 Sep 19	05 Mar 20
TII 0.125% Apr 19		-133.677				
TII 1.875% Jul 19		-31.806	-13.081	-125.788		
TII 1.375% Jan 20		8.484	38.545	50.658	163.439	
TII 0.125% Apr 20		9.044	33.710	44.714	120.840	168.391
TII 1.250% Jul 20		3.709	19.451	23.044	54.846	-96.611
TII 1.125% Jan 21		4.739	17.857	22.408	50.026	7.765
TII 0.125% Apr 21		4.563	16.304	20.560	45.108	15.230
TII 0.625% Jul 21		2.964	12.304	14.788	31.284	-8.802
TII 0.125% Jan 22		2.977	11.118	13.680	28.442	3.391
TII 0.125% Apr 22		2.931	10.527	13.008	26.913	5.953
TII 0.125% Jul 22		2.192	8.702	10.407	21.155	-2.779
TII 0.125% Jan 23		2.217	8.130	9.928	20.082	2.447
TII 0.625% Apr 23		2.183	7.815	9.552	19.262	3.282
TII 0.375% Jul 23		1.759	6.793	8.137	16.170	-1.002
TII 0.625% Jan 24		1.757	6.451	7.843	15.561	1.665
TII 0.125% Jul 24		1.489	5.585	6.701	13.164	0.061
TII 2.375% Jan 25		1.582	5.686	6.918	13.661	2.284
TII 0.250% Jan 25		1.487	5.363	6.503	12.810	1.860
TII 0.375% Jul 25		1.334	4.861	5.880	11.489	1.090
TII 2.000% Jan 26		1.406	4.943	6.027	11.835	2.584
TII 0.625% Jan 26		1.343	4.743	5.771	11.314	2.360
TII 0.125% Jul 26		1.191	4.265	5.184	10.115	1.707
TII 0.375% Jan 27		1.215	4.189	5.130	10.005	2.597
TII 2.375% Jan 27		1.294	4.488	5.503	10.760	2.944
TII 0.375% Jul 27		1.103	3.878	4.715	9.173	2.020
TII 1.750% Jan 28		1.170	4.000	4.917	9.587	2.987
	Default Repo:	2.586	2.581	2.610	2.644	2.630

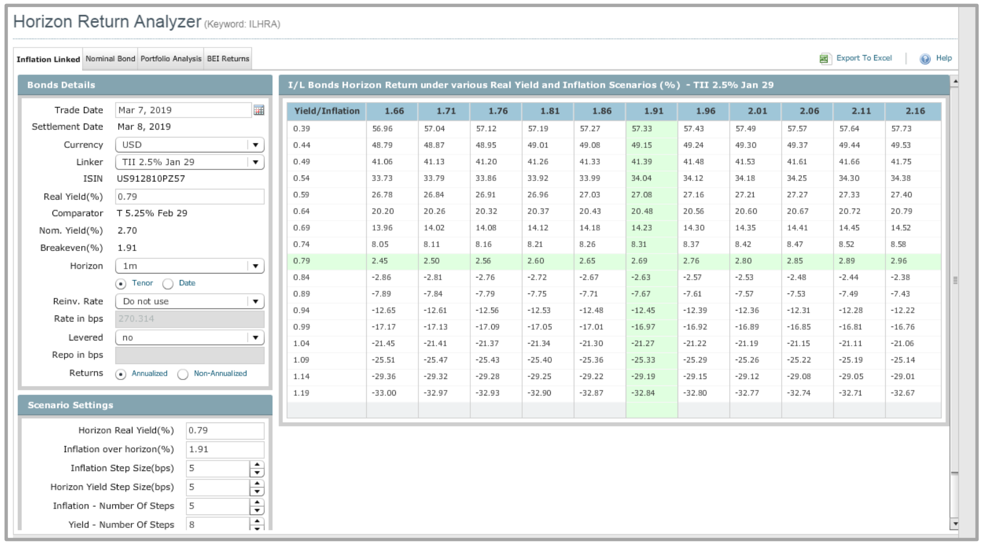
CPI NSA Actual and Forecast

Date	Index	YoY(%)	MoM(%)
Oct-18	252.885	2.522	0.177
Nov-18	252.038	2.177	-0.335
Dec-18	251.233	1.910	-0.319
Jan-19	251.712	1.551	0.191
Feb-19	252.827	1.541	0.443
Mar-19	253.256	1.483	0.170
Apr-19	254.457	1.561	0.474
May-19	255.052	1.377	0.234
Jun-19	255.581	1.425	0.207
Jul-19	255.791	1.502	0.082
Aug-19	256.193	1.605	0.157
Sep-19	256.599	1.648	0.158
Oct-19	256.438	1.405	-0.063
Nov-19	256.279	1.683	-0.062
Dec-19	256.365	2.043	0.034
Jan-20	257.348	2.239	0.383
Feb-20	258.461	2.228	0.432
Mar-20	259.127	2.318	0.258
Apr-20	260.652	2.435	0.589
May-20	261.238	2.425	0.225
Jun-20	261.757	2.416	0.199
Jul-20	261.903	2.389	0.056
Aug-20	262.258	2.367	0.136
Sep-20	262.624	2.348	0.140
Oct-20	262.390	2.321	-0.089
Nov-20	262.180	2.303	-0.080

Inflation-Linked Horizon Analyzer (Keyword*: ILHRA*)

Scenario analysis with total return calculations for inflation-linked bonds under various inflation realisations and real yield shifts through horizon. Users can:

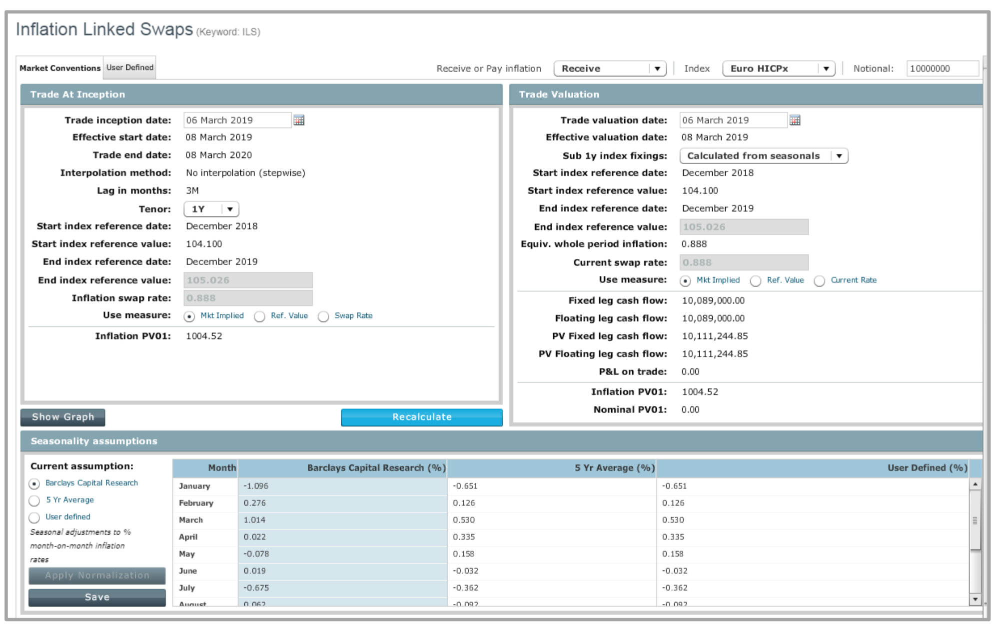
- Calculate nominal total returns under various nominal yield shifts through horizon.
- View aggregate scenario returns for an inflation-linked bond portfolio in the inflation-linked bonds 'Portfolio Analysis' tab.
- Analyse in multiple currencies, horizons and linker markets.



Inflation-Linked Swaps Calculator (Keyword: *ILSwaps*)

Inflation-Linked swap analysis with user-defined inputs that affect cash flows and P&L calculations. Users can:

- View month-on-month inflation rates that can be based on Barclays research, a five-year average, or user-defined.
- Define the inflation-linked index in multiple currencies.
- View outputs for inflation and nominal PV01 and cash flows on fixed and floating legs.

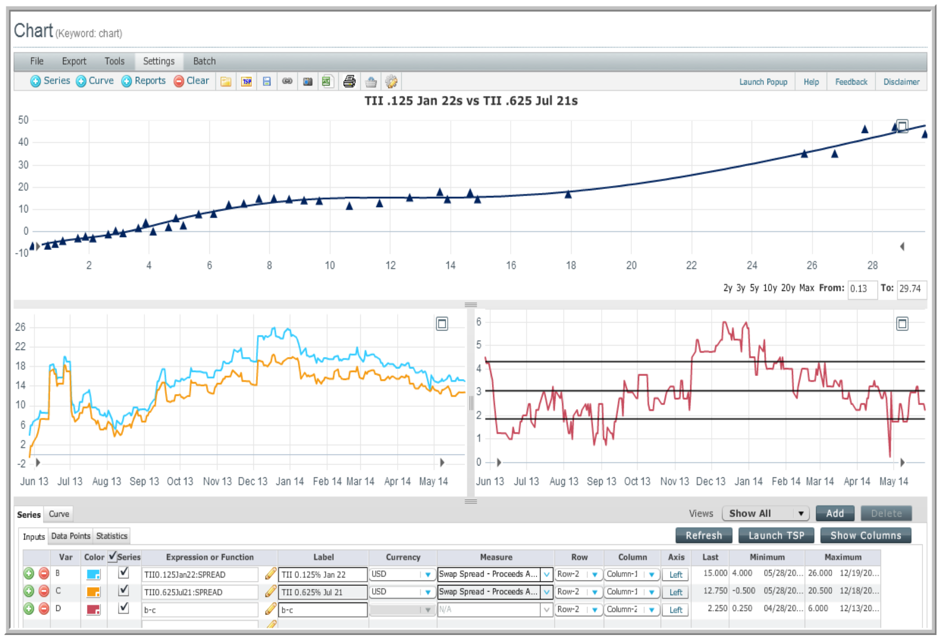


Relative Value Analytics and Market Data

Chart (Keyword: Chart)

This function enables users to perform time series and curve analysis for global inflation-linked markets or against other asset classes. In particular, users can:

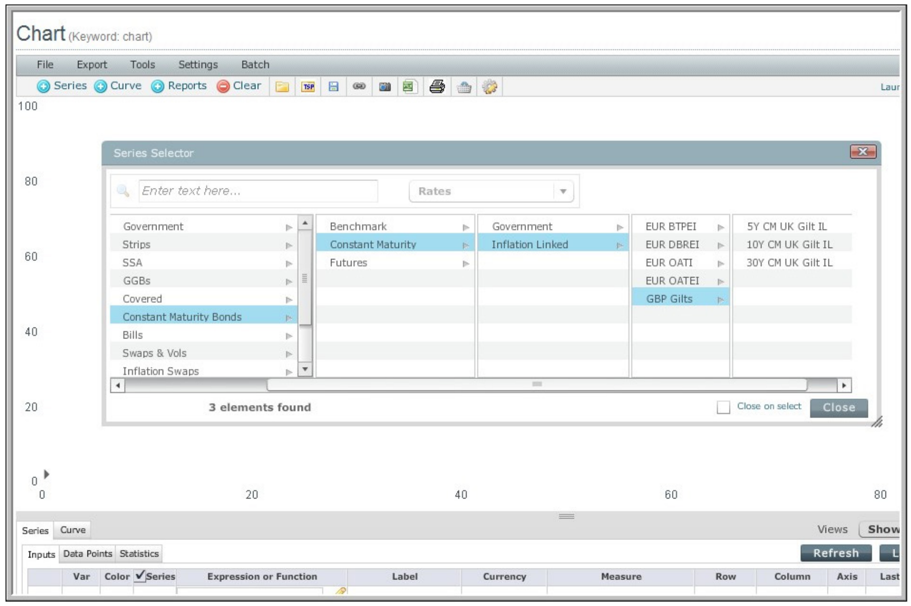
- Graph and download historical data for inflation-linked bond metrics.
- Compare linker spreads and yields by maturity or duration.
- View the change in a curve over specified periods to show the curve shape change and which linkers have out- or underperformed the most.
- Calculate statistics on the fly and view correlation, regression, or residual charts.
- Schedule batch email reports to receive charts and data automatically via email.
- Upload custom portfolios of bonds to track investments quickly and easily.



Constant Maturity Analysis in Chart

TIPS benchmark data have been available on Barclays Live for a number of years and are based on the current on-the-run bond. In Europe and the UK, the spacing between maturities can be significant; thus, we use an interpolation as opposed to a benchmark approach. We linearly interpolate between two liquid issues with maturities on either side of the tenor selected for the constant maturity series. For example, the 10y OAT€i constant maturity is a linear interpolation between the real yields and breakevens of the OAT€i27 and OAT€i30. The weighting is calculated as: w1= (Target Maturity – Short Bond life)/(Long Bond life – Short Bond life), so weightings may differ for the bonds on either side of the tenor. As such, the methodology is an approximation but is the best option, in our view, for the euro and UK inflation markets. Users can:

- Graph and download historical data for TIPS benchmarks and EU and UK linker constant maturities in the Chart + Series menu under Rates > Constant Maturity Bonds > Constant Maturity.



Pricing reports

Customisable reports are available that display market data and relative value metrics for individual issues in single or multiple currencies. Users can:

- Access the reports directly from Chart + Reports to view historical graphs for any data points displayed or pull from the pricing reports page within the Inflation-Linked Analytic Toolkit.
- Set up Batch reports of your Pricing Reports and heatmaps directly in Chart

Inflation-Linked Bond reports in Chart

- Users can customise the columns displayed and sort or filter by the categories. For instance, click on one of the z-spread columns to view rich/cheap bonds in order relative to the swap or cash curve.

TIPs

Last Updated: Thu Mar 7 19:24:00 GMT 2019 Refresh

Issue	Comparator	Maturity	Coupon	Modified Duration	Real Yield	Gross Price Index	Expected 3M Carry	Price	Breakeven Spread Current	Breakeven Protections 1M	Real Yield Forward 3M	Swap Spread Proceeds ASW	Breakeven Forward 1M	Swap Spread Calculated proceeds ASW	Swap Spread Z Spread ASW	Swap Spread - Linker Vs Comparator Z Spread ASW	Breakeven to Nominal Swaps 3M Z Score	Spread to Fitted Curve 3M Z Score	Breakeven Spread Chg on Mth	Swap Spread Comparator Z Spread ASW	Breakeven Spread 3M Average	3M Z Score
TII 0.625% Jan 24	T 2.750% Feb 24	15-Jan-24	0.625	4.775	0.576	107.81	7.84	100.24	1.887	1.96	0.703	12.6	1.867	11.33	12.0	17.01	1.31	1.53	9.56	-5.05	1.75	1
TII 0.125% Jul 24	T 2.375% Aug 24	15-Jul-24	0.125	5.327	0.517	103.40	6.70	97.93	1.973	1.62	0.634	15.1	1.957	13.09	14.1	17.32	1.30	0.15	9.74	-3.21	1.83	1
TII 2.375% Jan 25	T 2.000% Feb 25	15-Jan-25	2.375	5.490	0.615	146.90	6.92	110.11	1.906	1.66	0.729	14.5	1.890	14.18	14.3	16.79	1.30	0.86	8.83	-2.51	1.77	1
TII 0.250% Jan 25	T 2.000% Feb 25	15-Jan-25	0.250	5.799	0.609	103.69	6.50	97.94	1.913	1.57	0.718	15.8	1.897	13.86	14.7	17.18	1.36	-1.45	9.40	-2.51	1.78	1
TII 0.375% Jul 25	T 2.000% Aug 25	15-Jul-25	0.375	6.267	0.576	104.41	5.88	98.75	1.961	1.38	0.680	19.0	1.947	16.73	17.7	19.42	1.29	-0.08	8.10	-1.73	1.83	1
TII 2.000% Jan 26	T 1.625% Feb 26	15-Jan-26	2.000	6.426	0.653	138.00	6.03	109.02	1.902	1.42	0.759	17.9	1.888	17.31	17.4	19.15	1.31	-0.19	8.30	-1.75	1.78	1
TII 0.625% Jan 26	T 1.625% Feb 26	15-Jan-26	0.625	6.696	0.652	105.35	5.77	99.82	1.903	1.36	0.755	20.0	1.890	17.64	18.7	20.43	1.33	-1.41	8.39	-1.75	1.78	1
TII 0.125% Jul 26	T 1.500% Aug 26	15-Jul-26	0.125	7.301	0.626	100.76	5.18	96.41	1.946	1.19	0.724	23.8	1.934	20.53	21.7	23.15	1.24	-0.48	7.20	-1.45	1.83	1
TII 2.375% Jan 27	T 2.250% Feb 27	15-Jan-27	2.375	7.213	0.696	140.56	5.50	112.81	1.894	1.27	0.796	21.1	1.882	20.53	20.7	21.95	1.29	-1.13	6.33	-1.23	1.78	1
TII 0.375% Jan 27	T 2.250% Feb 27	15-Jan-27	0.375	7.718	0.694	101.22	5.13	97.57	1.897	1.19	0.789	24.5	1.885	21.10	22.5	23.69	1.29	-1.61	6.46	-1.23	1.78	1
TII 0.375% Jul 27	T 2.250% Aug 27	15-Jul-27	0.375	8.202	0.665	100.02	4.71	97.65	1.947	1.06	0.756	26.3	1.936	22.73	23.9	24.55	1.28	-1.68	6.23	-0.63	1.83	1
TII 1.750% Jan 28	T 2.750% Feb 28	15-Jan-28	1.750	8.225	0.731	130.25	4.92	108.72	1.894	1.11	0.825	24.3	1.883	23.26	23.2	23.86	1.27	-0.02	5.44	-0.68	1.79	1
TII 0.500% Jan 28	T 2.750% Feb 28	15-Jan-28	0.500	8.635	0.728	99.59	4.67	98.05	1.897	1.05	0.819	27.1	1.887	23.71	24.7	25.37	1.25	-1.59	5.49	-0.68	1.80	1
TII 3.625% Apr 28	T 2.875% May 28	15-Apr-28	3.625	7.876	0.759	196.08	5.15	125.17	1.879	1.17	0.851	21.5	1.867	22.24	22.0	22.54	1.22	1.42	5.16	-0.54	1.78	1
TII 0.750% Jul 28	T 2.875% Aug 28	15-Jul-28	0.750	9.013	0.701	100.28	4.39	100.44	1.942	0.97	0.789	28.1	1.932	24.86	25.7	26.28	1.18	2.16	4.73	-0.54	1.85	1
TII 2.500% Jan 29	T 2.625% Feb 29	15-Jan-29	2.500	8.832	0.747	136.38	4.62	116.63	1.898	1.03	0.839	25.0	1.887	24.19	24.4	26.36	1.27	1.30	5.19	-1.93	1.80	1

Inflation-Linked Swap reports in Chart

Users can:

- View inflation-linked zero coupon breakeven and real swap rates for spot and forwards with rich/cheap heat maps based on the one-year z-score.
- Access via Chart + Reports menu, Rates > Inflation Swaps. You can pull up reports for previous days and view the difference in the spot and forward rates between two dates.

Research

The following Inflation-Linked reports are available on Barclays Live under the Rates > Global > Inflation-Linked. The following publications can be subscribed to from the Subscriptions page of Barclays Live (*keyword: subscriptions*) or set up in Tiles to be viewed in your *Watchlist* on the desktop or on the Barclays Live app:

- Inflation-Linked Monthly
- Inflation-Linked Daily
- Weekly Commentary
- Inflation-Linked Special Reports and Instant Insights
- US TIPS Relative Value Report
- Monthly US CPI Monitor from the US Economics Team

You can view forecasts by region for consumer prices, real GDP, central bank rates, global bond yields, commodities and FX from the Global forecasts page (keyword: Forecasts).

Read research on the go with the Barclays Live app. Tiles in your Watchlist can be customised to include various research feeds and saved for off-line reading or viewed directly from your desktop.

To add a custom Inflation-Linked Research tile click here: Add to Watchlist

Glossary of Analytics calculated within Barclays Live

The Inflation Analytics leverage the vast proprietary data of our trading and research teams. This glossary provides a reference to the data available within the tools and the definitions/calculations behind these terms.

Inflation-Linked Constant Maturities – TIPS benchmark data are based on the current on-the-run bond. For Europe and the UK, linear interpolation is taken between two liquid issues with maturities either side of the tenor for which we want to construct a constant maturity series.

Real Yield – Ex-inflation return if bond is held to maturity.

Breakeven Spread Current – Rate of inflation that, if realised over the life of the bond, would result in a nominal and inflation-linked bond delivering identical total returns. For simplicity, calculated as Nominal Yield minus Real Yield.

Inflation Beta – Historical sensitivity of real yields to nominal yield moves.

Real Yield Forward – Forward real yield implied by realised inflation (if known) or Barclays inflation forecasts otherwise. Useful measure for checking whether real yield valuations are biased by upcoming inflation accrual.

Carry – Implied basis point carry assuming a long linker position. Calculated using Barclays' inflation forecasts beyond known inflation accrual. Calculated using Real Yield Forward minus Spot Real Yield; positive carry results in real yields cheapening.

Breakeven Forward – Forward nominal yield minus forward real yield.

Breakeven protection – The carry on a breakeven position – i.e., long linker/short nominal or linker carry minus nominal carry.

Breakeven to Swaps Current – Breakeven between the linker and the matched maturity on the swap curve (for BE to inflation swap, see Swap Spread – Linker vs Comparator Z Spread ASW).

Swap Spread – Proceeds ASW – Levels provided by Trading (for TIPS, calculated for other markets) and taking into account the floor valuations:

> Normally/theoretically, the "Swap Spread Proceeds ASW" should be cheaper than the "Swap Spread Calculated Proceeds ASW" levels, but given that they are calculated independently, this may not always be the case. ASW levels in chart are calculated using Libor self-discounting (3m in US, 6m in EUR, GBP) for historical consistency. For live trades, OIS-based discounting is now the norm.

Swap Spread – Calculated Proceeds ASW – Levels calculated by the system and do not take into account floor valuations.

Swap Spread – Z Spread ASW – Basis point bump applied to reference swap curve to make the discounted value of linker cash flows projected by using the inflation swap curve equal to the traded invoice price of the bond.

Swap Spread – Comparator Z Spread ASW – Z-spread ASW for linker comparator.

Swap Spread – Linker vs Comparator Z Spread ASW – The spread between linker asset swap spreads and nominal asset swap spreads. All comparators are listed via Chart + Reports.

Spread to Fitted Real Yield Curve (TIPS only) – Spread (in bp) between the bond's real yield and the matched maturity point on a cubic spline fitted to the real yield curve.

Spread to Fitted Real Yield Curve 3M Z Score (TIPS only) – Using a 3m z-score allows for removal of any persistent effects from seasonality and/or par floor values. Otherwise, July maturity TIPS would nearly always appear rich and April maturity issues cheap.

Spread to Adjusted Real Yield Curve (TIPS only) – Spread (in bp) between the bond's seasonally and par floor adjusted real yield and the matched maturity point on a cubic spline fitted to this adjusted real yield curve.

S-Spread – Basis point bump applied to issuer's nominal curve (built as a discount factor curve from all relevant conventional nominal bonds) to make the discounted value of linker cash flows projected using the inflation swap curve equal to the traded invoice price of the bond.

Floor Premium – % of notional – calculated using our internal pricing models and expressed as a percentage of notional of the bond.

> The strike is determined by the current index ratio of the linker. Therefore, the higher the current index ratio, the lower the strike and, thus, the more "out of the money" the floor is. The at-the-money level is determined by where the corresponding maturity point on the inflation swaps curve is trading. The vol input for the calculation is taken from the inflation vol (zero coupon caps and floors) market.

Floor premium in running terms, bps – Same as above, but expressed in basis points.

Deflation Probability – TIPS and Euro linkers have embedded deflation floor (UK linkers do not).

- Tenor of the embedded option is the maturity of the bond.
- Guarantees repayment of par at maturity, even if cumulative deflation is realised throughout the life of the bond. Does not apply to coupons.
- Option value is only material when "close to the money" – ie, before the bond has accrued much inflation.

Asset Swap Conventions – Convention is to quote par-par for EUR linkers using 6m Euribor. UK linkers and US TIPS are proceeds using 6m GBP Libor for UK Linkers and 3mUSD Libor for TIPS.

INFLATION THEMES

Asset allocation with linkers

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Improving the return/risk profile of a diversified portfolio is among the reasons investors make strategic allocations to the inflation-linked asset class. We review historical returns and correlations and build updated efficient frontiers and optimal portfolios using Markowitz, Black-Litterman, and Risk Parity approaches, within domestic and global portfolio contexts. Using modest return assumptions and portfolio constraints, we find that TIPS continue to add diversification benefits in a balanced portfolio. We also conclude that Risk Parity portfolios continue to outperform market value weighted ones across constructs and time frames.

Historical Review

With TIPS celebrating two decades of existence in 2017, we found it timely to review how they have fared since inception from a risk/return perspective, particularly versus other asset classes. We also analyze historical correlations across asset classes and, importantly, versus inflation. Finally, we build both domestic and global efficient frontiers using Markowitz and Black-Litterman approaches.

Historical returns: Linkers versus other asset classes

Figure 1 shows returns and risk (standard deviations) across various asset classes over different horizons. Over the past one- and three-year periods, TIPS have finished middle of the pack among most fixed income asset classes in returns, with one of the lowest levels of risk. In addition, global (developed market) and EM linkers have performed particularly well over those periods. However, corporates, HY, and equities have performed well over the past three years, despite the large sell-off toward the second half of last year.

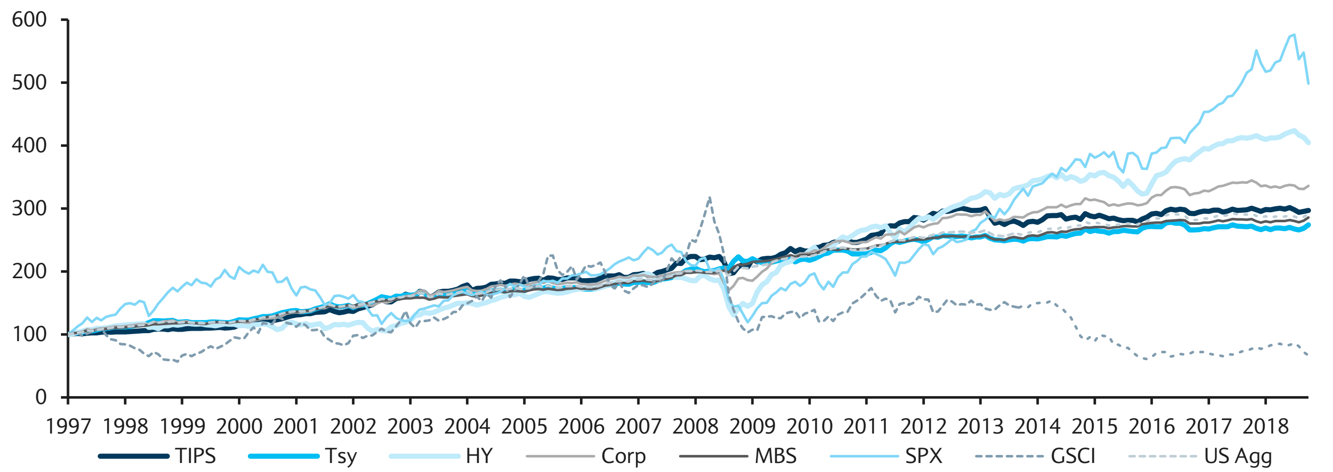
FIGURE 1
Asset risk/return profiles

		TIPS	Tsy	HY	Corp	MBS	SPX	GSCI	US Agg	Global Agg	WGILB	EMILB	Global Tsy	Global HY	Global Corp	Global Stock
	1y	-1.3%	0.9%	-2.1%	-2.5%	1.0%	-4.4%	-13.8%	0.0%	1.8%	0.3%	2.7%	2.8%	-2.7%	-1.0%	-8.9%
Annualize	3y	2.1%	1.4%	7.2%	3.3%	1.7%	9.3%	0.5%	2.1%	2.9%	4.6%	3.3%	2.9%	6.8%	3.6%	7.2%
Returns	5y	1.7%	2.0%	3.8%	3.3%	2.5%	8.5%	-14.5%	2.5%	3.4%	4.4%	2.9%	3.6%	4.4%	3.6%	4.8%
	10y	3.6%	2.1%	11.1%	5.9%	3.1%	13.1%	-5.8%	3.5%	3.8%	4.9%	4.2%	3.3%	11.5%	5.7%	10.1%
	Since	5.1%	4.7%	6.6%	5.7%	4.9%	7.7%	-1.9%	5.0%	5.1%	5.8%	4.7%	4.4%	7.9%	5.1%	6.3%
	1y	2.8%	3.6%	3.6%	3.3%	3.0%	15.3%	17.9%	3.1%	2.1%	3.0%	2.4%	2.2%	3.4%	2.3%	13.5%
Annualize	3y	3.1%	3.4%	4.7%	3.7%	2.3%	11.0%	15.6%	2.9%	2.4%	4.6%	2.8%	2.7%	4.4%	3.0%	10.6%
of monthly	5y	3.6%	3.2%	5.1%	3.7%	2.2%	10.9%	18.8%	2.8%	2.4%	4.5%	3.4%	2.7%	4.8%	3.0%	10.9%
returns	10y	4.9%	3.7%	7.7%	4.5%	2.2%	13.6%	19.3%	2.8%	2.4%	4.5%	3.7%	2.7%	7.5%	3.8%	14.6%
	Since	5.5%	4.3%	8.8%	5.2%	2.6%	15.0%	22.3%	3.4%	2.7%	4.8%	3.6%	2.8%	8.8%	4.1%	15.5%
Return/	5y	0.47	0.62	0.75	0.88	1.16	0.78	-0.77	0.90	1.42	0.98	0.86	1.35	0.93	1.19	0.44
Risk	10y	0.74	0.57	1.44	1.32	1.42	0.96	-0.30	1.22	1.55	1.08	1.14	1.22	1.52	1.51	0.69
	Since	0.94	1.10	0.75	1.10	1.92	0.51	-0.08	1.49	1.88	1.20	1.30	1.57	0.89	1.25	0.40

Note: Data from March 1997 to December 2018, where available. All returns are USD hedged. Source: Bloomberg, Barclays Research

FIGURE 2

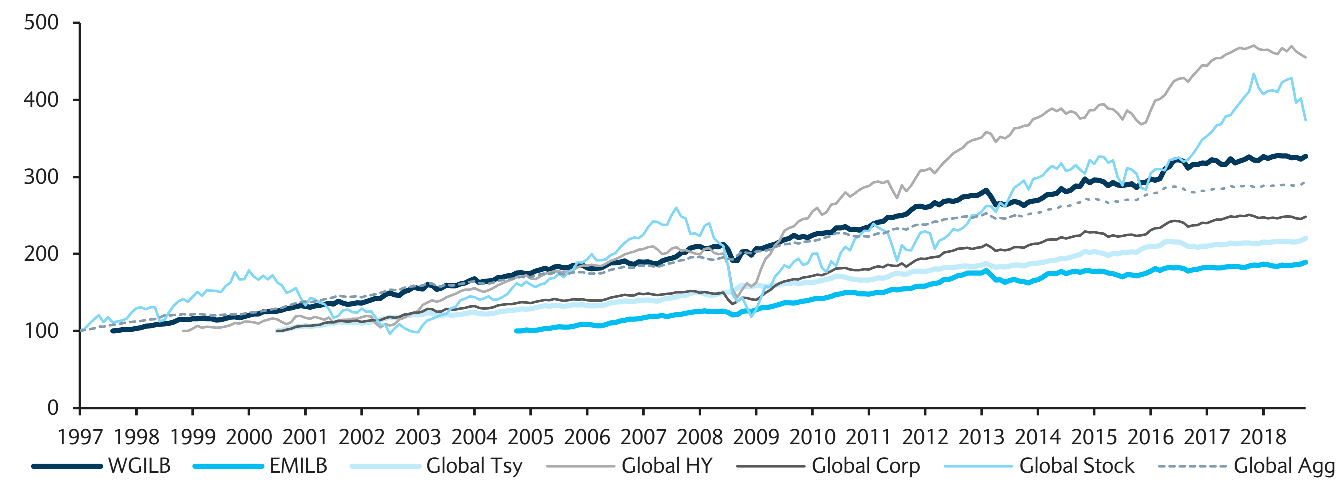
Cumulative domestic asset class returns, indexed



Source: Bloomberg, Barclays Research

FIGURE 3

Cumulative global asset class returns, indexed



Source: Bloomberg, Barclays Research

Over a 10y horizon, the value of TIPS becomes more evident, particularly versus other inflation hedges. Commodities finished the period down 6% annualized, and despite a 13% annualized rally in the S&P 500, it has come at much greater risk, resulting in a return/risk ratio in line with TIPS. Because linkers perform best in stagflationary periods of declining real growth and rising inflation, it is no surprise that global and EM linkers top the list from a 10y return/risk ratio perspective, as low growth around the world (and rising inflation in some pockets of EM) has allowed these assets to outperform with little volatility.

The post-crisis world has had unprecedented central bank accommodation, driving down (real) rates and inflating asset markets. This is evident in Figures 2 and 3, where we track the total return of these asset classes since TIPS inception (February 1997). Until the crisis, TIPS (and global linkers) had lower volatility and commensurate returns with equities and other asset classes. Since then, as central bank stimulus has kicked in, equities and credit (both IG and HY) have made all-time highs. Despite their recent underperformance, since inception, TIPS have held their own with a return/risk ratio of 0.94, roughly middle of the pack versus competing asset classes.

Correlations: Breakevens and commodities track inflation

Linkers are real rate instruments: exposed to real rates and inflation through the holding period

Moving to historical correlations, we look to see what assets have correlated most with inflation. Figure 19 shows m/m correlations, using all data back to TIPS inception, of multiple asset classes: fixed income, equities, commodities, real estate, currencies, and inflation. First, despite popular belief, equities, gold, "oil currencies," and even TIPS themselves show little correlation with actual CPI moves. The low TIPS correlation (0.08) makes sense intuitively, as linkers are real return instruments, whose nominal returns comprise real coupons + real prices changes due to real yield moves + inflation compensation, and we would not expect a strong relationship with inflation only. Because longer-tenor nominal yields track more closely with comparable real yields than they do with recent inflation trends, we expect linker returns to have a stronger relationship with nominal returns, and the results bear this out (TIPS and Treasury index correlation at 0.66). Conversely, the short TIPS 1-5y index shows slightly higher correlation to CPI (0.28), as shorter TIPS returns are more affected by actual near-term inflation (and especially moves in crude, which also shows a strong correlation to CPI).

Breakevens, on the other hand, show a strong correlation with actual inflation. A breakeven position, long linkers versus nominals, is a purer expression of inflation expectations, as it removes real rate exposure and leaves inflation compensation as the key driver of returns, compared with an outright linker position alone. As such, these positions more closely track moves in actual inflation. The 5y BE index proves slightly more correlated than the 10y BE index (0.43 vs. 0.40), which again makes sense, as shorter breakevens respond more to recent inflation prints, while the longer 10y BE index will be more influenced by inflation expectations. In addition, inflation tends to persist in the near term, making it more correlated with the shorter index.

Finally, as mentioned above, crude, a driver of the important Energy CPI basket, shows an understandably high relationship with CPI (0.33). In addition, the expected negative correlation with Treasuries is evident, though fairly weak (-0.20). Equity returns also do not offer a good hedge for inflation (0.03); neither does gold (0.05). Last, the correlation between CPI and the "oil currencies" (proxied by CAD) also is quite low at -0.15 (the negative correlation is simply an artefact of the currency quoting convention).

Efficient Frontiers and Optimal Portfolios

With our historical review complete, we look to create current optimal portfolios using historical data on returns, volatility, and correlations (Markowitz approach) and market-implied returns (Black-Litterman approach) as inputs to a mean-variance optimization problem, with constraints.

We consider three portfolio constructs:

- A domestic portfolio allocating across TIPS, Treasuries, HY, corporates, MBS, the S&P 500, the GSCI commodities index, and 3m T-bills, constraining each asset class to 25% of the portfolio.
- A domestic portfolio allocating across TIPS, HY, the S&P 500, GSCI, 3m T-bills, and the US Agg, constraining each of the first five to 25% and the US Agg to 40%. This portfolio mimics a typical 60/40 stock/bond portfolio, keeping core fixed income constrained to 40% and allowing optimal allocations across 'risk' assets, not just equities.
- A global portfolio allocating across global (developed market) linkers, global treasuries, global HY, global corporate, global stocks (MSCI ACWI), GSCI, and 3m T-bills, again with a 25% constraint on each asset class. For historical analysis, all returns have been hedged to USD, as we take the viewpoint of a US-based investor taking no currency risk.

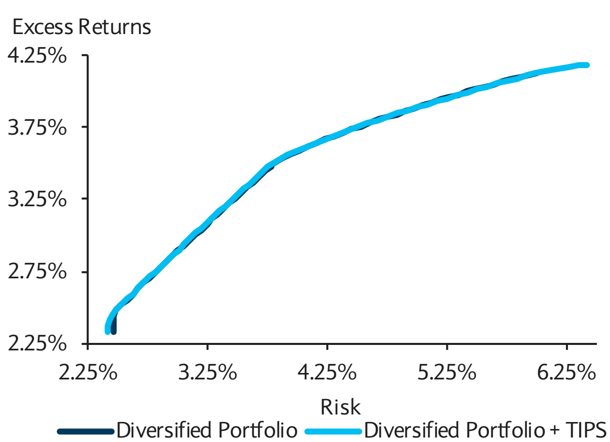
Markowitz MVO

We begin with a typical Markowitz mean-variance optimization,[1] using historical average annual returns and the derived covariance matrix as inputs to the optimizer, using the aforementioned constraints across asset classes (plus no negative weights). Figures 4 and 5 present the results of the optimization for our domestic portfolio construct. Using historical returns, given the recent weak return/risk ratio for TIPS as a result of central bank stimulus and the strong correlation to nominal Treasuries, it is no surprise that TIPS are underrepresented in the optimal portfolio across total portfolio risk levels. As a result, the efficient frontier fails to push out meaningfully when TIPS are included in the diversified portfolio. Moreover, TIPS are essentially competing with recently stronger performing fixed income asset classes, particularly MBS, which has a much higher return/risk ratio. Nonetheless, as TIPS offer real returns, protecting the purchasing power of investors, and are therefore unlike other asset classes, we still find it wise to include them in a diversified fixed income centric portfolio.

Turning to our 60/40 domestic portfolio, the story is quite a bit different, as seen in Figures 6 and 7. At all risk levels, TIPS push out the efficient frontier and nearly max out at a 25% allocation. This portfolio can be viewed more as a holistic stock ('risk') and bond ('safety') portfolio. Within this context, the investor keeps his core 40% safety of the US Agg, while risk assets (not just equities) compete for the remaining allocations. As TIPS are now competing with poorer return/risk assets such as equities and commodities, they have a much larger allocation in this new portfolio. Furthermore, adding TIPS on an outright basis, when the decision is between purchasing TIPS or another fixed income product, is essentially a breakeven position, and we previously saw that breakevens have a strong correlation to inflation. Therefore, an outright position in TIPS offers a good inflation hedge. Add the real return not offered in other asset classes, and the case for TIPS remains strong for any diversified portfolio.

FIGURE 4

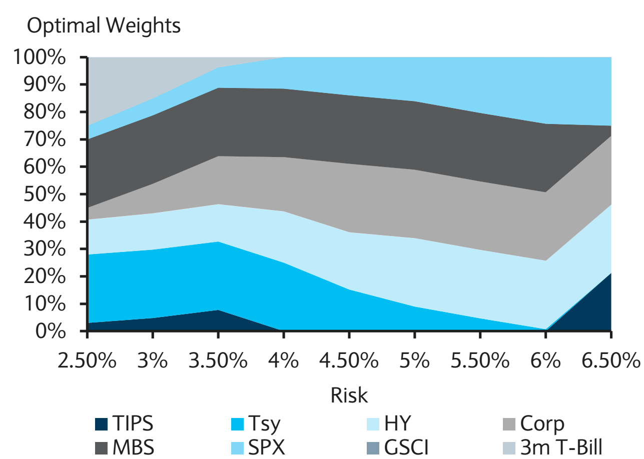
TIPS add marginal value when using historical returns



Source: Bloomberg, Barclays Research

FIGURE 5

TIPS allocations larger at higher portfolio risk, using historical returns

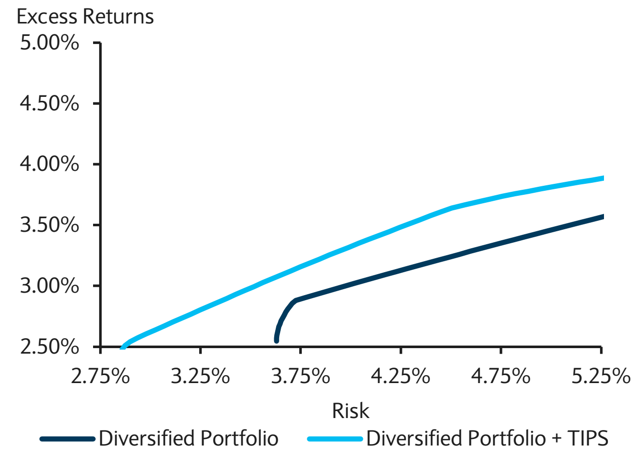


Source: Bloomberg, Barclays Research

[1] Markowitz, H. (1952). "Portfolio Selection." *The Journal of Finance*, 7(1), 77-91.

FIGURE 6

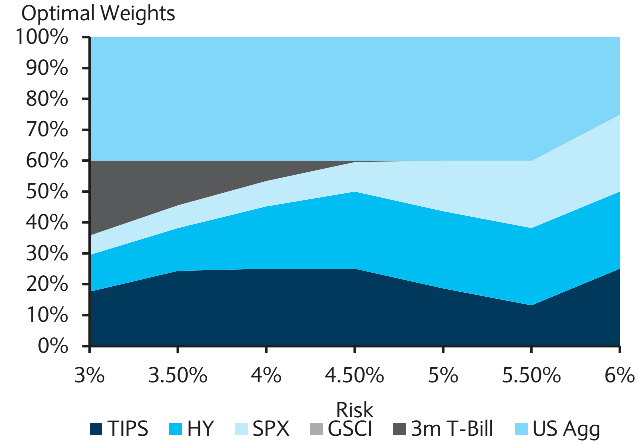
TIPS push out the efficient frontier of a 60/40 domestic portfolio, using historical returns



Source: Bloomberg, Barclays Research

FIGURE 7

TIPS max out at most risk levels in a 60/40 domestic portfolio, using historical returns



Source: Bloomberg, Barclays Research

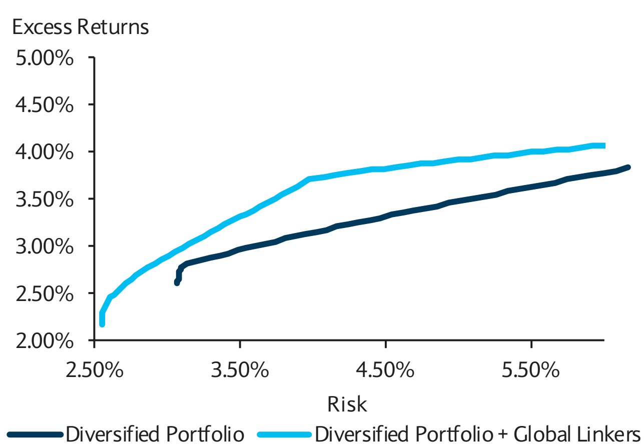
Last, moving to the global portfolio, Figures 8 and 9 show that global linkers add great diversification benefits. The efficient frontier moves out quite impressively, and global linkers max out at all portfolio risk levels. With global linkers' historical return/risk ratios dominating competing asset classes, this comes as no surprise.

Black-Litterman

Historical returns-based mean-variance optimization is notoriously unstable in that slight variations in expected returns (inputs) can lead to large moves in outputted asset class weights. Unless positively constrained, in fact, the optimization can produce large negative allocations across asset classes – a less-than-desirable result from a practical long-only investment stance. Furthermore, Markowitz mean-variance requires the portfolio manager to make return estimates about each and every asset class involved in the optimization; oftentimes, managers may have educated return estimates on a particular asset class but have no view on others. Last, as we know, past performance is no guarantee of future results, making historical return averages quite poor forecasts of future returns (though historical covariances can be a good guide for future covariances).

FIGURE 8

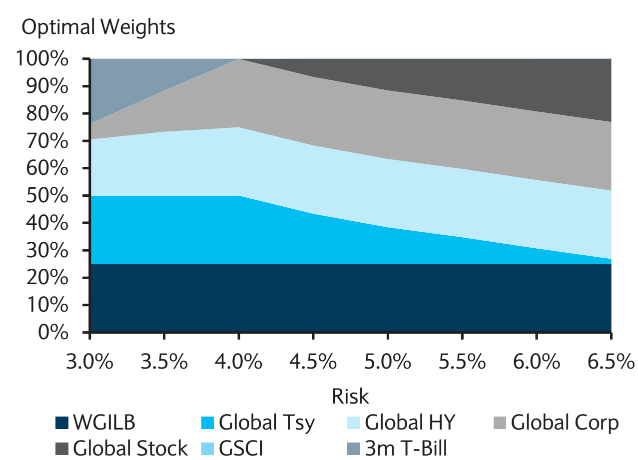
Global linkers push out global efficient frontier, using historical returns



Source: Bloomberg, Barclays Research

FIGURE 9

Global linkers max out at all risk levels, using historical returns



Source: Bloomberg, Barclays Research

The Black-Litterman model[2] attempts to resolve many of these issues by solving for equilibrium returns implied by the market portfolio, before possibly incorporating the investor's views. Specifically, if we assume the market is efficient and the market portfolio is at equilibrium, ie, supply equals demand, then we should hold the market portfolio, as this is the most efficient portfolio and market capitalization-based weights are optimal weights. Using historical covariances and assuming market capitalization-based weights are optimal, we can back out returns across asset classes that would justify this market portfolio, in a process known as reverse optimization[3]. Mathematically, we have:

$$\prod = \lambda \sum \omega \quad \text{where,}$$

$\prod = \text{Excess Market Equilibrium Returns},$

$\lambda = \text{Risk Aversion Coefficient},$

$\sum = \text{Historical Variance/Covariance Matrix},$

$\omega = \text{Market weights for each asset class}$

The one unknown to this equation is the risk aversion coefficient, representing the expected risk/return trade-off inherit in the market portfolio. To estimate this, we simply divide the market portfolio's historical excess return by its historical risk, using an expected 1y future risk-free rate of 2.4% (3m T-bills). We can then plug this risk aversion coefficient in the above equation to derive the market equilibrium excess returns. The optimal weights for this portfolio will be the market capitalization weights, by design. If investors have no expected return views to the contrary of those derived by this process, then they will hold the market cap weight of each asset class.

To build a full efficient frontier across risk levels, we feed these newly derived equilibrium returns into a mean-variance optimizer to solve the constrained optimization problem, using the same constraints as in our Markowitz analysis. Figures 10-12 summarize our market portfolios. Excess equilibrium returns for equities are quite high relative to other asset classes, as this return is needed to justify the higher weight held in the optimal market portfolio. Also, TIPS equilibrium excess returns are quite low compared with historical returns, which we shall see affects their weights in our diversified portfolios.

FIGURE 10

Domestic portfolio market equilibrium portfolio weights/returns

Asset	Investable Market Size ($Bn)	Market/Equilibrium Portfolio Weights (%)	Excess Equilibrium Returns (%)
TIPS	1,179	2.7	0.58
Tsy	8,103	18.7	-0.14
HY	1,170	2.7	3.05
Corp	5,065	11.7	1.11
MBS	5,877	13.6	0.12
SPX	21,027	48.5	7.51
GSCI	280	0.6	3.18
3m T-Bill	649	1.5	0.00

Note: Risk aversion coefficient = 6.87, risk-free rate = 2.4%. Source: Bloomberg, Barclays Research

[2] Black, F., & Litterman, R. (1992). "Global Portfolio Optimization." *Financial Analysts Journal*, 48(5), 28-43.
[3] Sharpe, W. (1974). "Imputing Expected Security Returns from Portfolio Composition." *The Journal of Financial and Quantitative Analysis, 9(3), 463-472.*

FIGURE 11

Domestic 60/40 portfolio market equilibrium portfolio weights/returns

Asset	Investable Market Size ($Bn)	Market/Equilibrium Portfolio Weights (%)	Excess Equilibrium Returns (%)
TIPS	1,179	2.6	0.61
HY	1,170	2.6	3.13
SPX	21,027	46.6	7.64
GSCI	280	0.6	3.24
3m T-Bill	649	1.4	0.00
US Agg	20,836	46.2	0.32

Note: Risk aversion coefficient = 7.23, risk-free rate = 2.4%. Source: Bloomberg, Barclays Research

FIGURE 12

Global portfolio market equilibrium portfolio weights/returns

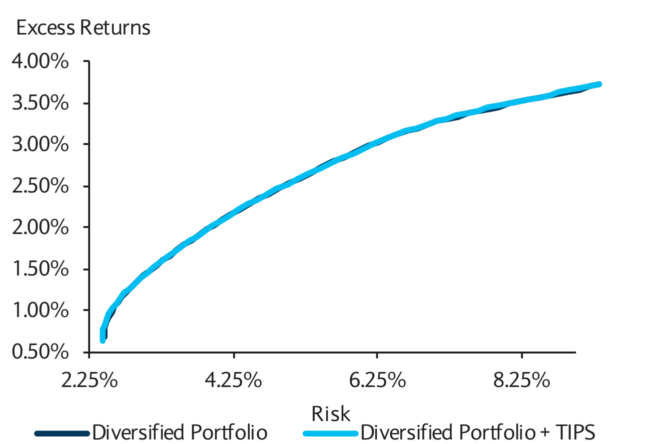
Asset	Investable Market Size ($Bn)	Market/Equilibrium Portfolio Weights (%)	Excess Equilibrium Returns (%)
WGILB	2,833	3.4	0.51
Global Tsy	27,415	32.9	-0.14
Global HY	2,279	2.7	2.71
Global Corp	9,364	11.2	0.76
Global Stock	40,585	48.7	6.06
GSCI	280	0.3	3.00
3m T-Bill	649	0.8	0.00

Note: Risk aversion coefficient = 5.11, risk-free rate = 2.4%. Source: Bloomberg, Barclays Research

Figures 13 and 14 present efficient frontiers and optimal weights for our domestic portfolio using our new excess return estimates from our Black-Litterman model. With a smaller return forecast compared with history, but the same level of risk, it becomes intuitive why TIPS play a small role in this diversified portfolio. GSCI commodities increase in allocation compared with the Markowitz model as the equilibrium returns of 3.18% compare favourably with history. In addition, with MBS returns estimated lower than history, their return/risk appeal deteriorates and become less prominent in the Black-Litterman output.

FIGURE 13

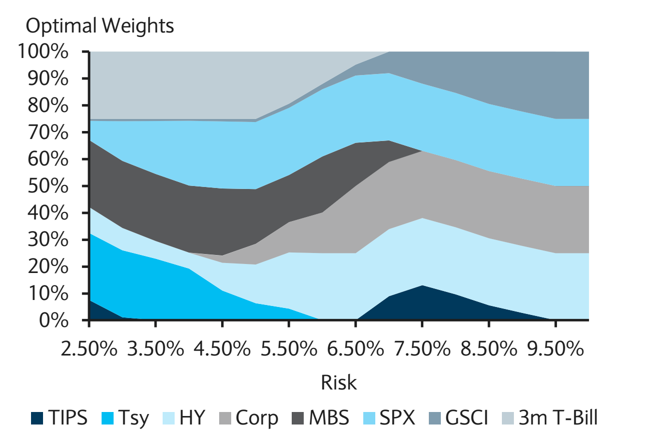
Domestic equilibrium market portfolio efficient frontier



Source: Bloomberg, Barclays Research

FIGURE 14

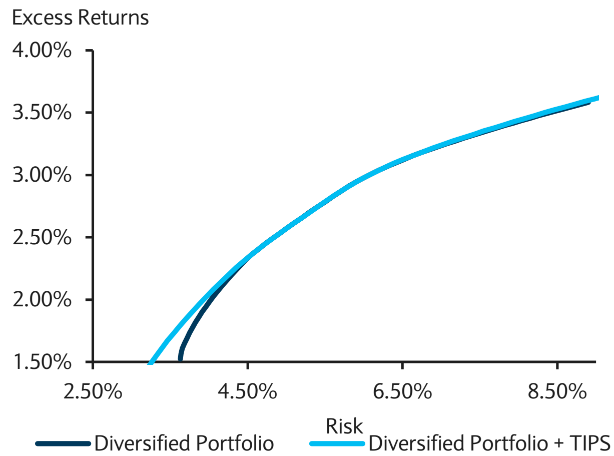
Optimal weights of the domestic equilibrium market portfolio



Source: Bloomberg, Barclays Research

FIGURE 15

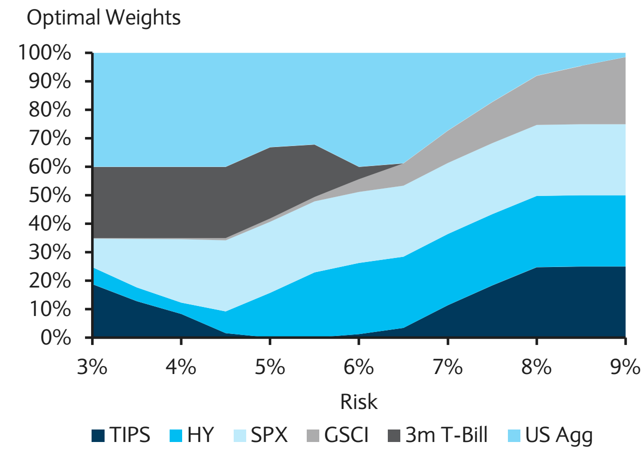
TIPS push out the 60/40 domestic equilibrium market portfolio's efficient frontier



Source: Bloomberg, Barclays Research

FIGURE 16

TIPS feature at lower and higher levels of portfolio risk in the 60/40 domestic equilibrium market portfolio



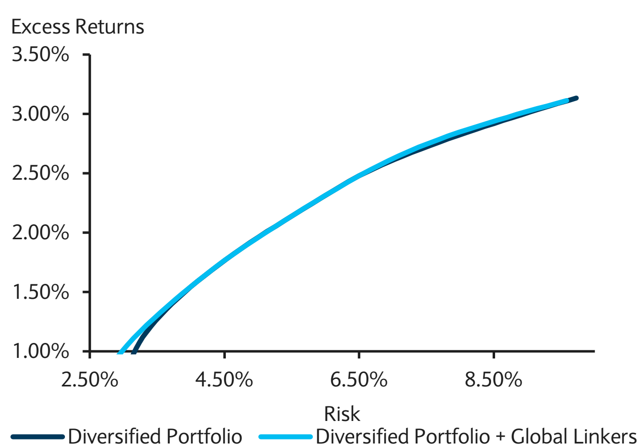
Source: Bloomberg, Barclays Research

Turning to our 60/40 domestic portfolio (Figures 15 and 16), TIPS continue to play a prominent role, as in the Markowitz analysis. This is more a result of the US Agg's new expected returns than anything else. With new excess returns at just 0.32% implied by market equilibrium, the asset class's return/risk ratio severely diminishes and several other asset classes make up the slack, notably TIPS, T-bills and commodities.

Last, similar to our first domestic portfolio, global linkers' returns are much lower in the equilibrium portfolio, justifying a lower allocation across risk levels in the updated portfolio. Again, this comes at the benefit of commodities. Nonetheless, global linkers still push out the efficient frontier at both lower and higher portfolio risk levels, as seen in Figures 17 and 18.

FIGURE 17

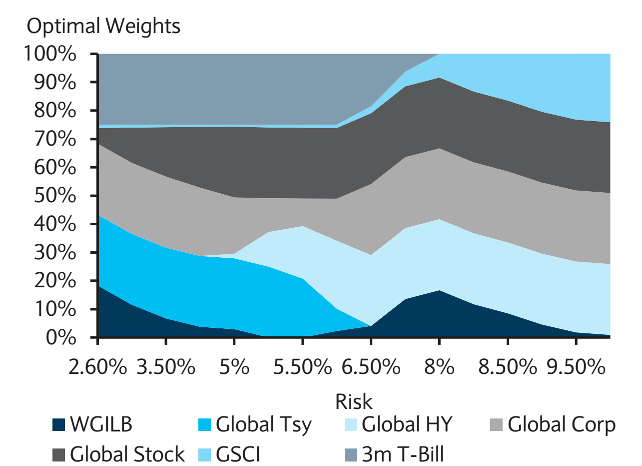
Global linkers push out the global equilibrium market portfolio's efficient frontier



Source: Bloomberg, Barclays Research

FIGURE 18

Global linkers feature at lower and higher levels of portfolio risk in the equilibrium market portfolio



Source: Bloomberg, Barclays Research

FIGURE 19

Correlations of m/m asset returns and inflation

	TIPS	TIPS 1-5y	Tsy	HY	Corp	MBS	SPX	GSCI	3m T-Bill	US Agg	WGILB	Global Agg	5y BE	10y BE
TIPS	1.00	0.85	0.66	0.28	0.69	0.63	0.02	0.22	0.05	0.76	0.84	0.67	0.43	0.34
TIPS 1-5y	0.85	1.00	0.27	0.51	0.51	0.42	0.24	0.45	0.10	0.49	0.67	0.33	0.68	0.60
Tsy	0.66	0.27	1.00	-0.17	0.61	0.83	-0.28	-0.12	0.14	0.91	0.64	0.88	-0.36	-0.50
HY	0.28	0.51	-0.17	1.00	0.53	0.03	0.62	0.30	-0.10	0.17	0.30	0.09	0.63	0.61
Corp	0.69	0.51	0.61	0.53	1.00	0.65	0.21	0.12	0.00	0.85	0.71	0.79	0.28	0.12
MBS	0.63	0.42	0.83	0.03	0.65	1.00	-0.11	-0.10	0.18	0.90	0.60	0.84	-0.14	-0.25
SPX	0.02	0.24	-0.28	0.62	0.21	-0.11	1.00	0.26	-0.01	-0.06	0.06	-0.09	0.50	0.51
GSCI	0.22	0.45	-0.12	0.30	0.12	-0.10	0.26	1.00	0.07	-0.03	0.11	-0.11	0.73	0.61
3m T-Bill	0.05	0.10	0.14	-0.10	0.00	0.18	-0.01	0.07	1.00	0.12	0.04	0.15	0.12	0.06
US Agg	0.76	0.49	0.91	0.17	0.85	0.90	-0.06	-0.03	0.12	1.00	0.75	0.94	-0.06	-0.22
WGILB	0.84	0.67	0.64	0.30	0.71	0.60	0.06	0.11	0.04	0.75	1.00	0.74	0.26	0.14
Global Agg	0.67	0.33	0.88	0.09	0.79	0.84	-0.09	-0.11	0.15	0.94	0.74	1.00	-0.20	-0.32
5y BE	0.43	0.68	-0.36	0.63	0.28	-0.14	0.50	0.73	0.12	-0.06	0.26	-0.20	1.00	0.86
10y BE	0.34	0.60	-0.50	0.61	0.12	-0.25	0.51	0.61	0.06	-0.22	0.14	-0.32	0.86	1.00
CPI NSA	0.08	0.28	-0.20	0.12	-0.14	-0.15	0.03	0.36	0.11	-0.16	-0.01	-0.19	0.43	0.40
NAREIT	0.25	0.27	-0.03	0.61	0.37	0.07	0.57	0.16	-0.04	0.19	0.29	0.16	0.32	0.29
Case Shiller	-0.01	-0.14	-0.05	0.06	0.07	-0.10	0.08	0.13	0.04	-0.01	0.01	0.01	0.00	-0.02
EMILB	0.58	0.42	0.31	0.49	0.61	0.43	0.29	0.15	0.07	0.56	0.57	0.52	0.24	0.20
Global Tsy	0.58	0.15	0.89	-0.15	0.57	0.76	-0.32	-0.25	0.11	0.84	0.69	0.95	-0.42	-0.52
Global HY	0.32	0.54	-0.13	0.97	0.58	0.08	0.65	0.34	-0.08	0.22	0.35	0.14	0.64	0.61
Global Corp	0.67	0.47	0.53	0.55	0.98	0.59	0.22	0.13	-0.03	0.80	0.72	0.78	0.27	0.15
Global Stock	0.08	0.33	-0.27	0.68	0.28	-0.09	0.95	0.35	-0.01	-0.03	0.12	-0.08	0.59	0.57
SP Agr	0.23	0.37	0.03	0.23	0.20	0.04	0.23	0.38	0.01	0.10	0.13	0.03	0.34	0.28
Gold	0.40	0.47	0.24	0.13	0.29	0.31	0.01	0.28	-0.02	0.30	0.30	0.24	0.26	0.14
Crude	0.14	0.38	-0.16	0.28	0.06	-0.12	0.22	0.91	0.05	-0.07	0.06	-0.14	0.68	0.57
CAD	-0.25	-0.39	0.11	-0.52	-0.29	-0.05	-0.53	-0.49	-0.02	-0.09	-0.15	0.00	-0.54	-0.51

Note: Data from March 1997 to December 2018, where available. All returns are USD hedged. Source: Bloomberg, Barclays Research

FIGURE 19

Correlations of m/m asset returns and inflation (cont.)

	CPI	NAREIT	Case Shiller	EMILB	Global Tsy	Global HY	Global Corp	Global Stock	SP Agr	Gold	Crude	CAD
TIPS	0.08	0.25	-0.01	0.58	0.58	0.32	0.67	0.08	0.23	0.40	0.14	-0.25
TIPS 1-5y	0.28	0.27	-0.14	0.42	0.15	0.54	0.47	0.33	0.37	0.47	0.38	-0.39
Tsy	-0.20	-0.03	-0.05	0.31	0.89	-0.13	0.53	-0.27	0.03	0.24	-0.16	0.11
HY	0.12	0.61	0.06	0.49	-0.15	0.97	0.55	0.68	0.23	0.13	0.28	-0.52
Corp	-0.14	0.37	0.07	0.61	0.57	0.58	0.98	0.28	0.20	0.29	0.06	-0.29
MBS	-0.15	0.07	-0.10	0.43	0.76	0.08	0.59	-0.09	0.04	0.31	-0.12	-0.05
SPX	0.03	0.57	0.08	0.29	-0.32	0.65	0.22	0.95	0.23	0.01	0.22	-0.53
GSCI	0.36	0.16	0.13	0.15	-0.25	0.34	0.13	0.35	0.38	0.28	0.91	-0.49
3m T-Bill	0.11	-0.04	0.04	0.07	0.11	-0.08	-0.03	-0.01	0.01	-0.02	0.05	-0.02
US Agg	-0.16	0.19	-0.01	0.56	0.84	0.22	0.80	-0.03	0.10	0.30	-0.07	-0.09
WGILB	-0.01	0.29	0.01	0.57	0.69	0.35	0.72	0.12	0.13	0.30	0.06	-0.15
Global Agg	-0.19	0.16	0.01	0.52	0.95	0.14	0.78	-0.08	0.03	0.24	-0.14	0.00
5y BE	0.43	0.32	0.00	0.24	-0.42	0.64	0.27	0.59	0.34	0.26	0.68	-0.54
10y BE	0.40	0.29	-0.02	0.20	-0.52	0.61	0.15	0.57	0.28	0.14	0.57	-0.51
CPI NSA	1.00	0.05	0.14	-0.02	-0.27	0.14	-0.13	0.05	0.01	0.05	0.33	-0.15
NAREIT	0.05	1.00	0.16	0.41	0.03	0.60	0.40	0.59	0.20	0.12	0.09	-0.45
Case Shiller	0.14	0.16	1.00	-0.05	-0.03	0.07	0.12	0.09	-0.05	-0.11	0.08	-0.10
EMILB	-0.02	0.41	-0.05	1.00	0.37	0.54	0.60	0.40	0.27	0.37	0.11	-0.39
Global Tsy	-0.27	0.03	-0.03	0.37	1.00	-0.11	0.58	-0.29	-0.04	0.21	-0.29	0.16
Global HY	0.14	0.60	0.07	0.54	-0.11	1.00	0.59	0.73	0.24	0.19	0.32	-0.57
Global Corp	-0.13	0.40	0.12	0.60	0.58	0.59	1.00	0.31	0.18	0.27	0.06	-0.29
Global Stock	0.05	0.59	0.09	0.40	-0.29	0.73	0.31	1.00	0.28	0.12	0.30	-0.62
SP Agr	0.01	0.20	-0.05	0.27	-0.04	0.24	0.18	0.28	1.00	0.28	0.21	-0.32
Gold	0.05	0.12	-0.11	0.37	0.21	0.19	0.27	0.12	0.28	1.00	0.21	-0.39
Crude	0.33	0.09	0.08	0.11	-0.29	0.32	0.06	0.30	0.21	0.21	1.00	-0.41
CAD	-0.15	-0.45	-0.10	-0.39	0.16	-0.57	-0.29	-0.62	-0.32	-0.39	-0.41	1.00

Note: Data from March 1997 to December 2018, where available. All returns are USD hedged. Source: Bloomberg, Barclays Research

Introduction to Risk Parity

The risk parity framework allocates equal risk across asset classes

Traditional asset allocation, such as in a market value (MV) weighted stock/bond paradigm, comes short of true diversification when viewed through the lens of contribution to overall risk from each asset class in the portfolio. Specifically, in such a construct, as the volatility of stocks is far greater than bonds, stocks contribute north of 80% of overall portfolio risk (Figure 20). While balanced in terms of dollar invested, the portfolio is far from diversified when it comes to risk budgeting. As a 'solution', risk parity (RP) advocates allocating equal risk across asset classes. To achieve this diversification, we need to overweight (in dollar terms) lower risk assets and underweight risky assets. As a result of these portfolio tilts, our return and risk expectations will, intuitively, be reduced. To alleviate this problem, the RP investor will then leverage up the risk-balanced portfolio to achieve the desired return and risk level.

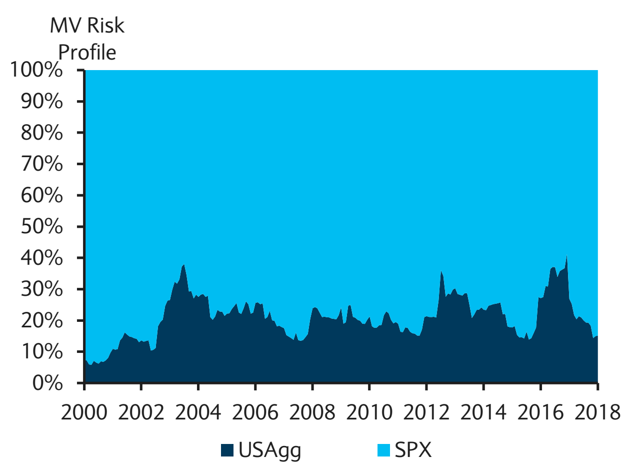
The theory behind RP is based on the observation that safer assets consistently outperform risky assets, on a risk-adjusted basis, both across and within asset classes and countries.[4] This happens because many risk-seeking investors are unable to apply leverage to an optimal portfolio to achieve higher returns. As such, they overweight risky (high-beta) assets instead of applying leverage, driving up prices and driving down expected returns of these assets. Similarly, they underweight lower risk (low-beta) assets, causing them to trade at lower prices and increasing their expected returns; this phenomenon is known as the 'low beta anomaly.' Then, an investor that is less leverage averse or constrained can benefit by overweighting these low-beta assets, underweighting high-beta assets, and applying leverage to the new portfolio, resulting in higher risk-adjusted returns than the traditional MV portfolio. This theory is termed 'leverage aversion,'[5] as the leveraged investor is rewarded for taking on leverage risk instead of market or beta risk.

A RP portfolio allocates equal amounts of risk across all asset classes, assumes they are all uncorrelated, and uses leverage to achieve the desired risk level. Furthermore, no return assumptions are required, compared with the Markowitz mean-variance or Black-Litterman approaches.

To construct our simple RP portfolio, we borrow the process from Asness, Frazzini, and Pedersen (2012). We use monthly returns data since TIPS inception in February 1997, rebalancing monthly. At the end of each month, we compute the portfolio weight of each

FIGURE 20

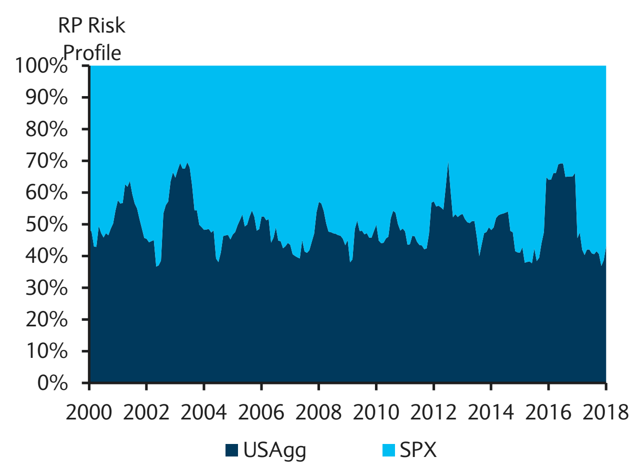
MV stock/bond portfolio risk profile is dominated by high stock vol



Source: Bloomberg, Barclays Research

FIGURE 21

RP stock/bond portfolio risk profile is balanced across asset classes



Source: Bloomberg, Barclays Research

4 Frazzini, A., & Pedersen, L.H., (2010). "Betting Against Beta." *NBER Working Paper 16601* (December).

5 Asness, C., Frazzini, A., & Pedersen, LH., (2012). "Leverage Aversion and Risk Parity." *Financial Analysts Journal,* 68(1), 47-59.

asset class as the inverse of its one-year monthly rolling volatility, up to the previous month, scaled to sum to 1. Then, we divide last month's ex-post volatility of the MV portfolio by last month's ex-post volatility of our RP portfolio (again, using a one-year monthly rolling timeframe) to arrive at this month's leverage factor. This ensures the leveraged RP portfolio has the same risk as the MV portfolio. Finally, to compute this month's RP leveraged return, we multiply the unleveraged RP portfolio by the leverage factor and subtract the cost of that leverage, assuming financing at 1m USD Libor.

Mathematically, the weight of each asset class, i, at month, t, in the RP portfolio is

$\omega_{t,i} = \sigma_{t,i}^{-1} / \sum_i \sigma_{t,i}^{-1}$, where σ is measured as the one-year rolling volatility of monthly asset returns.

The leverage factor, x, for a particular month is then

$x_t = \sigma_t^{MV} / \sigma_t^{URP}$, where MV = market value portfolio and URP = unleveraged risk parity portfolio

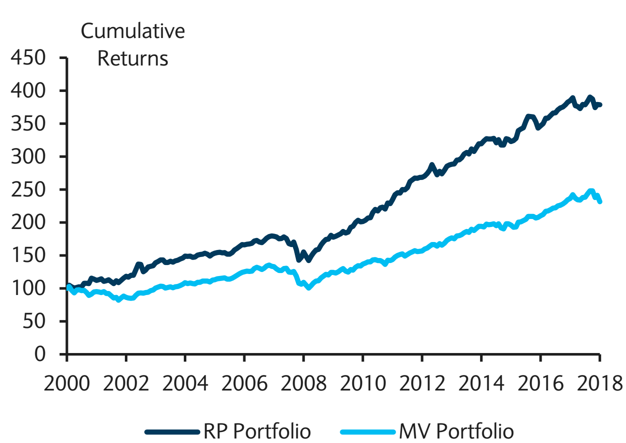
And the leveraged risk parity (RP) portfolio return in each month becomes

$r_t^{RP} = x_{t-1} * \sum_i \omega_{t-1,i} * r_{t,i} - (x_{t-1} - 1) * rf_t/12$, where r is the USD gross asset class return and rf is the financing rate, taken to be 1m USD Libor here. Note that the unleveraged risk parity portfolio return is equal to the first term in the above equation, before applying the leverage factor.

Figure 21 shows the improved risk diversification of the RP portfolio for the stock/bond portfolio. We see that risk is roughly equally balanced throughout time, as expected. Figure 22 presents the results of implementing the RP portfolio, versus the traditional MV portfolio, showing the impressive outperformance over the past roughly two decades, as low Sharpe ratio stocks are underweighted in the RP portfolio (versus the MV portfolio) and high Sharpe ratio bonds are overweighted. Specifically, the RP portfolio has cumulatively outperformed the MV portfolio by 63%. Last, to confirm we have designed the RP portfolio as intended, Figure 23 shows the ex-post volatility of the MV and (leveraged) RP portfolio, confirming portfolio risk is broadly in line across the period. So despite higher leverage, the RP portfolio manages to match the risk profile of the MV portfolio while significantly outperforming it. This is achieved by overweighting low risk/high Sharpe ratio asset classes,

FIGURE 22

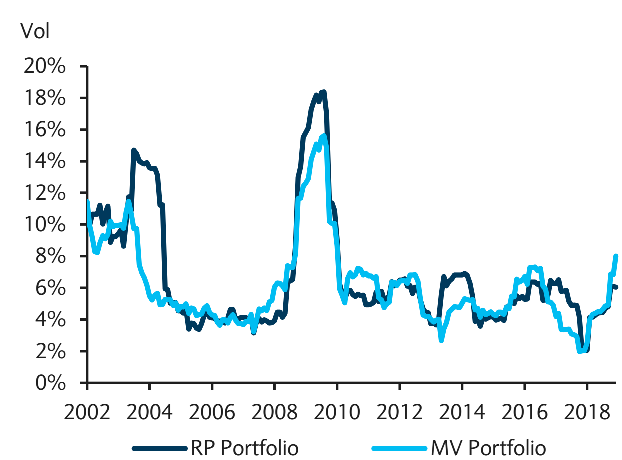
RP stock/bond portfolio has vastly outperformed MV portfolio



Source: Bloomberg, Barclays Research

FIGURE 23

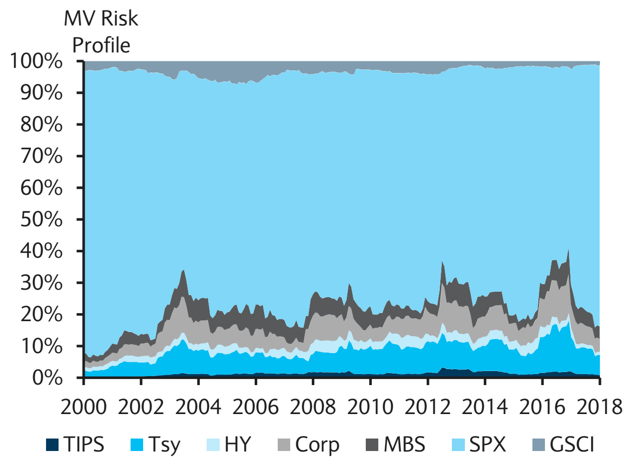
RP ex-post vol largely in line with MV portfolio, despite higher leverage



Source: Bloomberg, Barclays Research

FIGURE 24

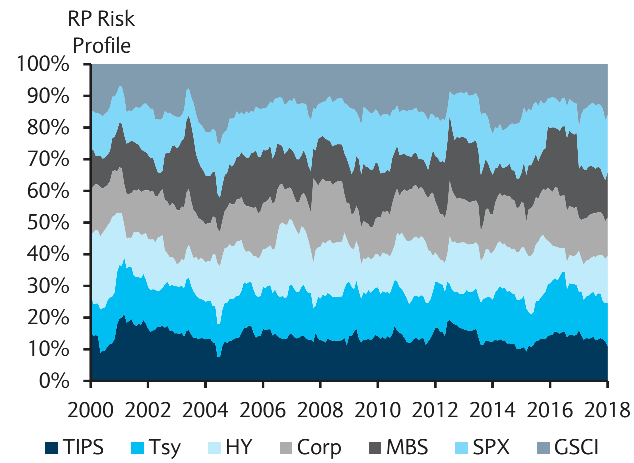
MV risk profile dominated by equities, domestic portfolio



Source: Bloomberg, Barclays Research

FIGURE 25

RP risk profile well diversified across asset classes, domestic portfolio



Source: Bloomberg, Barclays Research

leading to higher returns with the same level of risk at the portfolio level, and ultimately a higher overall portfolio Sharpe ratio. Indeed, over the full data set, the RP and MV portfolios exhibit an annualized return/risk ratio of 1.00 and 0.66, respectively.

Risk Parity with TIPS

With the generic stock/bond RP portfolio analyzed, we return to our three TIPS inclusive portfolios from above, and use our new RP framework to evaluate optimal portfolio weights of TIPS in each.

Recall, we had the following three portfolio constructs:

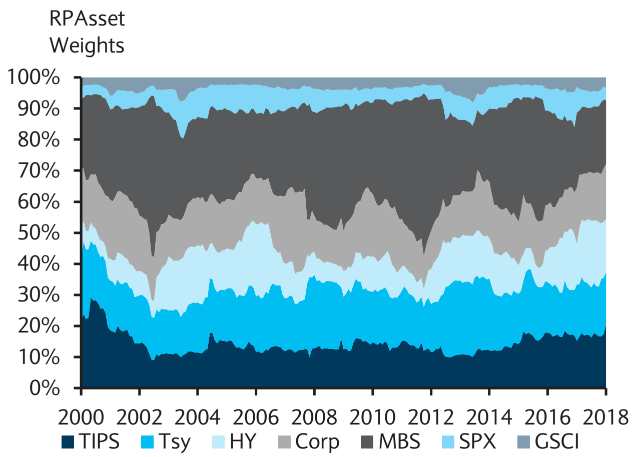
- A domestic portfolio allocating across TIPS, Treasuries, HY, corporates, MBS, S&P 500, GSCI commodities index, and 3m T-Bills.
- A domestic portfolio allocating across TIPS, HY, S&P 500, GSCI, 3m T-Bills and the US Agg. We termed this our '60/40 domestic portfolio' because on a market value basis, the S&P 500 and US Agg average roughly 60% and 40%, respectively.
- A global portfolio allocating across global (developed market) linkers, global treasuries, global HY, global corporate, global stock (MSCI ACWI), GSCI, and 3m T-Bills.

In each, we now drop the 3m T-Bills from our investable universe because T-Bills, a form of 'cash,' are used to provide the leverage in a RP implementation and are not treated as a distinct asset class. Furthermore, if they were included, given their extremely low volatility and the fact that weights in RP are inversely proportionally to risk, the resulting portfolio would result in an unrealistically high weight in the asset class.

We analyze each portfolio in turn and compare a RP portfolio to a MV portfolio using the available asset classes. Starting with our first domestic portfolio, while the S&P 500 averages 54% in market value terms, equities contribute an average of 76% of overall portfolio risk (Figure 24). Using our RP methodology, risk is evenly balanced across asset classes (Figure 25). Moreover, we show the dollar allocations in our new RP portfolio in Figure 26, where it comes as no surprise that the S&P 500 is vastly underweighted and lower risk fixed income assets are overweighted. For example, the high Sharpe ratio of MBS leads to high allocations throughout time. TIPS are another notable allocation in the RP portfolio. While the MV portfolio would constrain TIPS allocations, by definition, to their market value, maxing out at 2.8%, the RP portfolio takes allocations as high as 32%.

FIGURE 26

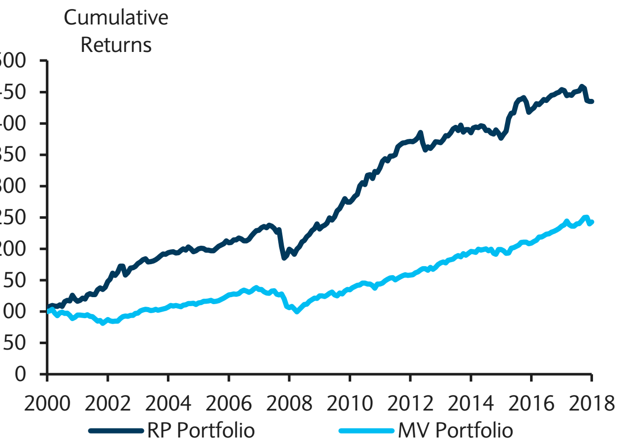
High Sharpe/low risk assets dominate domestic RP portfolio



Source: Bloomberg, Barclays Research

FIGURE 27

Domestic RP significantly outperforms MV portfolio



Source: Bloomberg, Barclays Research

Furthermore, asset class allocations descend roughly in line with historical return/risk ratios (Figure 1); MBS, corporates, and Treasuries, having the highest Sharpe ratios, have the largest weights across time, followed by TIPS, which in turn are followed far behind by HY, equities and commodities. The average leverage used is 2.3 (borrow 130% of asset equity) and the current (end of December 2018) leverage factor is 2.7.

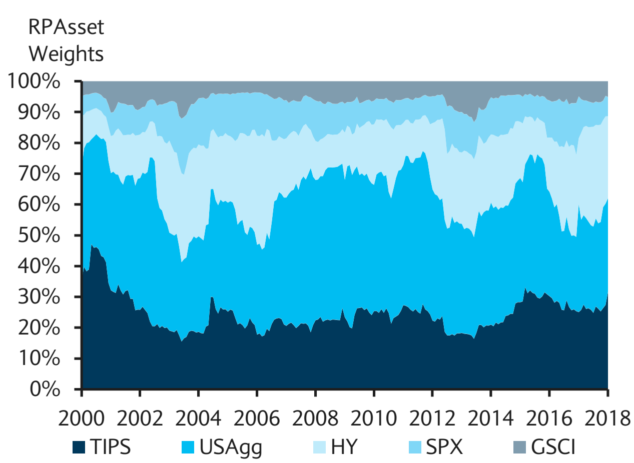
There are a few notable allocation shifts through history. First, in 2003, as the stock market left the dot-com bubble behind and equity vol declined, equity allocation increased at the expense of TIPS and several other asset classes. Then, as the financial crisis hit, the TIPS allocation remained unchanged; instead, corporate and HY allocations declined and moved into low risk MBS and treasuries. Last, we present the historical return comparison in Figure 27. Even after including the cost of leverage, the RP portfolio greatly outperforms the MV portfolio in this first construct, by roughly 80%.

Allocation to TIPS within a RP framework is sizable in our three portfolio constructs

Our second construct, the 60/40 domestic portfolio, shows similar results. First, the MV portfolio has a disproportionate risk contribution from equities, while the RP portfolio roughly equalizes risk across asset classes (not shown). The resulting dollar allocations are shown in Figure 28. As we would expect, low-risk, higher risk-adjusted return assets,

FIGURE 28

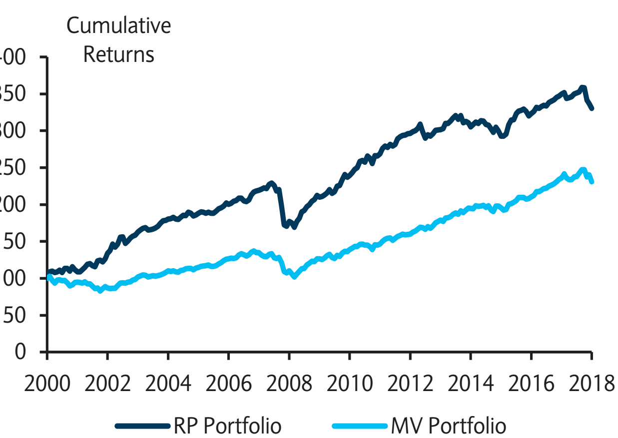
Domestic 60/40 RP portfolio overweights low risk assets



Source: Bloomberg, Barclays Research

FIGURE 29

Domestic 60/40 RP portfolio significantly outperformed MV portfolio



Source: Bloomberg, Barclays Research

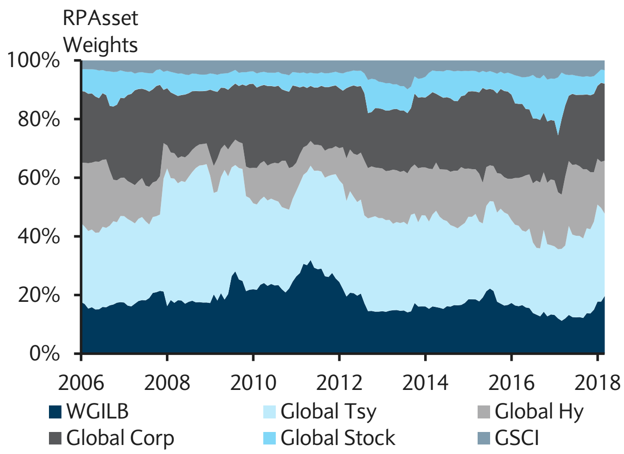
including TIPS and the US Agg, are overweighted versus HY, equities and commodities. In fact, allocation to TIPS and the US Agg average 26% and 38%, respectively. Through history, we see allocation shifts similar to the previous domestic portfolio. Equity (and HY) allocations increase at the turn of the century but fall during the financial crisis. The bulk of this last move is into the US Agg, from HY and equities. During the taper tantrum of mid-2013, with rate vol picking up, we see the RP portfolio allocate away from the US Agg and TIPS and increase allocations in HY, equities, and commodities. The average leverage used is 1.8 (borrow 80% of asset equity), and the current leverage factor is 2.4. Again, as shown in Figure 29, the RP portfolio vastly outperforms the MV portfolio over our roughly two-decade horizon, to the tune of 43%.

Finally, turning to our global portfolio, we see the outperformance of RP again. As noted above, the 'low beta anomaly' is not confined to the US; we see empirical evidence of the phenomenon across countries and on a global basis, and it is encouraging to see a risk-balanced portfolio dominating an MV implementation in a global context. As before, the MV portfolio is highly concentrated in (global) equity risk, and the RP portfolio manages to equate risk across asset classes (not shown). Data on our global indices date back only to 2004, so we are confined to a shorter history, but see similar allocation moves to our domestic portfolios (Figure 30). During the financial crisis, most asset class allocation decreased as global treasuries took the bulk of these moves. In addition, around the taper tantrum, global linkers (and treasuries, to a lesser extent) were reduced as rate vol rose and global stocks took this allocation. Through this all, global linkers averaged an 18% weight in the RP portfolio, again showing their sizable position in a balanced portfolio. The average leverage used is 2.0 (borrow 100% of asset equity), and the current leverage factor is 3.0. Last, as before, but less impressively, the performance record of the global RP portfolio compares favorably with its MV counterpart (Figure 31), outperforming by 22%.

Some may point out that the period chosen was a significant bull market for bonds, with rates hitting all-time lows, so overweighting bonds would have necessarily led to significant outperformance over this period. We have decided to keep all our analysis to start with the inception of TIPS in February 1997 (or later in the global case) and are thus confined by the data, but Asness, Frazzini, and Pedersen (2012) show the empirical outperformance of RP over the MV portfolio for a stock/bond construct dating back to 1926, during which markets had several rate cycles. We believe the same would have held for our three portfolios as well and expect the outperformance to continue.

FIGURE 30

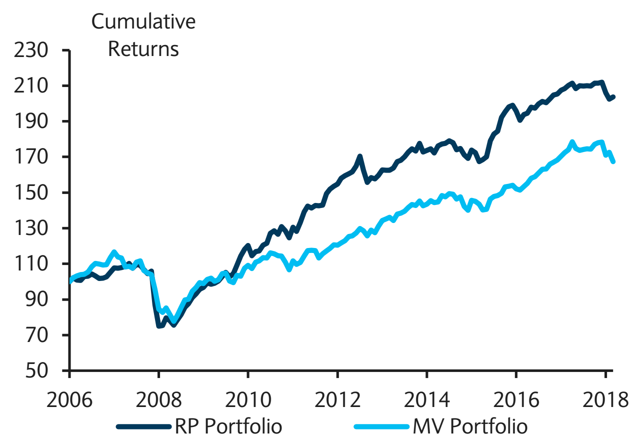
Global RP portfolio concentrates in global linkers and treasuries



Source: Bloomberg, Barclays Research

FIGURE 31

Global RP portfolio cumulatively outperforms MV portfolio despite drawdown during financial crisis



Source: Bloomberg, Barclays Research

Clearly, for a large portfolio and/or one where leverage is not allowed, the RP methodology may not be feasible. In addition, the investor may augment the above analysis by forecasting key economic variables (inflation, growth, fed funds) and predicting future market regimes to add portfolio tilts to the pure RP output. In our view, not withstanding flight-to-quality episodes, where (de-)leveraging can become an acute issue for an RP portfolio, smaller portfolios can benefit dramatically from implementing such a strategy. We have also seen that TIPS (and global linkers) have played a prominent role within the RP framework across portfolio constructs and time periods.

Appendices

APPENDIX

Key information sources

FIGURE 1
Barclays links

www.barclays.com	Barclays
live.barclays.com	Barclays Live (Publications & Analytics)

FIGURE 2
Barclays Live keywords (type into search box)

inflation	Inflation Portal
ilbond	Inflation-linked Bond analytics tool
ilswaps	Inflation-linked Swaps analytics tool
ilhra	Inflation-linked Bonds Horizon Returns Analysis
chart	Chart: Time Series and Curve plotting

FIGURE 3
Issuer links

www.aofm.gov.au	Australian Office of Financial Management
www.bankofcanada.ca	Bank of Canada
www.aft.gouv.fr	Agence France Tresor (AFT)
www.bundesbank.de	German Bundesbank
www.dt.tesoro.it/en	Public Debt Division, Italian Treasury
www.mof.go.jp/english	Japanese Ministry of Finance
www.nzdmo.govt.nz	New Zealand DMO
www.treasury.gov.za	South African National Treasury
www.riksgalden.se	The Swedish National Debt Office
www.dmo.gov.uk	UK Debt Management Office
www.treas.gov	US Treasury
www.treasurydirect.gov	US Treasury Direct
www.minhacienda.gob.ar/en/	Argentinean Finance Ministry
www.tesouro.fazenda.gov.br	Brazilian National Treasury
www.shcp.gob.mx	Mexican Ministry of Finance and Public Credit
www.hacienda.cl	Chilean Ministry of Finance
www.mf.gov.pl	Polish Ministry of Finance
www.minhacienda.gov.co	Colombian Ministry of Finance
www.maliye.gov.tr	Turkish Finance Ministry
english.mosf.go.kr	South Korean Ministry of Finance

FIGURE 4
Useful links

www.federalreserve.gov	US Federal Reserve
www.boj.or.jp	Bank of Japan
www.ecb.int	European Central Bank
www.bls.gov	US Bureau of Labor Statistics
www.bankofengland.co.uk	The Bank of England
www.statistics.gov.uk	UK National Statistics Office
www.riksbank.com	Riksbank
www.rba.gov.au	Reserve Bank of Australia
www.bcb.gov.br	Brazilian Ministry of Finance
www.banxico.org.mx	Banco de Mexico
www.bcentral.cl	Chilean Central Bank
www.nbp.pl	National Bank of Poland

FIGURE 5
Bloomberg pages

BINF	Barclays Inflation-Linked Menu
BARX	Barclays Electronic Trading
BCAP7	Barclays Inflation Forecasts
BTIP	Barclays TIPS Prices
BXEI	Barclays Euro Inflation-Linked Prices
BXGL	Barclays UK Index Linked Prices
BISW	Barclays Inflation Derivatives
ILB	Global Inflation-Linked Bonds
ILBE	Bloomberg World Inflation Breakeven Rates
ILBI	Inflation-Linked CPI Indices
SWIL	Bloomberg default inflation settings
SWPM	Bloomberg swap pricing
IN	Bloomberg Barclays Indices
DMO1	UK DMO announcements
TREX	Agence France Trésor
BKIT	Banca D'Italia

Summary sovereign table

FIGURE 1

Developed markets overview

	US	UK	France	Germany	Italy	Spain	Sweden	Denmark	Canada	Australia	New Zealand	Japan
Generic name	Treasury Inflation Indexed Securities, TIIS, TIPS	United Kingdom Index-Linked Gilts	OATi, OAT€i, BTAN€i	OBL€i DBR€i	BTP€i	SPGB€i	Swedish Govt Index-Linked	DGBi	Canadian Real Return Bonds	Australian Capital Indexed Bonds	New Zealand Inflation-indexed Bonds	JGBi
No bonds Outstanding*	40	29	15	5	10	6	7	2	8	8	4	7
Market value outstanding bn*	$1,335bn	£672bn	€245bn	€80bn	€143bn	€51bn	SEK236bn	DKK48bn	CAD77bn	AUD48bn	NZD22bn	¥10tn
Market value outstanding $bn*	$1,335bn	$891bn	$279bn	$91bn	$163bn	$58bn	$26bn	$7bn	$58bn	$34bn	$15bn	$90bn
First issue date	Jan 97	Mar 81	Sep 98	Mar 06	Sep 03	May 14	Apr 94	May 12	Dec 91	Jul 85	Nov 95	Mar 04
Linking Index	CPI All urban consumers NSA	RPI	French CPI ex-tobacco Euro HICP ex-tobacco	Euro HICP ex-tobacco	Euro HICP ex-tobacco	Euro HICP ex-tobacco	CPI NSA	Denmark CPI NSA	CPI All Items NSA	All groups CPI	All groups CPI	Nationwide CPI General ex-Fresh Food
Linking Index Bloomberg ticker	CPURNSA Index	UKRPI Index	FRCPXTOB Index, CPTFEMU Index	CPTFEMU Index	CPTFEMU Index	CPTFEMU Index	SWCPI Index	DNCPINEW Index	CACPI Index	AUCPI Index	NZCPCCPI Index	JCPNGENF Index
Indexation lag	2-3 months	8 months or 2-3months	2-3 months	2-3 months	2-3 months	2-3 months	2-3 months	2-3 months	2-3 months	6 months	6 months	2-3 months to 10th of month
Floor?	Par floor	No floor	Par floor	Par Floor	Par floor	Par floor	5 with par floor, 2 without	Par floor	No floor	Coupon and principal par floor	Coupon and principal par floor	Par floor
Coupon frequency	Semi-annual	Semi-annual	Annual	Annual	Semi-annual	Annual	Annual	Annual	Semi-annual	Quarterly	Quarterly	Semi-annual

Note: * At 1 March 2019, excludes bonds sub-1y maturity

Source: Bloomberg Barclays Indices

FIGURE 2

Emerging markets overview

	Brazil	Mexico	Argentina	Chile	Colombia	Israel	South Africa	Turkey	Poland	South Korea	Thailand	Russia
Generic name	NTN-Bs, NTN-Cs	Udibonos	Argentinean Government Inflation-Linked	BCU	TES	Galil, ILCPI	South Africa Index-Linked	TURKGB	POLGB	KTBi	THAIGB	RFLBI
No. bonds outstanding*	13	7	2	7	2	10	10	16	1	6	2	2
Market value outstanding bn*	BRL986bn	MXN1.5tn	ARS114bn	CLP4.7tn	COP3.9tn	ILS186bn	ZAR540bn	TRY212bn	PLN5bn	KRW10tn	THB212bn	RUB290bn
Market value outstanding $bn*	$260bn	$78bn	$3bn	$7bn	$1bn	$51bn	$38bn	$39bn	$1bn	$9bn	$7bn	$4bn
First issue date in current format	May 00	May 96	Dec 03	Sept 02	Oct 02	Jun 06	Mar 00	Feb 07	Sept 03	Feb 07	Jul 11	Jul 15
Linking Index	IPCA, IGPM	Unidas de Inversion (UDI)	CER Consumer Price Index	UF Consumer Price Index	UVR Consumer Price Index	Israel CPI	South Africa CPI NSA	Turkish CPI	Polish CPI	Korean CPI	Thailand CPI	Russia CPI
Linking index Bloomberg ticker	BZPIIPCA Index	MXUDI Index	ARCPI Index	CLUFUF Index	COCPI Index	ISCPINM Index	SACPI Index	TUCPI Index	POCPIYOY Index	KOCPI Index	THCPI Index	RUCPNL Index
Indexation lag	Up to 4 weeks, includes forecast	Up to 2 weeks	T-5, T-10 to ACERCER Index	1 month to 9th of month	1 month to 15th of month	Up to 1.5 months, adjusted on inflation release	3-4 months	2-3 months	2-3 months	2-3 months	2-3 months	3-4 months
Floor?	No floor	No floor	No floor	No floor	No floor	Coupon and principal par floor (Galils), No floor (ILCPI)	Par floor	Par floor	Par floor	No floor	Par floor	Par Floor
Coupon frequency	Semi-annual	Semi-annual	Monthly or semi-annual	Semi-annual	Monthly	Annual	Semi-annual	Semi-annual	Annual	Semi-annual	Semi-annual	Semi-annual

Note: * At 1 March 2019, excludes bonds sub-1y maturity

Source: Bloomberg Barclays Indices

Real yield histories

FIGURE 1
US 10y TIPS real yield

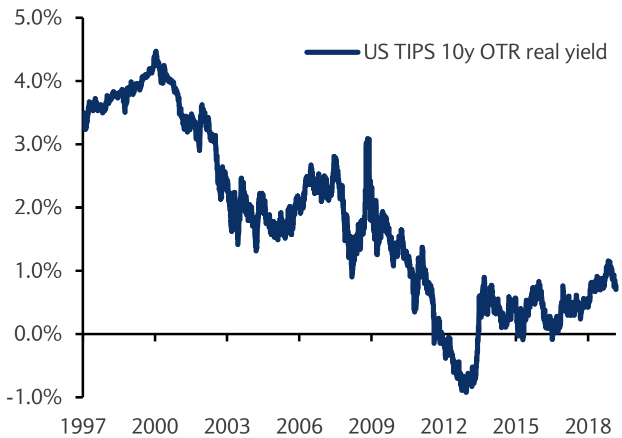


FIGURE 2
UK 10y real yield

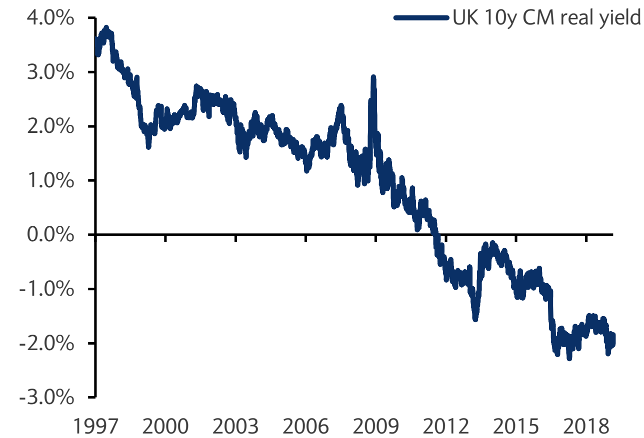


FIGURE 3
France 10y real yields

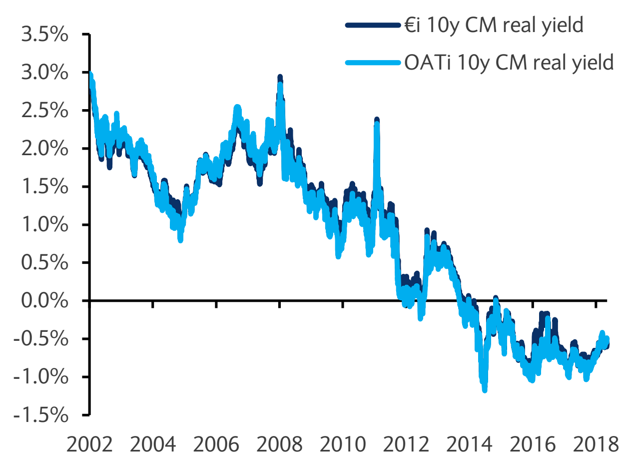


FIGURE 4
Germany DBR€i 10y real yield

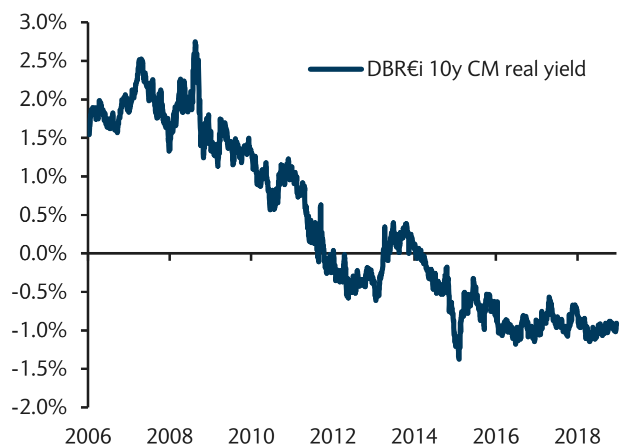


FIGURE 5
Italy 10y BTP€i real yield

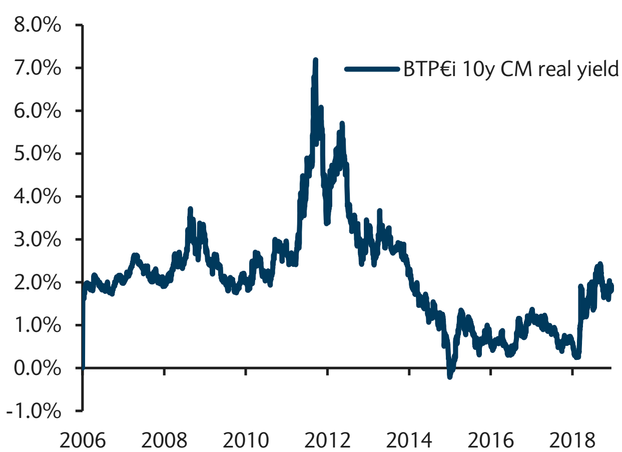
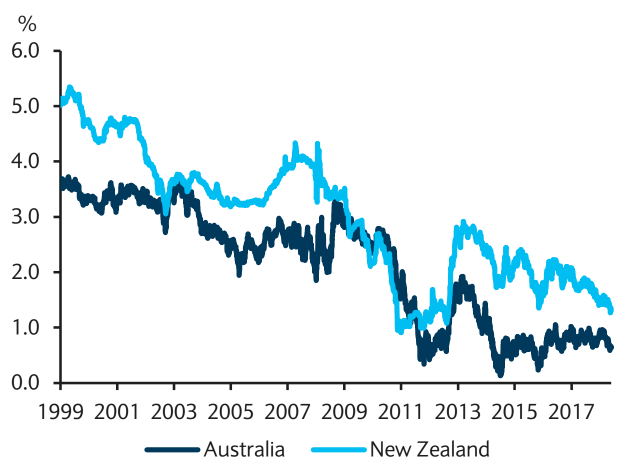


FIGURE 6
Australia and New Zealand index real yield



Source: Bloomberg, Barclays Research

FIGURE 7
Canada 10y real yield

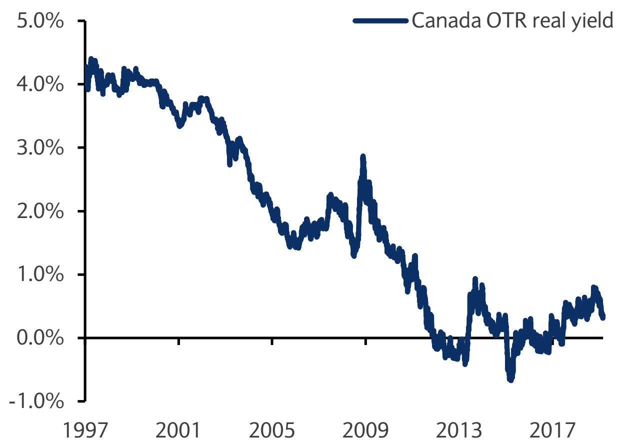


FIGURE 8
Japan OTR real yield

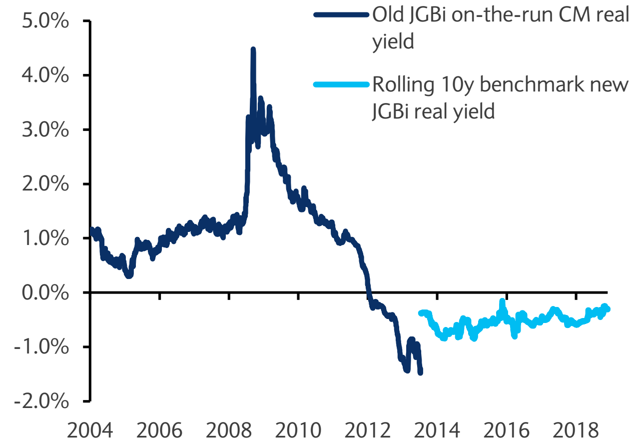


FIGURE 9
Sweden 10y real yield

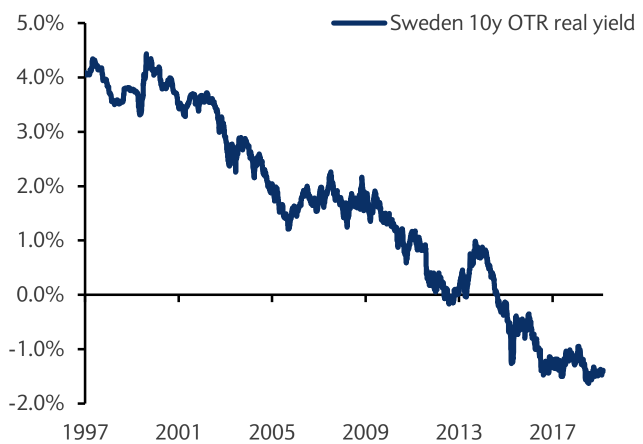


FIGURE 10
Israel index real yield

FIGURE 11
South Africa index real yield

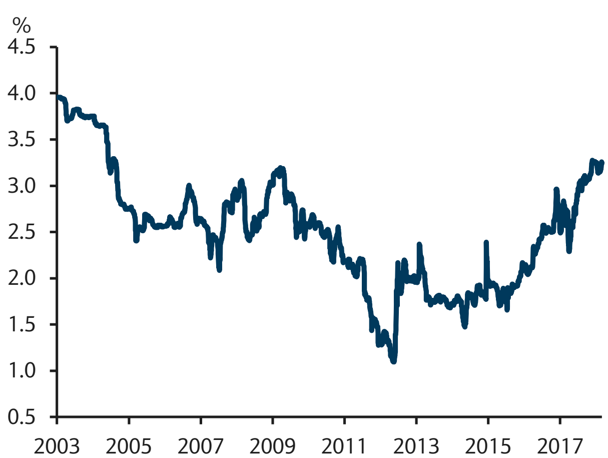


FIGURE 12
Thailand index real yield

Source: Bloomberg, Barclays Research

FIGURE 13
South Korea index real yield

FIGURE 14
Brazil index real yield

FIGURE 15
Chile index real yield

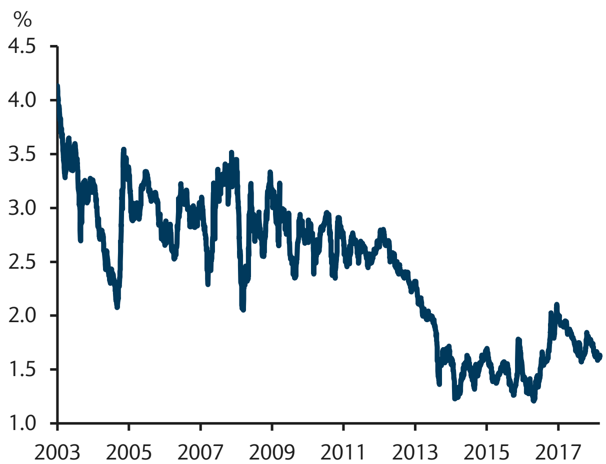


FIGURE 16
Colombia index real yield

FIGURE 17
Mexico index real yield

FIGURE 18
Turkey index real yield

Source: Bloomberg, Barclays Research

Breakeven inflation histories

FIGURE 1
US 10y TIPS breakeven vs. realised inflation

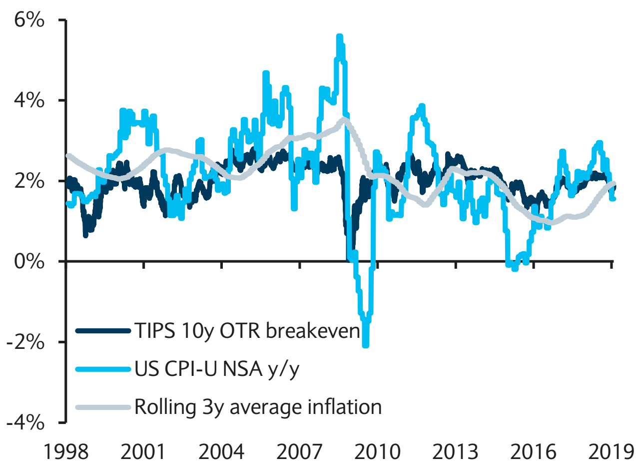


FIGURE 2
UK 10y breakeven vs. realised inflation

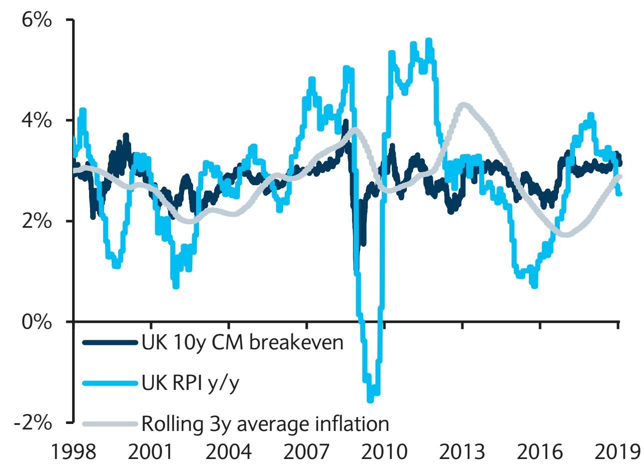


FIGURE 3
France 10y OATi breakeven vs. realised inflation

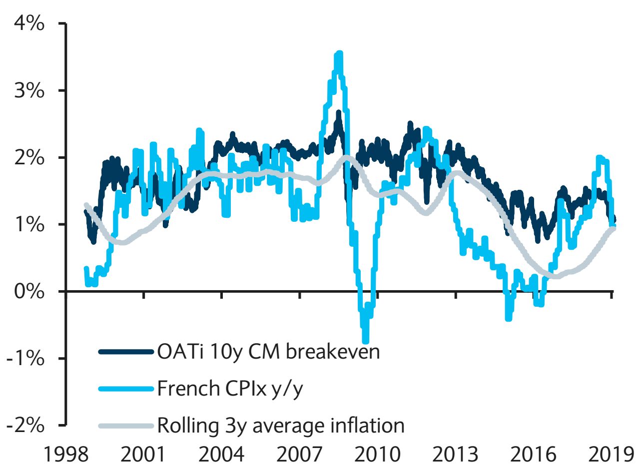


FIGURE 4
France 10y OAT€i breakeven vs. realised inflation

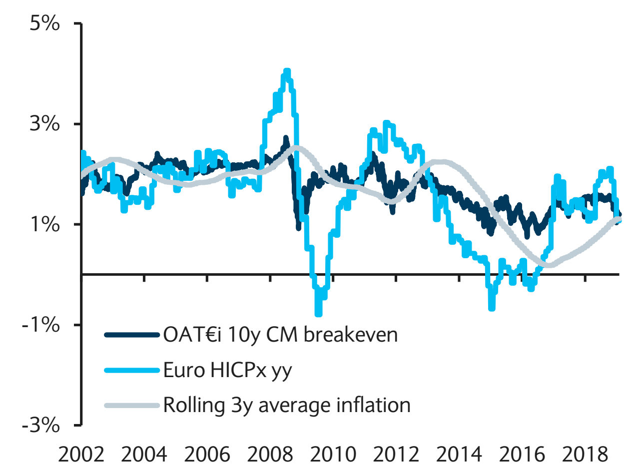


FIGURE 5
Canada 10y breakeven vs. realised inflation

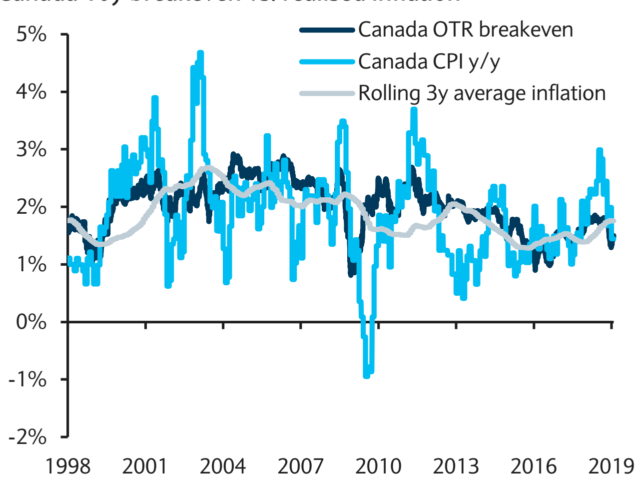
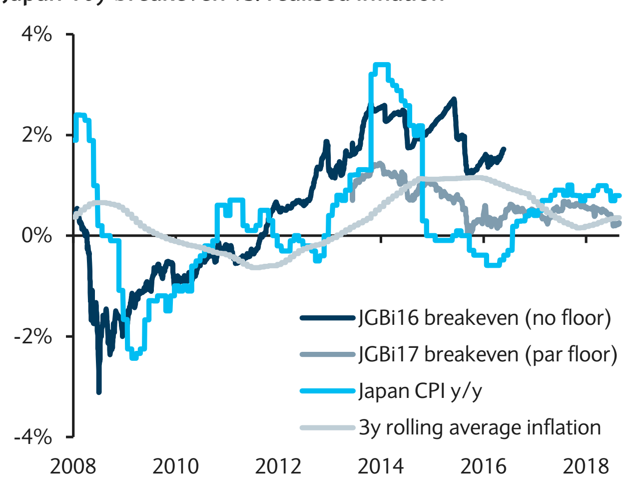


FIGURE 6
Japan 10y breakeven vs. realised inflation



Source: National Statistics Agencies, Bloomberg, Barclays Research

Key inflation market histories

FIGURE 1
5y real yields

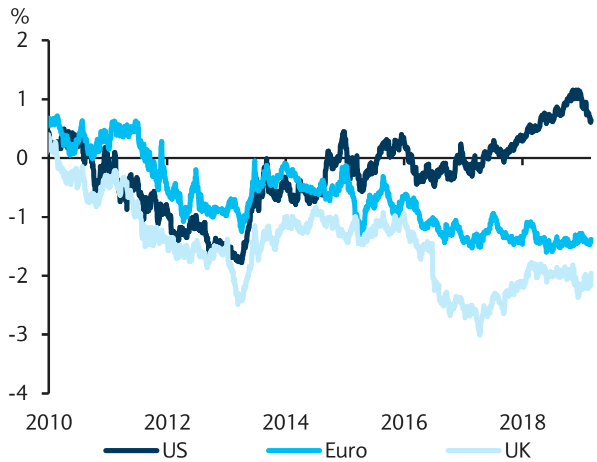


FIGURE 2
5y breakevens

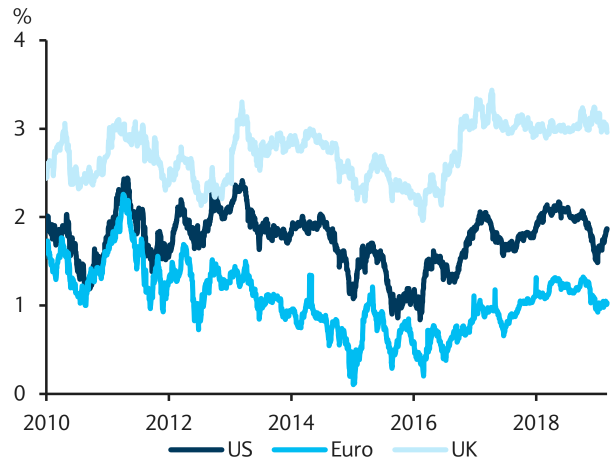


FIGURE 3
30y real yields

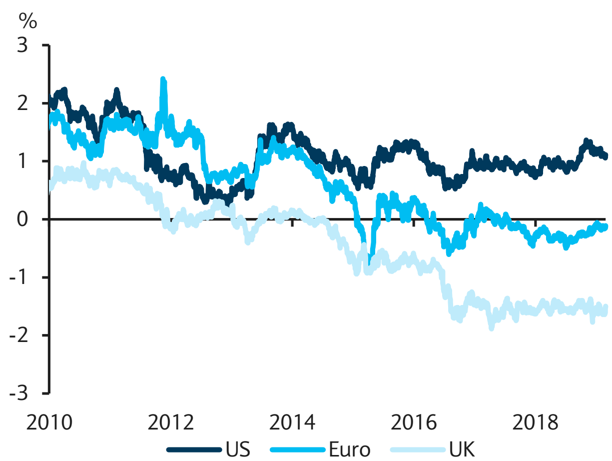


FIGURE 4
30y breakevens

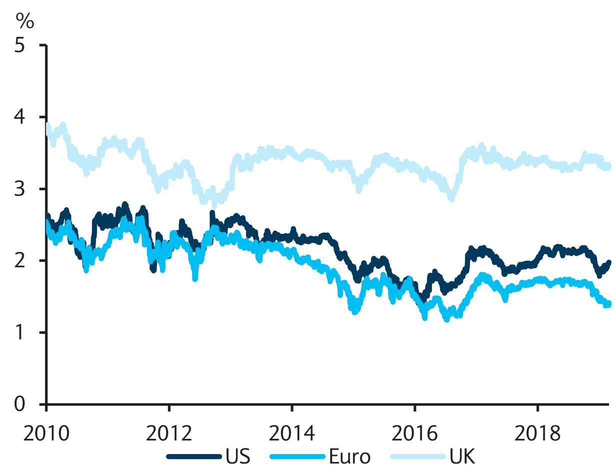


FIGURE 5
US 5y5y and 10y20y forward real yields

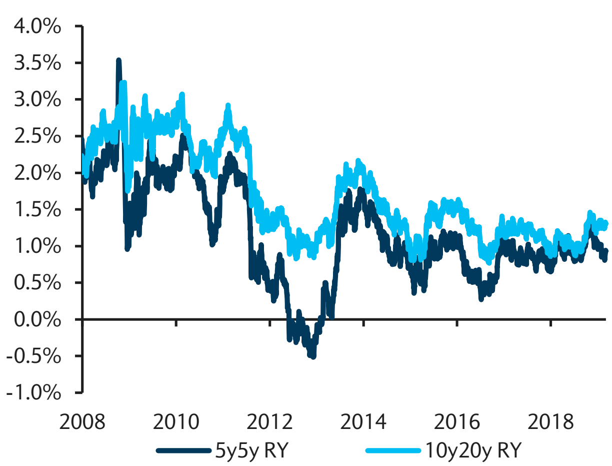
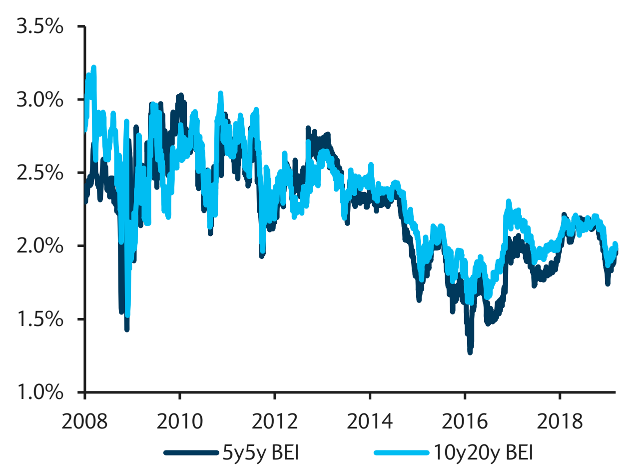


FIGURE 6
US 5y5y and 10y20y forward breakevens



Source: Bloomberg, Barclays Research

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