A guide to Inflation Linked Bonds

EXECUTIVE SUMMARY

Since the issue of OATi Jul09 in September 1998, the ILB market has grown rapidly in the eurozone. Italy, France, Germany and Spain are active issuers of inflation products and the real curve in these countries covers a wide range of tenors. The current outstanding amounts to EUR 530bn.

In the following pages, we revisit the most important characteristics of these bonds (structure, basic working, carry calculations, total return and beta analysis). Then we look at the most important factors driving breakeven inflation and real yields in the eurozone.

INFLATION LINKED BONDS FORM A COMPLETE REAL CURVE

Source: Bloomberg, UniCredit Research
INSTRUMENT STRUCTURE

1. Basic concepts of inflation-linked bonds

Inflation-linked bonds (ILBs) are financial instruments designed to provide a known real rate of return. Unlike fixed coupon bonds (where the nominal cash flows are known ex-ante while the real return is uncertain), ILBs have uncertain nominal cash flows which consist of two parts: a fixed one (real component) and an inflation-linked component.

The fixed component corresponds to a real coupon, and is calculated as a percentage of the indexed principal. The value of the real coupon is set when an ILB is launched (depending on market conditions) and remains fixed until maturity.

The variable part evolves according to inflation; in fact, it is this part that specifically safeguards the investor from inflation. To provide protection from inflation, the principal is revalued on a daily basis according to inflation. This preserves the real value of nominal coupons as well as of the redemption capital. Moreover, European ILBs offer protection vs. deflation as they are issued with a minimum redemption clause at par.

The indexed principal on any period is defined as:

\[ R_t = \left( \frac{D_t}{B} \right) \cdot N \]

and at maturity:

\[ R_t = \text{Max}\left( \frac{D_t}{B} \cdot N, N \right) \]

Where:

R: Indexed principal at time t
D(t): Daily Inflation Reference at date t (see next)
B: Base index, the level of (interpolated) CPI at the time of the bond’s creation
N: nominal bond value, 100.

The nominal coupon is calculated as a fixed percentage of the indexed principal.

\[ \text{CouponPaid} = \text{Coupon Real} \cdot \frac{D_t}{B} \cdot N \]

The ratio of the Daily Inflation Reference to the Base Index is commonly known as the IndexRatio.

Because inflation is available only with a monthly frequency and it must be possible to trade bonds on a daily basis, a mechanism to obtain a daily value for the CPI is needed. A daily inflation reference is simply obtained via linear interpolation.
As CPI figures are only available with some lag, the daily inflation reference uses t-3 and t-2 CPIs to ensure that it is always possible to calculate the index on any trading day. The formula is the following:

Daily inflation reference on day (d) = CPI_{m-3} + ((nd-1)/ NDm) * (CPI_{m-2} – CPI_{m-3})

Where:

CPI_{m-2}: price index of month m-2,

CPI_{m-3}: price index of month m-3,

nd: actual number of days since the start of the month

NDm: Number of days in month m

The formula is a simple linear interpolation, with the slope equal to the monthly inflation of two previous months. Using CPIs t-3 and t-2 ensures that a calculation is possible on any trading day. Note that, on any given day, it is possible to calculate the accrual dynamics only up to a given period in the future (usually 6-weeks on the day of CPI release, less on other days).

An example can be useful to sum up: the next graph shows the simulation of the flows of an inflation-linked bond with a real coupon of 3%, 10Y maturity and the assumption that inflation stays constant at 2%. The nominal coupon reaches the value of 2.43% at redemption date and the investor receives a redemption value equal to 121.899.

**INFLATION, NOMINAL COUPON AND REVALUED PRINCIPAL: AN EXAMPLE**

Note that for a level of inflation close to 2% (i.e. the values that approximately should be observed in the eurozone), the capital indexation follows approximately a linear pattern. Higher levels of inflation would produce a more accentuated curvature.

Inflation-linked bonds are usually quoted in real yield terms. In other words, the quoted price is simply the discounted value of real coupons.
The cash price an investor has to pay can be expressed as:

\[
\text{RealPrice} = \sum_{i=1}^{T} \frac{\text{RealCoupon}}{(1+r)^i} + \frac{100}{(1+r)^T}
\]

The cash price an investor has to pay can be expressed as:

\[
\text{Cash Price} = \left[ \text{RealPrice} + \text{Accrual} \right] \times \text{IndexRatio}
\]

In the next section, we will go into the details on how to calculate the prices of ILBs.

2. An example using Bloomberg

Inflation-linked bonds can be easily evaluated with Bloomberg.

Above, we have included a print out from Bloomberg to explain the main features of an ILB in line with the previous section. The screen is divided into several sections: the top section that provides pricing information and security descriptions and 4 quadrants below. Note first of all that the price quoted (112.24) is clean of any inflation uplift. Some useful numbers can be seen in the top left section of the screen. The “Inflation Assumption” is the expected 12 month annualized change in the reference CPI value (can be adjusted by the user). This is updated on a daily basis using daily CPI interpolations. It is assumed to hold for the entire period of the bond in the “Annual Yield w/Infl Assumption”, this assumption helps to calculate the nominal return of the ILBs in case actual inflation equals the “inflation assumption” cell. This cell provides an easy way to calculate the market estimate for breakeven inflation. All that is needed is to adjust the “inflation assumption” until the “yield with inflation assumption” cell reaches the yield of a similar maturity plain vanilla bond.
The other important sector on the screen is the **Sensitivity Analysis**. Here the duration-type measures of the bond can be manually scaled depending upon one's view on how sensitive the real bond is going to be relative to the nominal bond. Since this assumption is absolutely key to understanding the behavior of ILBs, we refer the reader to the section entitled “The Beta”.

Most of the section on **Economic Factors** simply provides a breakdown of the CPI index for use in subsequent calculations in the payment invoice. In particular, on top of the quadrant there are the base CPI value, and the Reference CPI Value, which we used in the previous paragraph. In particular, the latter results from the two indices calculated in May and April 2015, respectively. The last variable included in this quadrant, the Index Ratio, is calculated as:

\[
\frac{D}{B}
\]

Where:

- $D$: Daily Inflation Reference at date $t$ (see next)
- $B$: Base index, the level of (interpolated) CPI at the time of the bond’s creation

The total amount in the **Invoice (Principal)** can be quite simply calculated as the gross real price multiplied by the nominal amount and then by the index ratio (reported in the Economic Factors section, 1.00869 in our example). The next step is to add the coupon accrual, appropriately revalued by the index ratio. The sum then gives the invoice amount.

### 4. Inflation basis risk (or imperfect inflation protection)

ILBs are designed to protect the investor from inflation and offer a (known) real return. In the real world, however, full protection cannot be achieved because of a number of reasons, which we outline below. We leave to the investor the evaluation of how important each reason is in his personal situation.

#### BASIS RISK BETWEEN THE INVESTOR BASKET AND THE CPI INDEX

Basis risk is the difference between the inflation basket that the bond tracks and the one that is relevant to an investor. Basis risk obviously arises because ILBs need to be standardized and cannot be tailored to each investor's specific needs. Basis risk can be mitigated (for example by offering to an Italian resident a bond linked to Italian inflation) but will be fully eliminated only for those investors who consume in the exact portion as the CPI basket.

#### REINVESTMENT RISK

The second risk to perfect inflation protection comes from the rate at which the coupons are reinvested. The reinvestment risk is rather small when yields are low. Also, the shorter the life of the bond and the lower the real coupon, the lower the reinvestment risk will be. Compared to nominal bonds, the reinvestment risk is much lower since a lot of the cashflow comes from the increased principal.

#### INDEX LAG

Cash flows are linked to inflation levels from 3 to 8 months before. This is a small problem for the coupon payments but leaves the investor without inflation protection in the final 3-8 months of the life of the bond. Should prices accelerate rapidly in these last few months, then there will be no protection provided at all.
MATURITY MISMATCH

While this is becoming less of a problem after the IL market growth in recent years, European ILBs do not yet constitute a complete curve and so matching assets and liabilities cannot be perfect. That said, the addition of recent bonds has helped in the development of the inflation-linked swap market where tailor-made structures can be purchased.

3. The breakeven inflation rate calculation

Breakeven is a key parameter when dealing with inflation-linked bonds, used to indicate the level of inflation that equalizes the return from an inflation-linked bond and that from a fixed-coupon bond. Usually, breakeven is calculated as the difference between nominal and real yields. This is a good approximation, but the correct way to calculate the BEI is to lay out the cash flows of the two bonds and find the level of inflation that equalizes the returns. The example below illustrates the idea. Consider a nominal 10Y bond with a 5% annual coupon and an inflation-linked bond with 3% real annual coupon.

<table>
<thead>
<tr>
<th>Date</th>
<th>Nominal</th>
<th>ILB</th>
<th>Infl. index</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-Jul-15</td>
<td>100</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td>20-Jul-16</td>
<td>5</td>
<td>3.06</td>
<td>101.94</td>
</tr>
<tr>
<td>20-Jul-17</td>
<td>5</td>
<td>3.12</td>
<td>103.22</td>
</tr>
<tr>
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<td>5</td>
<td>3.18</td>
<td>105.94</td>
</tr>
<tr>
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<tr>
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<td>3.30</td>
<td>110.09</td>
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<td>112.23</td>
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<td>3.43</td>
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<td>19-Jul-23</td>
<td>5</td>
<td>3.50</td>
<td>116.63</td>
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<td>18-Jul-24</td>
<td>5</td>
<td>3.57</td>
<td>118.90</td>
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<tr>
<td>18-Jul-25</td>
<td>105</td>
<td>124.84</td>
<td>121.21</td>
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<tr>
<td>IRR</td>
<td>5.00%</td>
<td>5.00%</td>
<td>1.94%</td>
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</table>

Source: UniCredit Research

As the example shows, the rate of inflation that makes the IRR equal for the nominal bond and for the ILB is 1.94%. This is slightly less than the simple difference between nominal and real yields. The reason can be explained with the following equality:

\[(1 + \text{BEI}) \times (1 + \text{real yield}) = (1 + \text{nominal yield})\]

From which we can obtain:

\[\text{BEI} = \frac{(\text{nominal yield} - \text{real yield})}{(1 + \text{real yield})}\]

For low levels of real yield, the approximation \(\text{BEI} = \text{nominal yield} - \text{real yield}\) works reasonably well, as shown in the following table. The table also shows that calculating the BE as a simple difference between nominal and real yields always overestimates the correct value:
Nominal yields

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</table>

The table shows the difference in basis points between the BE calculated as simple difference between nominal and real yields and the BEI inflation calculated with the analytical formula. The table does not consider the case of negative real yields.

Source: UniCredit Research

3. Breakeven inflation as a measure of inflation expectations

As the name indicates, BE inflation represents the level of inflation that makes a nominal bond and an ILB equivalent in terms of return. It is not conceptually different from a forward rate, which indicates the level of future spot rate that makes the return of a short-term bond equal to that of a long-term bond.

A key question is if BE inflation reflects market inflation expectations. After all, BE inflation should be related to inflation expectations: if an investor has a strong view that future inflation will differ from BE inflation, he will find it profitable to enter a trade of ILBs vs. nominal bonds. If the investor’s community behaves in this way, BE inflation should reflect the consensus view on inflation. There are a few caveats, though.

The most important one is that the equality between expectations and BE would hold only under risk-neutrality. In other cases, investors will pay a premium to hold the instrument with a higher degree of certainty. One should expect investors to prefer certainty over real cash flows. If this is the case, then BE should be higher than inflation expectations. In fact, for a nominal bond:

\[ Y_N = r + \pi_e + P \]
\[ BE = Y_N - Y_R = r + \pi_e + P - r = \pi_e + P \]

A second caveat is related to the convexity offered by ILBs. This is another advantage of linkers vs. nominal bonds and would act in a direction similar to the inflation risk premium.

A third caveat relates to liquidity premium, and acts in the opposite direction. As inflation-linked bonds are less liquid compared to nominal bonds, investors should require a premium to hold this asset class.

A fourth caveat, which is highly technical, is that BE will exceed inflation expectations because of the compounding effect. In essence, the investor will receive over N years a payoff equal to \((1+\pi)^N\). We can compare this payoff to expected inflation \((1+\pi_e)^N\). It can be shown that the following inequality holds:

\[ \mathbb{E}[(1+\pi)^N] > [1+\mathbb{E}(\pi)]^N \]

The bottom line is that, while BE mainly reflects inflation expectations, one should always be aware of these caveats when interpreting BE as an exact measure of inflation expectations.
The following chart compares the 10Y BE with inflation and a survey-based measure of inflation expectations in the US. Evidence suggests that BEs have undershot both the level of realized inflation (which must be an important component of any inflation forecast) and a survey-based measure of inflation expectation. The chart on the right compares the average 10Y BE with realized inflation for the US, UK, and EMU. The gap is fairly large in the EMU. One reason is because the chart shows the level of BE quoted in ZC swap contracts and another one may be related to the credibility of the ECB 2% inflation target. 10Y BE in the US have averaged ca. 2%, a bit lower than realized inflation. This can reflect that investors attach a high credibility to the Fed inflation goal. It could also reflect weak demand for inflation products, which drives down the level of BE.

In the UK, 10Y BE are fairly in line with the level of realized RPI inflation.

### BE AND REALIZED INFLATION

![Chart comparing 10Y BE with realized inflation and U-Michigan inflation survey](chart.png)

The chart shows the average inflation and BE since 1999. For the EMU the average starts in 2004.

Source: UniCredit Research

### CARRY CALCULATIONS

5. Carry calculations

As for nominal bonds, carry is a crucial variable in determining the profitability of a short or long position also for ILBs. In general, the carry is the difference between the cost of financing an investment and the income coming from holding a bond (generated via the coupon).

Carry can be translated in the yield space and is calculated as the difference between spot and forward rates. If forward yields are higher than spot yields, we are in a positive carry environment and vice versa.

The forward curve can be easily calculated for nominal bonds, making it easy to assess the carry. On the contrary, the forward curve cannot be easily calculated for inflation-linked bonds, which makes it a little tricky to determine the carry.

In particular, when an investor buys an inflation-linked bond, he cannot determine what is the carry on a medium-term horizon because that will depend on the index accrual.

Calculating the carry of an ILB is similar to nominal bonds; but we need to take the inflation uplift into account. Assuming for simplicity that no coupon is paid out during the calculation period:

\[
\text{Carry} = \text{Income} - \text{Repo costs}
\]
Also:

\[ \text{Income} = \text{Real coupon} + \text{Inflation Accrual} \]

Hence:

\[ \text{Carry} = \text{Real coupon} + \text{Inflation Accrual} - \text{Repo costs} \]

The **Inflation Accrual** (the variable component) is known only for relatively short horizons (from 2 to 6 weeks), as we have explained in the first section. For longer periods one needs to rely on inflation forecasts to calculate the carry. Let's now look at the calculations in detail.

When an investor buys an ILB, the cash price he has to pay is:

\[ \text{GP}_{t1} = (\text{NP}_{t1} + \text{Coupon Accrual}_{t1}) \times \text{IR}_{t1} \]

Where GP is the gross price and NP is the net price, IR is the index ratio and Coupon Accrual refers to the real component.

The gross cash price is needed as a base for the repo costs. At the evaluation date of the carry, the cash value of the position will be the initial level plus the repo. Subtracting the accrued coupon and dividing by the index ratio will yield the forward price:

\[ \text{FwP} = \frac{(\text{NP}_{t1} + \text{Coupon Accrual}_{t1}) \times \text{IR}_{t1} + \text{Repo} - \text{Coupon Accrual}_{t2}}{\text{IR}_{t2}} \]

This can be rearranged as:

\[ \text{FwP} = \frac{\text{NP}_{t1} \times \text{IR}_{t1}/\text{IR}_{t2} + \text{Repo}/\text{IR}_{t2} + \text{Coupon Accrual}_{t1} - \text{Coupon Accrual}_{t2}}{\text{IR}_{t2}} \]

Which is the standard expression for the forward price (initial price – income + costs)

Note that the higher the inflation during the holding period of the bond, the lower the forward price and the higher the carry. Also consider that the index ratio has a few months lag. So for example on 1Aug15, the relevant index ratio will be the May one and on 1Sep15 it will be the June one. A month such as July (which has a high negative seasonality in the CPTFEMU) will tend to create a negative carry during September. As investors anticipate this, they will sell an ILB ahead of September. This should depress the level of BEs.

### 6. Carry calculation in Bloomberg

Fortunately, we do not necessarily have to do the carry calculations: Bloomberg will do it for us! The calculations can be done with the function FPA (Forward Pricing Analysis). We provide here an example and a brief explanation of the important elements on this page.

As an example, consider to buy the BTPei Sep24 at a price of 112.47. We are interested in the carry of this trade for a 1-month horizon. The trade settlement is 21Jul 2015, the relevant inflation indices are May (117.76) and June (117.74). Inflation between May and June has been slightly negative (-0.02% m/m). As a result, our position will lose money on the inflation component and will cost in terms of repo. Note that, at the time of writing, repo rates are very low. Finally, the position will earn from coupon accrual (ca. 0.2% per month).
In the top part of the page, there is the "spot price". Then the Repo rate and the Termination date need to be adjusted appropriately. All calculations assume that the coupon is reinvested in to the bond (as can be seen on the right of the screen).

In our example, to calculate the carry for the BTPei Sep24, Bloomberg sets the Repo rate at -0.019% and the termination date as 24 August 2015 (31 days from the settlement date). Bloomberg will calculate the forward price at the termination date we insert (the user can either insert a specific date or the number of days ahead in time).

Once we have set all the parameters, we obtain the full and the net forward prices and the forward yield. Furthermore, Bloomberg provides us with the calculation of the yield drop or the yield increase. For the bond proposed, with settlement date at 23 July, termination date one month after, Repo rate at -0.019%, net spot price of 112.475 and an inflation assumption of 0.14459%, we obtain a forward net price of 112.21. This corresponds to a forward yield of 0.943%. Thus, the bond has a positive carry of 1.64bp. This can also be seen by the fact that the forward price is 26 cents lower than the spot.

If inflation was higher (say that the term reference CPI was 119 rather than 117.74), the carry would be 14bp. The forward price would be 111.01. If, on the other hand, inflation was lower (say that the term reference CPI was 117 rather than 117.74), the carry would be -6.2bp. The forward price would rise in this case to 112.93.
RISK PROFILE OF INFLATION LINKED BONDS

How do ILBs compare to fixed coupon bonds in terms of risk? There are a few important aspects worth investigating:

1. Volatility of real yields vs. nominal yields
2. Duration of ILBs vs. fixed coupon bonds
3. Sensitivity of real yields to nominal yields (beta and convexity)

1. Volatility of real yields vs. nominal yields

To study the relative volatility of nominal and real yields, it is useful to start from the Fisher equation:

\[ Y = R + \text{Expected infl}; \]

So that:

\[ \text{Variance (Y)} = \text{Variance (R)} + \text{Variance (Expected infl)} + 2 \times \text{Covariance (r, Expected infl)} \]

This formula implies that, if the covariance between real yields and break-even is non-negative (which is what we generally observe), real yields are less volatile than nominal yields. Furthermore, the higher the volatility of inflation expectations, the higher will be the difference in volatility between real and nominal yields (for a given level of the covariance). This is the key reason why linkers are considered as less risky than nominal bonds.

What do we observe empirically?

The following charts show the historical behavior of the yield variance of the OATei Jul32 and the OAT Oct32. The analysis suggests that nominal yields have been more volatile than real yields but only modestly. The chart also shows that inflation expectations have been remarkably stable in the EMU and their volatility is considerably lower compared to yield volatility. This is likely the result of the ECB monetary policy. Empirically, the covariance between real yields and BE has been zero until the beginning of the crisis and then it has turned negative. Negative covariance means that a rise in the real yield goes along with a decline in inflation expectations. Note that negative covariance tends to reduce the gap in volatility between real and nominal yields.

Source: UniCredit Research
A market for inflation-linked bonds in the EMU is a relatively recent thing. The next two charts show the behavior of real and nominal yields for the UK and the US. The key message is that during the nineties, inflation expectations were relatively volatile, while real yields were pretty stable. Likely as a result of a stronger focus on the inflation-fighting role of monetary policy, inflation expectations stabilized in the early 2000s and remained fairly stable until the eruption of the financial crisis. The main implication is that, while nominal yields were more volatile than real yields when ILBs were introduced, now their volatility is less different.

Another important message is that, during the early stage of the financial crisis, real yields became considerably more volatile than nominal yields. This went along with a strong negative covariance between real yields and inflation expectations. In the US, real yields were more volatile than nominal yields also during the tapering. It is not easy to justify economically a higher volatility of real yields, especially as this goes along with a negative covariance of real yields and inflation expectations.

### REAL AND NOMINAL YIELD VOLATILITY – UK & US

[Graph showing real and nominal yield volatility for the UK and US]

2. Duration

We define real duration as the duration of the real part of an inflation-linked bond. In other words, the duration calculated using the real coupon and the non-revaluated principal. The real duration can be used very much as the duration of a nominal bond, applied to the real component:

\[
\frac{d(RealP)}{RealP} = -\frac{RealDuration}{(1 + r)} dr
\]

Inflation-linked bonds have usually a higher duration than nominal bonds, as their coupons and yields tend to be lower.

The real duration tells us how the price of an inflation-linked bond changes with respect to the real yield. What we are interested to know, however, is how the price of ILBs changes in relation to nominal yields. At this stage, it is essential to introduce the concept of beta, which is the sensitivity of real yields to changes in nominal yields.
3. Beta and convexity

Beta is defined as the coefficient of the following regression:

\[ dY_R = \alpha + \beta dY_N + \varepsilon \]

Where \( Y(R) \) is the real yield and \( Y(N) \) is the nominal yield.

The beta indicates the sensitivity of real yields to changes in nominal yields. Intuitively, changes in nominal yields will be due in part to inflation expectations and in part to real factors. As a result, the beta should be between zero and one. It will be close to one when inflation expectations are relatively stable and will be close to zero when most of the change in nominal yields is caused by changes in inflation expectations.

The fact that beta should be between zero and one means that ILBs tend to be defensive instruments: in an environment of rising nominal yields, ILBs tend to outperform nominal bonds (and vice versa). Consider that the \( \beta \) can be expressed as:

\[ \beta = \text{Cov}(dY_n, dY_r) / V(dY_n) \]

taking into account that \( Y_r = Y_n - \pi \), we can obtain:

\[ \beta = 1 - \text{cov}(Y_n, \pi) / V(Y_n) \]

which indicates that \( \beta \) is close to one when the covariance between nominal yields and inflation expectations is low. This is intuitive and simply means that beta is close to 1 when most of the changes in nominal yields are due to changes in real yields.

What is the empirical evidence on the beta? The chart below on the left shows the estimated beta for the EUR 5Y ZC swaps. A first important indication is that the beta is time-varying. Both in the EMU and in the US it has been as low as 0.4 and has been above 1 at times. Since 2004, it has been on average 0.90 in the US and 0.75 in the EMU. There seems no be stable relation between betas and the level of yields.

**CORRELATION BETWEEN BETAS AND THE LEVEL OF YIELDS**

![Correlation chart](image)

The chart shows the relationship between US 5Y swap nominal rate and the 4M rolling beta calculated on daily changes in 5Y real swap rates and 5Y nominal swap rates.

Source: UniCredit Research
CONVEXITY

What can we say about the convexity of ILBs? When looking at the real component only, ILBs generally have a higher convexity compared to fixed coupon bonds. However, ILBs also have higher duration, so a comparison with fixed coupon bonds has to take this into account. To do this, we compare two portfolios, one fully invested in fixed coupon bonds and the other invested in an inflation-linked bond and cash, so as to obtain the same duration as the first portfolio. The chart below shows the price response of a portfolio of ILBs relative to a portfolio of fixed coupon bonds. The underlying assumption is that beta=1. The difference in convexity is slightly in favor of ILBs. When beta falls below 1, the convexity is in favor of fixed coupon.

CONVEXITY OF ILBS: AN EXAMPLE WITH BETA =1

The example plots the value of two portfolios, one invested in the OAT Apr41 and the other in the OATei Jul41 and in cash, so that they have the same initial duration.

In this example above, the beta of real yields to nominal yields is assumed to be 1. As we have observed previously, however, the beta is generally different from 1. The following example show a case for beta=0.75.

CONVEXITY OF ILBS: AN EXAMPLE WITH BETA =0.75

The example plots the value of two portfolios, one invested in the OAT Apr41 and the other in the OATei Jul41 and in cash, so that they have the same initial duration.
TOTAL RETURN ANALYSIS

What are the main drivers of total return for ILBs? There are three sources: price return, coupon accrual and inflation accrual. Price return is the dominant factor in the short term, while the other two are more relevant in the medium term.

Inflation-linked bonds are usually evaluated vs. fixed coupon bonds, so an important question is what drives the relative performance between the two. In the short term, the main factor is how BE changes (the beta of real yields vs. nominal yields comes into play here). In the medium term, it is also important how actual inflation differs from BE.

Consider that ILBs usually have lower coupons than nominal bonds, so their (real) duration is higher. If real yields rise by the same amount as nominal yields (for example because growth accelerates with no effects on inflation expectations), ILBs will underperform nominal bonds. The opposite is true when yields fall. The following table shows an example.

EXAMPLE 1: YIELDS FALL – BETA=1

<table>
<thead>
<tr>
<th></th>
<th>BE</th>
<th>Nominal</th>
<th>Real</th>
<th>Infl</th>
<th>P ILB</th>
<th>P Nom</th>
<th>TotRet Nom.</th>
<th>ILB</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>2.00%</td>
<td>4.00%</td>
<td>2.00%</td>
<td></td>
<td>100.00</td>
<td>100.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>2.00%</td>
<td>3.00%</td>
<td>1.00%</td>
<td>2.00%</td>
<td>108.57</td>
<td>107.79</td>
<td>11.8%</td>
<td>12.8%</td>
</tr>
</tbody>
</table>

EXAMPLE 2: YIELDS RISE – BETA=1

<table>
<thead>
<tr>
<th></th>
<th>BE</th>
<th>Nominal</th>
<th>Real</th>
<th>Infl</th>
<th>P ILB</th>
<th>P Nom</th>
<th>TotRet Nom.</th>
<th>ILB</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>2.00%</td>
<td>4.00%</td>
<td>2.00%</td>
<td></td>
<td>100.00</td>
<td>100.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>2.00%</td>
<td>5.00%</td>
<td>3.00%</td>
<td>2.00%</td>
<td>92.21</td>
<td>92.89</td>
<td>-3.1%</td>
<td>-3.9%</td>
</tr>
</tbody>
</table>

Source: UniCredit Research

However, beta is usually not one. When beta is lower than one, a rise in nominal yields goes along with a less-than-proportional rise in real yields (and hence a rise in BE), and vice versa. The following table illustrates what happens in this case.

EXAMPLE 3: YIELDS FALL – BETA=0.5

<table>
<thead>
<tr>
<th></th>
<th>BE</th>
<th>Nominal</th>
<th>Real</th>
<th>Infl</th>
<th>P ILB</th>
<th>P Nom</th>
<th>TotRet Nom.</th>
<th>ILB</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>1.50%</td>
<td>4.00%</td>
<td>2.00%</td>
<td></td>
<td>100.00</td>
<td>100.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>1.50%</td>
<td>3.00%</td>
<td>1.50%</td>
<td>2.00%</td>
<td>104.18</td>
<td>107.79</td>
<td>11.8%</td>
<td>8.3%</td>
</tr>
</tbody>
</table>

EXAMPLE 4: YIELDS RISE – BETA=0.5

<table>
<thead>
<tr>
<th></th>
<th>BE</th>
<th>Nominal</th>
<th>Real</th>
<th>Infl</th>
<th>P ILB</th>
<th>P Nom</th>
<th>TotRet Nom.</th>
<th>ILB</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>2.00%</td>
<td>4.00%</td>
<td>2.00%</td>
<td></td>
<td>100.00</td>
<td>100.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>2.50%</td>
<td>5.00%</td>
<td>2.50%</td>
<td>2.00%</td>
<td>96.01</td>
<td>92.89</td>
<td>-3.1%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

Source: UniCredit Research

As these examples show, the difference in performance between nominal bonds and ILBs is highest in the case of rising yields and beta lower than 1. Intuitively, this is a case when the rise in yields is mainly due to an increase in inflation expectations, the situation for which ILBs are designed to provide protection. The example also illustrates that the difference in performance when beta is one (stable BE) is relatively small.
We now turn our attention to the impact of actual inflation relative to the level priced in the BE. In this example, we consider two 10-year bonds. BE is 200bp and real yields trade at 2%. After one year, realized inflation has exactly matched BE (so 2%). Nominal and real yields have remained stable. ILBs and fixed coupons have the same return (unsurprisingly). Now consider that inflation turns out to be 2.2%, higher than expected. BE do not change as markets see the higher inflation as temporary. ILBs outperform fixed coupon bonds.

**EXAMPLE 5: HIGHER-THAN-EXPECTED INFLATION, NO CHANGE IN YIELDS**

<table>
<thead>
<tr>
<th></th>
<th>BE</th>
<th>Nominal</th>
<th>Real</th>
<th>Infl</th>
<th>P ILB</th>
<th>P Nom</th>
<th>TotRet Nom.</th>
<th>ILB</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>2.00%</td>
<td>4.00%</td>
<td>2.00%</td>
<td></td>
<td>100.00</td>
<td>100.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>2.00%</td>
<td>4.00%</td>
<td>2.00%</td>
<td>2.50%</td>
<td>100.00</td>
<td>100.00</td>
<td>4.0%</td>
<td>4.5%</td>
</tr>
</tbody>
</table>

Source: UniCredit Research

Finally, we consider the case of higher-than-expected inflation, which leads to a rise in BE (beta less than one). This is again an ideal environment for linkers. First, they benefit from higher-than-expected inflation and second from the rise in breakeven.

**EXAMPLE 6: HIGHER-THAN-EXPECTED INFLATION, RISE IN NOMINAL YIELDS, BETA=0.5**

<table>
<thead>
<tr>
<th></th>
<th>BE</th>
<th>Nominal</th>
<th>Real</th>
<th>Infl</th>
<th>P ILB</th>
<th>P Nom</th>
<th>TotRet Nom.</th>
<th>ILB</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>2.00%</td>
<td>4.00%</td>
<td>2.00%</td>
<td></td>
<td>100.00</td>
<td>100.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>2.25%</td>
<td>4.50%</td>
<td>2.25%</td>
<td>2.50%</td>
<td>97.98</td>
<td>96.37</td>
<td>0.4%</td>
<td>2.5%</td>
</tr>
</tbody>
</table>

Source: UniCredit Research

These examples are stylized cases, real-life cases will be a mix of different factors. The following chart shows, for the UK market, the relative performance of a basket of ILBs vs. a basket of nominal coupon bonds.

**ILBS VS FIXED COUPONS TOTAL RETURN**

Relative performance is highly driven by BE …

The chart shows the 10Y UK BE and the return of a portfolio of ILBs vs. nominal bonds. The portfolio is scaled to 100 in January 1999. Values above 100 indicate an outperformance of ILBs.

Rule of thumb for UK: 100bp BE change=7% ILB outperformance

Source: Bloomberg, UniCredit Research
WHAT DRIVES REAL YIELDS AND BREAKEVEN

We have so far described the workings of inflation-linked bonds and some concepts related to their fixed income mathematics. In this section, we turn our attention to what drives the economic variables that are reflected in inflation-linked bonds.

According to the Fisher equation, linkers can be decomposed into a real yield part, expected inflation and a risk premium. In the following sections, we will examine the first two bits separately. We leave aside the risk-premium analysis, which would require a separate publication.

4. Real yields

Any economic textbook will tell you that the real interest rate is determined by the demand and supply of loanable funds. This comes from the definition of aggregate supply, Yd:

\[ \text{Yd} = C + I + G \]

where C is planned consumption, I is planned investment and G is planned government spending (and we are ignoring the foreign sector). If there is goods-market equilibrium, then aggregate demand must equal aggregate supply:

\[ \text{Yd} = Y \]

where Y is income (or output or aggregate supply). Now, income is either consumed, saved or taxed away, thus we can "decompose" Y into:

\[ Y = C + S + T \]

where the terms follow their traditional definitions (S is savings, T is taxes). Consequently, in equilibrium:

\[ C + I + G = C + S + T \]

which can be rewritten as:

\[ I + (G-T) = S \]

This equilibrium condition requires that savings are enough to finance planned investment and the government deficit.

While a relatively clean concept to visualize in this textbook vision, the market clearing real interest rate is a little more difficult to predict in the real world.

One observation is that real yields tend to be cyclical. As the economic data improve, there is more demand for investment and this pushes up real yields.

The following chart helps to visualize this concept in the US, plotting the ISM vs. the US real yield (measured as the 10-year Treasury minus CPI y-o-y) from December 1982 until present. The chart illustrates a basic relationship whose sign should be quite stable over time. However, its strength can be time varying, as the chart below illustrates: from April 2002 to the present, the link between the ISM Index and US real yields has considerably weakened.
Between 2004 and 2007, this could have been due to a structural factor concerning the US economy in that specific period.

In 2005, Alan Greenspan reported the most important factors that were preventing bond yields from behaving like in past cycles. He described the situation as a “conundrum”:

- The presence of abundant liquidity enhanced the demand for investment; as a consequence, yields decreased. Greenspan referred specifically to the increasing pressure on pension funds and insurance companies “to make significant additions to longer-term bond portfolios”; this was due to the increase in the retirement population in the developed world.
- The accumulation of US Treasury obligations by foreign monetary authorities contributed to lower long-term Treasury yields.
- The increasing globalization in goods, services and financial markets contributed to lower inflation pressure and this, in turn, brought about a decline in long-term yields.

From 2008, the decline in real yields was due to the aggressive Fed easing policy (which included quantitative easing). The chart shows that even when the US economy started to improve after the Lehman crisis, real yields remained on a downward trajectory until very recently. This was partly due to risk aversion stemming from the EMU debt crisis, partly to the implementation of additional phases of QE and partly to structural factors, such as the increase in the saving rates and the decline in investments (due to risk aversion), which pushed many investors into US Treasuries.

5. What affects the BEI curve movements?

As we have outlined in previous paragraphs, the relative performance of ILBs vs. fixed coupon bonds depends on the way expected inflation changes. This is especially the case for relatively short holding periods.

In this paragraph, we look at historical correlations between the most important economic variables and the BE inflation, to provide an indication of what are its main drivers.

We start from the US market, which has a longer history compared to the eurozone when it comes to the inflation-linked market.
On Bloomberg, series of BE inflation are available for different tenors (2Y, 5Y, 10Y and 30Y); it is hence possible to analyze the correlation of the various economic variables with the BE inflation at different maturity buckets. The following table shows the historical correlation calculated on the sample Jan99/Jun15.

<table>
<thead>
<tr>
<th></th>
<th>CPI X level, t-2</th>
<th>CPI level, t-2</th>
<th>Core PCE level, t-2</th>
<th>IP level, t-2</th>
<th>ISM level</th>
<th>NFP level, t-1</th>
<th>Unempl level, t-2</th>
<th>Oil 3M ret.</th>
<th>CRB 3M ret.</th>
<th>Gold 3M ret.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2Y</td>
<td>14.5%</td>
<td>15.9%</td>
<td>28.3%</td>
<td>49.0%</td>
<td>61.2%</td>
<td>63.3%</td>
<td>-30.8%</td>
<td>55.0%</td>
<td>53.2%</td>
<td>11.3%</td>
</tr>
<tr>
<td>5Y</td>
<td>8.2%</td>
<td>26.3%</td>
<td>33.2%</td>
<td>46.6%</td>
<td>61.6%</td>
<td>63.4%</td>
<td>-34.8%</td>
<td>47.1%</td>
<td>42.7%</td>
<td>10.3%</td>
</tr>
<tr>
<td>10Y</td>
<td>-14.9%</td>
<td>13.9%</td>
<td>22.6%</td>
<td>40.7%</td>
<td>62.4%</td>
<td>53.8%</td>
<td>2.0%</td>
<td>40.8%</td>
<td>45.3%</td>
<td>10.6%</td>
</tr>
<tr>
<td>30Y</td>
<td>-18.0%</td>
<td>13.0%</td>
<td>27.7%</td>
<td>25.2%</td>
<td>56.0%</td>
<td>36.4%</td>
<td>2.0%</td>
<td>38.5%</td>
<td>50.9%</td>
<td>21.2%</td>
</tr>
</tbody>
</table>

Source: Bloomberg, UniCredit Research

The table highlights some interesting results. First, the PCE core is the measure on inflation that is most correlated with market inflation expectations. It has a better performance compared to headline CPI or core CPI. Second, and in line with economic theory, inflation expectations are highly correlated with economic activity, especially employment and the ISM. Industrial production appears to be less relevant. Third, oil prices and commodities have a high impact on inflation expectations, while gold is a lot less correlated.

The following charts show the historical relation between US BE inflation and some economic variables.
We can replicate the same analysis for the EMU. Unfortunately, the inflation-linked market is more recent in the EMU and government bond curves are less dense. In addition, in recent years, due to the sovereign debt crisis, ILBs issued by different countries have been priced in a different way due to the credit and liquidity risk components. Therefore, we will use ZC swap inflation contracts, which are available for a set of maturity buckets since mid-2004. This reduces the historical depth of the analysis, compared to the US.

Compared to the US, inflation plays a more relevant role in the EMU in driving inflation expectations. As in the US, PMIs are well correlated with inflation expectations. Notably, other popular business surveys display a very low level of correlation with the BE (look for example at the IFO in the table above). As in the US, unemployment and oil/commodity prices have a high degree of correlation with BEs. Similar to the US, the following charts illustrate the relation between 10Y ZC swap inflation and economic variables.
1. Inflation-linked bonds vs. other assets

In this section, we look at the performance of ILBs in terms of total return relative to other investment opportunities. We are particularly interested in the return vs. volatility balance as well as in the correlation vs. other asset classes. Data on total return for ILBs are calculated from the Barclays indices, while for fixed coupon bonds we use the EFFAs indices. Finally, for equities we take the MSCI index.

Total return for ILBs is available from 1997 in the US and UK. In the eurozone, we will analyze France and Italy, for which the data are available a bit later. We look at the total return index for a portfolio of ILBs in the 1-10Y bucket.

US and UK inflation-linked bonds have performed well in this period, better than fixed coupon bonds which likely reflects the presence of an inflation premium. Inflation-linked bonds have also outperformed short-dated bonds. This is not surprising and confirms that short-term rates adjust to inflation relatively slowly.

While offering a larger total return, ILBs have also experienced a higher volatility compared to fixed coupon bonds. This is particularly the case for Italy, as BTPei have been under strong pressure during the sovereign debt crisis.

In the sample we are analyzing, ILBs have also outperformed equities.
ILB  Fixed long  Fixed short  Equity  Comm.
Avg. ret.  5.15  4.68  3.58  6.96  2.16
St.dev    4.18  3.08  1.42  18.20  8.39
Sharpe   1.23  1.52  2.51  0.38  0.26

ILB  Fixed long  Fixed short  Equity  Comm.
Fixed long  0.68  1.00
Fixed short  0.59  0.90  1.00
Equity   -0.05  -0.28  -0.24  1.00
Comm.    0.14  -0.13  -0.09  0.20  1.00

Source: Bloomberg, UniCredit Research
France

<table>
<thead>
<tr>
<th></th>
<th>ILB</th>
<th>Fixed long</th>
<th>Fixed short</th>
<th>Equity</th>
<th>Comm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. ret.</td>
<td>4.49</td>
<td>4.60</td>
<td>3.08</td>
<td>3.61</td>
<td>4.11</td>
</tr>
<tr>
<td>St.dev</td>
<td>3.57</td>
<td>3.01</td>
<td>1.33</td>
<td>21.63</td>
<td>8.49</td>
</tr>
<tr>
<td>Sharpe</td>
<td>1.26</td>
<td>1.53</td>
<td>2.32</td>
<td>0.17</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Italy

<table>
<thead>
<tr>
<th></th>
<th>ILB</th>
<th>Fixed long</th>
<th>Fixed short</th>
<th>Equity</th>
<th>Comm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. ret.</td>
<td>5.01</td>
<td>4.91</td>
<td>3.54</td>
<td>2.12</td>
<td>4.11</td>
</tr>
<tr>
<td>St.dev</td>
<td>6.73</td>
<td>4.32</td>
<td>2.32</td>
<td>23.24</td>
<td>9.21</td>
</tr>
<tr>
<td>Sharpe</td>
<td>0.74</td>
<td>1.14</td>
<td>1.52</td>
<td>0.09</td>
<td>0.45</td>
</tr>
</tbody>
</table>

On average, ILB returns have a 65/70% correlation with fixed coupon bonds (for Italy this is higher). The correlation with a bond portfolio in the 1-3Y area is a bit lower (55%/60%). In the US, UK and France, ILBs are weakly negatively correlated with equities.

The chart below shows the combination of average return and volatility for short-dated nominal bonds, nominal bonds in the 1-10Y bucket and ILBs in the 1-10Y bucket. In the selected period inflation-linked bonds have had a higher average return and a higher volatility compared to fixed coupon bonds. The chart on the right shows for the US only standard deviation and average return for various asset classes.
Fixed income assets – a comparison

US: equities, commodities and fixed income

<table>
<thead>
<tr>
<th>Avg. Ret.</th>
<th>US</th>
<th>UK</th>
<th>FR</th>
<th>IT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Avg. Ret.</th>
<th>Nominal</th>
<th>NominalS</th>
<th>ILB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The chart shows historical return and standard deviation since 1997 for the US and UK, since 1999 for France and since 2003 for Italy.

Source: Bloomberg, UniCredit Research
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15 September 2015
Economics & FI/FX Research

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