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NBIM DISCUSSION NOTE

Risks and Rewards of Inflation-Linked Bonds

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Inflation-linked bonds are fixed-income securities whose principal and coupons are linked to price indices. They are designed to eliminate the risk of unexpected inflation to the holders of the bonds. In this discussion note, we compare the risks and rewards of inflation-linked bonds with those of nominal fixed-income securities. We also evaluate the role of index-linked bonds in diversified portfolios.

Main findings

- Inflation-linked bonds have benefits for issuers and investors alike. Issuers may be able to lower their cost of financing, demonstrate commitment to low inflation, extract information for monetary policy purposes, and contribute to the completeness of financial markets.

- For investors, inflation-linked bonds without credit risk are the safest long-term asset, allowing them to reduce long-horizon risk and hedge liabilities, but also take short-term positions on inflation expectations.

- While nominal bonds can serve the strategic purpose of hedging the volatility of the equity risk premium in the short-to-medium term, the strategic function of inflation-linked bonds, when held to maturity, is to hedge long-run inflation risk. The strategic role of inflation-linked bonds therefore differs from that of nominal bonds.

- The yield spread between nominal and real bonds – the so-called break-even inflation rate – is influenced by expected inflation, but can also incorporate an inflation risk premium and a liquidity premium.

- In the intermediate term, the relative return of linkers versus nominal bonds depends on the evolution of break-even inflation rates. Real bonds outperform when break-even inflation rises, which is usually caused by higher expected inflation and/or inflation uncertainty. When break-even inflation falls, for example in a disinflationary scenario, nominal bonds do better than linkers.

- The real yield of linkers reflects the expected path of real short rates, which in turn depends on the outlook for economic growth and inflation. It is also influenced by structural factors such as liability hedging demand from pension funds and insurance companies. The real return might therefore differ from underlying economic growth.

- The appeal of developed-country inflation-indexed bonds to long-term investors currently comes at a high cost in terms of expected returns, as real yields have declined over the last decade and are around zero for an index of developed-country linkers. Emerging-market linkers offer higher real yields.

1 Introduction to inflation-linked bonds

Investors are concerned with the real purchasing power of their savings, yet most fixed-income securities and other savings arrangements are constructed and traded on a nominal basis. Thus, cash flows from most debt instruments are "fixed" only in nominal terms and the real purchasing power of those cash flows is uncertain. Inflation-linked bonds are a notable exception to the dominance of nominal financial instruments.

In this note, we provide a survey of inflation-linked bonds as an asset class. We start by describing the price indexation mechanism that distinguishes linkers from nominal bonds. In Section 2, we review the rationale for linkers from the issuer's point of view. In Section 3, inflation-linked bonds are evaluated from the investor's point of view. We describe the rationale for linkers for long-term investors, discuss the concept of break-even inflation and the inflation-hedging properties of different fixed-income assets. Finally, we study inflation-linked bonds in the portfolio context in Section 4.

1.1 Definition

We use the terms "inflation-indexed bonds", "inflation-linked bonds" and "linkers" interchangeably to mean debt securities whose coupons and repayment are indexed to some index of consumer prices. Inflation-linked securities aim to provide purchasing power certainty for a bondholder and similarly a constant real or inflation-adjusted cost of debt for a borrower or issuer.

Although debt repayments defined as baskets of commodities can be traced back to the 18th century, and some Latin American economies experiencing high inflation issued index-linked bonds during the 1950s and 1960s, the modern index-linked market as we know it today really took off in the early 1980s when the UK Treasury initiated its inflation-linked bond programme. Australia followed suit in 1985, Canada in 1991, Sweden in 1994 and the US in 1997. The US index-linked bonds commonly known as TIPS (Treasury Inflation-Protected Securities) paved the way for widespread acceptance of the asset class, as well as growth in the volume outstanding and improvements in trading liquidity.

France led the way for countries of the euro area in issuing inflation-linked bonds in 1998, followed by Italy in 2003 and Greece in 2004. With Japan introducing its linkers programme in 2004 and Germany in 2006, all the major developed-country issuers of nominal government bonds had by then responded to growing demand for inflation-indexed securities.

As can be expected from this staggered evolution of national linkers markets, the asset class has not developed in a uniform fashion. Each market has its own conventions and idiosyncrasies. Differences in regulatory and tax treatment lead to diverging demand and supply patterns in the various markets. Despite the differentiated national market structures, the aims that issuers of linkers pursue are broadly similar across countries, as are the motivations of investors in inflation-linked securities.

1.2 Indexation

In this section, we introduce the mechanics of the most commonly used type of inflation-indexed government bond.

Most newly issued inflation-linked bonds follow the so-called "Canadian" model in the indexation of inflation. The Canadian model of indexation allows a fixed-income security to be traded on the basis of its real yield and is considerably simpler than the model originally introduced by the UK Treasury. The advantages of the Canadian model soon became apparent and even the UK authorities switched to it for their inflation-indexed Gilts issued from 2005 onwards.

The important innovation in security design is the use of an index ratio to inflate principal and coupon for a given settlement date. In the Canadian model, the real yield and the so-called break-even inflation can easily be viewed as separate concepts. The real (inflation-adjusted) hold-to-maturity return of an inflation-linked bond is known in advance.

In contrast to nominal government bonds, however, the nominal return of linkers is uncertain and depends on the realised future path of the relevant price index. The mechanics of a Canadian style index-linked bond are illustrated in Table 1 below. The example assumes that the three-year bond is issued with a real coupon of 1.5 percent at a par price of 100 percent and with the relevant price index at a level of 100. Inflation turns out to be 2 percent in the first year, 3 percent in the second and 2.3 percent in the third. The "real" cash flows of the bond are multiplied by the index ratio, which is the price index value at the time of the cash flow divided by the value at time of issuance, to arrive at the appropriate nominal figures. In this example, the nominal return of 3.96 percent can only be computed after the bond has been repaid, while the real return of 1.50 percent is the ex-post and ex-ante return.

Table 1: Simplified indexation mechanics of Canadian-style linker

Period	Inflation	Price index at period end	Cash Flow = Real cash flow x Index ratio	Cash Flow
0		100.00	-100.00	-100.00
1	2.00%	102.00	1.50 x (102.00/100)	+1.53
2	3.00%	105.06	1.50 x (105.06/100)	+1.58
3	2.30%	107.48	(100 + 1.50) x (107.48/100)	+109.09
Ex-post nominal yield				3.96%
Ex-ante and ex-post real yield				1.50%

In practice, the design of the securities varies between countries and is a great deal more complex than that of nominal bonds. Despite some international standardisation due to the success of the Canadian-style security, notable differences remain, which are discussed in detail in our discussion note "The Structure of Inflation-Linked Bond Markets". Some countries, like the US and the euro area issuers, equip their inflation-indexed bonds with guaranteed redemption at par. At issuance, these linkers are not only protected against unexpected inflation but also deflation. Other countries, notably the UK and Japan, do not offer redemption of inflation-linked bonds at par.

Inflation and deflation protection may not be perfect because the reference index (for example the CPI) and the price index most relevant to investors can differ. In other words, investors are exposed to basis risk when the behaviour of the reference index diverges substantially from the prices of the goods and services they ultimately want to consume. For example, the liabilities of a pension fund could be indexed to wage inflation rather than consumer price inflation. University endowments in the US view the Higher Education Price Index (HEPI) as the relevant inflation gauge, while inflation-protected securities are linked to the CPI.

2 Why issue inflation-linked bonds?

The advantages from an issuer's point of view can briefly be summarised as follows:

- **Cost of financing**
  Ex-ante, and in the long run, linkers should be cheaper debt to the issuer than nominal bonds because nominal bonds incorporate an inflation risk premium.

- **Commitment to low inflation**
  A large share of inflation-indexed bonds relative to the total stock of government debt may reduce the sovereign's incentive to inflate and serve as a commitment device.

- **Market completeness**
  Issuance of linkers free of default risk may have social welfare benefits as they contribute to market completeness by providing a truly safe asset to long-term investors.

- **Information extraction**
  Policymakers may be able to infer market expectations of inflation from linkers which is of value for the conduct of monetary policy.

We discuss these perceived benefits to the sovereign in turn.

Cost of financing
A conventional argument in favour of inflation-linked bonds is that they allow the issuer to reduce the cost of financing. This implicitly assumes that investors are more averse to unfavourable changes in consumer prices than issuers and that the former are willing to pay a premium for protection against inflation. This "inflation risk premium" will be reflected in a lower (ex-ante real) yield paid by the issuer on debt instruments that confer such protection. In particular, investors who want to finance a real consumption stream, but have few assets that correlate positively with consumer prices (for example human capital), have a great deal to gain from having access to an inflation-protected asset.

A related argument in favour of linking the sovereign's debt to prices is that it allows more precise matching of the government's assets and liabilities (e.g. Barro 1997). A large share of the government's income is quasi-indexed to inflation in the sense that taxes are mostly levied on nominal bases. This is most evident with value-added taxes on sales, but is also true for direct taxes on personal and corporate incomes. Governments may be able to reduce the risk in their balance sheet by making their liabilities inflation-linked in a similar way that their assets (the net present value of tax revenues) already are. This asset/liability argument also suggests that sovereign and some corporate issuers with explicit or implicit inflation indexation in their revenues (such as retailers and utility companies) are able to bear the inflation risk that some investors would like to reduce.

Some sovereign issuers have rationalised their decisions to issue inflation-linked bonds with the potential for cost savings. Reschreiter (2004) shows that the UK has been able to reduce the real cost of government financing ex-post. Although there is evidence that this is the case for some other countries, Sack and Elsasser (2002) suggest that the US is a counterexample.

While it is not entirely clear why the US experience was different, a possible explanation is that replacing nominal debt with inflation-linked bonds may create segmentation of public debt into a greater number of less liquid issues. If governments have to pay a higher real yield on linkers to attract investors to a relatively illiquid asset class, the additional cost of doing so may offset the savings on the inflation risk premium embedded in nominal bonds.

Commitment to low inflation
Kydland and Prescott (1977) show that a government's plan to keep inflation low may lack credibility because it is "time-inconsistent". Policymakers are tempted to renege on their commitment to low inflation in favour of surprise inflation and a temporary boost to growth. Unexpected inflation may be in the interest of a highly indebted fiscal authority as it reduces the real cost of nominal liabilities.

However, Persson, Persson and Svensson (1987) show that the temptation to erase government debt via inflationary surprises decreases as the share of inflation-linked government debt to total debt increases.

The issuance of inflation-linked bonds may also have an indirect positive effect on the government cost of financing by reducing the inflation risk premium borne by the nominal debt outstanding. On other hand, Miller (1997) argues that an independent central bank can overcome the commitment problem faced by policymakers. In that context, both independent central banks and indexed bonds can be thought of as institutions that signal credible pre-commitments to low inflation. A country with central bank independence and high credibility in delivering low inflation may have less need for issuing indexed bonds as an additional signal of commitment to economic agents.

Therefore, most central banks have historically been less than enthusiastic about the issuance of inflation-linked bonds. In addition to central bank independence being perceived as a substitute for indexed bonds as a commitment device, there was the fear that indexing government debt might lead to more widespread indexation of financial contracts as well as wages. The experience with linkers in the last three decades has shown that this concern was probably overstated.

However, neither central bank independence nor indexed bonds are absolute commitments. The independence of central banks can be reversed or undermined politically and issuers of inflation-linked bonds can expropriate investors after the fact by manipulating the published rate of inflation and in other ways.

Market completeness

While reducing the cost of financing for the issuer superficially appears to be a rationale for issuing linkers that is at the expense of investors, the desire to commit to low inflation discussed earlier is borne out of social welfare considerations. Market completeness is another social benefit that may motivate sovereign issuers of index-linked bonds. As we will demonstrate later, inflation-linked bonds fulfil a unique function in financial markets as they are the only asset – in the absence of credit risk and when held to maturity – to provide a long-horizon hedge against the risk of unanticipated inflation and variations in real interest rates. The coexistence of nominal bonds and inflation-linked bonds also allows market participants to take speculative positions on inflation expectations and thus contributes to market completeness.

In theory, inflation-indexed corporate bonds (or more generally indexed securities issued by private entities) could take the role that we have implicitly assigned to sovereign linkers so far. However, most government bonds probably have a comparative advantage over privately issued bonds. Since sovereigns have the power to tax and often also issue their own currency, governments bonds are mostly as close as investors get to an asset that simultaneously provides protection against both credit risk and inflation risk.

By offering inflation-linked bonds, the government can also help to overcome one of the disadvantages that private individual pensions have compared to public pensions (and some employer pension schemes). Typically, public pension benefits are explicitly linked to consumer prices, i.e. they protect their beneficiaries against increases in the cost of living. The availability of index-linked bonds makes it easier for private pension providers to convert retirement accounts into inflation-indexed annuities that are similar in credit risk to public pension payments.

Information extraction

A side benefit of issuing inflation-indexed securities is that policymakers may be able to gauge the market's expectation of future inflation from the spread between nominal and real yields. This can be valuable in the conduct of monetary policy when timely readings on the public's inflation expectations can give indications of coming inflationary or disinflationary pressures. However, as we discuss in detail in Section 3, the yield spread between nominal and indexed bonds can be more accurately thought of as the compensation required to offset expected future inflation and the related risks. It is commonly known as the "break-even inflation" (BEI) rate.

While such a measure of inflation compensation could be used as a proxy for inflation expectations, it has several shortcomings (Sack 2000). There have been substantial differences between the liquidity of nominal bonds and linkers, diminishing the value of the yield spread as a pure expectations measure. Furthermore, the inflation risk premium embedded in nominal bonds may be non-negligible and time-varying, also complicating the interpretation of the break-even inflation rate. Sack (2000) and Pflueger and Viceira (2012) show that these challenges are surmountable, however, and that inflation risk premia and liquidity differentials can be quantified.

We argue in Section 4 that a decomposition of break-even inflation can be informative from the investor's point of view as well. Breaking down the spread between nominal and real yields into expectations and risk premia components may enable investors to gauge the relative attractiveness of nominal versus inflation-linked bonds over time.

3 Inflation-linked bonds from the investor's point of view

Although issuers and investors may at first sight have conflicting objectives when it comes to inflation-linked securities, a thorough examination of the motivations reveals that the relationship is not necessarily adversarial.

3.1 Why buy inflation-linked bonds?

The availability of inflation-linked bonds has a number of potential benefits for different types of investors. We discuss the following three:

- **Risk reduction for long-term investors**
  Linkers can narrow the distribution of real return outcomes at long horizons or eliminate the risk altogether if credit risk is absent. Other assets such as nominal bonds and T-bills cannot achieve that objective to the same degree.

- **Hedging real liabilities**
  Pension funds and other institutional investors often have liabilities that are explicitly linked to inflation. Indexed debt will allow such investors to hedge the inflation sensitivity of their obligations.

- **Taking short-term positions**
  Investors with shorter time horizons can take positions in inflation-linked and nominal bonds to express views on inflation relative to what market expectations are.

Risk reduction for long-term investors
The most important benefit to long-term investors is that inflation-linked bonds offer protection against unexpected increases in inflation over long investment horizons. In the absence of credit risk, inflation-linked bonds provide a real yield to maturity that is known at the time of purchase. Arguably, linkers therefore are the best available hedge against inflation risk and real interest rate risk when held to maturity, as first shown by Campbell and Viceira (2001). The important role of inflation-linked bonds for long-term conservative investors is succinctly summed up by Campbell, Shiller and Viceira (2009):

"An inflation-indexed perpetuity delivers a known stream of real spending power to an infinite-lived investor, and a zero-coupon inflation-indexed bond delivers a known real payment in the distant future to an investor who values wealth at that single horizon."

Related to this argument is the portfolio diversification view, which studies the mean-variance efficiency of portfolios with and without inflation-indexed bonds. Using historical covariances, Kothari and Shanken (2004) argue that a substantial weight should be given to US TIPS in efficient portfolios. Roll (2006) also shows that a diversified portfolio of US equities and nominal bonds would be improved by the addition of TIPS.

Classical mean-variance optimisation essentially takes a one-period asset allocation view. For long-lived investors, such a view might not be the most appropriate. Campbell, Shiller and Viceira (2009) study the benefits of having inflation-indexed bonds at an investor's disposal when the investment horizon is longer. The measure that quantifies the benefit is the reduction in long-run portfolio standard deviation that the availability of linkers makes possible. Since indexed bonds deliver a certain real return over their term, the minimum long-run risk portfolio consists entirely of these bonds and has zero long-run risk (if the investment horizon coincides with the term of the bonds). The risk reduction achievable can be obtained by computing the long-run standard deviation of a portfolio of other assets chosen to minimise long-run risk (the global minimum variance portfolio, GMV). Campbell, Shiller and Viceira (2009) conduct this exercise with portfolios of US stocks, nominal five-year Treasury bonds, and three-month Treasury bills. They show that the annualised ten-year standard deviation of the real return of the GMV portfolio varies considerably over time, from around 1 percent in the 1960s to as high as 4 percent in the early 1980s and around the crisis of 2008. The risk reduction achievable using TIPS is certainly substantial for long-term investors.

Whether inflation-linked bonds should form part of a particular investor's portfolio depends not only on their risk properties, but also on their expected returns relative to other asset classes and the investor's risk tolerance.

Hedging real liabilities

Pension funds and insurance companies often have long-dated liabilities that are explicitly or economically tied to inflation. For example, defined-benefit employer pension benefits are often linked to salaries and their present value is computed by discounting them at long-term real interest rates. When the latter is the case, inflation-linked bonds can be used to hedge against changes in the actuarial value of liabilities. The UK and the Dutch pension fund regulations have been particularly strict in requiring institutional investors to discount liabilities using real market rates. The structural demand for inflation-indexed bonds has been commensurately high in these countries, and contributed to reducing the real yields on indexed bonds in the UK and the euro area (Vayanos and Vila 2009).

Taking short-term positions

Long-term inflation-indexed bonds can also be used to express views on inflation relative to what is discounted in market prices. While nominal bonds are a bet on unexpected disinflation or even deflation, linkers benefit from higher-than-anticipated inflation. Indexed bonds can also be used to take outright positions on predicted changes in real yields. When sold before maturity, the return of linkers can vary greatly depending on intermediate movements in real yields.

Like nominal bonds, inflation-indexed debt was generally an effective hedge against declines in stock markets during the downturns of the early and late 2000s, which can make them attractive to short-term equity investors.

Inflation-indexed bonds are less liquid than their nominal counterparts, which could be a disadvantage to short-term investors. However, as the financial crisis demonstrated, the liquidity premium embedded in linkers can vary greatly over time and opportunistic investors may want to invest in linkers when liquidity premia are high.

3.2 Break-even inflation

The concept of break-even inflation is of great relevance when comparing inflation-indexed bonds with nominal bonds. It can be derived from the following variant of the Fisher equation for a nominal and an inflation-indexed security of the same maturity.

$$1 + i = (1 + r) \cdot (1 + \pi_{BE}) \qquad (1)$$

The nominal gross yield *(1 + i)* of a conventional bond is the product of the real yield *(1+ r)* (here the one of inflation-linked bonds) and break-even inflation (in the original Fisher equation this is expected inflation). Break-even inflation is so called because when, from the time of purchase until maturity, realised inflation turns out to be exactly the same as break-even inflation, the nominal ex-post return is the same for linkers and nominal bonds.

When yields and inflation rates are low, this can be approximated by a simpler relationship, which is commonly used in developed linkers markets: break-even inflation is approximately the yield spread, the difference between the yield from nominal bonds and the real yield from inflation-linked bonds.

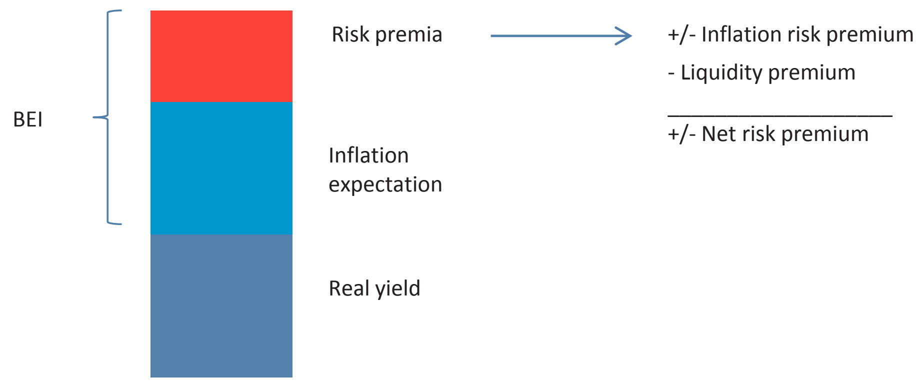
$$\pi_{BE} \approx i - r \qquad (2)$$

As yields and inflation rates rise – for example, they are usually higher in emerging markets than in developed linkers markets – the approximation error of this relationship gets larger and it will become preferable to use the exact version in Equation (1).

Very importantly, break-even inflation is not the same as expected inflation although some market participants and even policymakers sometimes loosely treat it as such.

As mentioned earlier, nominal bonds are riskier than linkers in real return terms. Risk-averse long-term investors would prefer linkers if the (guaranteed) real yield on linkers was the same as the expected (but uncertain) real yield on nominals. The yield spread, the break-even inflation rate, therefore is the sum of expected inflation and various risk premia (see Chart 1). For that reason, break-even inflation is sometimes called inflation compensation.

Chart 1: Decomposition of break-even inflation



The risk premia component comprises information about the perceived risks surrounding inflation expectations (as an inflation risk premium). Given that nominal bonds expose long-term investors to inflation risk while linkers do not, nominal bonds should carry a positive inflation risk premium, which raises break-even inflation. More recent research by Pflueger and Viceira (2011) suggests that the inflation risk premium can sometimes be negative when nominal bonds are a good hedge for equity risks.

On the other hand, linkers are less liquid than nominal bonds, which tends to reduce the break-even inflation rate. Pflueger and Viceira (2012) show that the liquidity differential is quantitatively significant in the US and has varied considerably over time. They estimate the liquidity premium to be around 30 basis points under normal market conditions, but it was significantly higher when TIPS were first issued in 1997 (around 70-100 basis points) and reached as much as 150 basis points at the height of the financial crisis in the autumn of 2008.

Depending on the sign and relative magnitude of inflation risk and liquidity premia, the net risk premium of nominal bonds vis-à-vis linkers can be positive or negative.

The calculation of break-even inflation is straightforward, but the decomposition into its components is subject to model choice. Surveys can be used to measure expectations, and liquidity cost scores to measure the liquidity premium.

Table 2: Hold-to-maturity returns of linkers vs. nominal bonds

Scenario	Relative hold-to-maturity performance
Realised inflation = BE inflation	Linker return = Nominal bond return
Realised inflation > BE inflation	Linker return > Nominal bond return
Realised inflation < BE inflation	Linker return < Nominal bond return

Moreover, there is a useful interpretation of break-even inflation in terms of the relative hold-to-maturity return of linkers versus nominal bonds under different inflation scenarios, which is summarised in Table 2. If realised inflation turns out to be exactly the same as break-even inflation, linkers will have the same ex-post return as nominal bonds, i.e. they break even with nominal bonds. If realised inflation exceeds BEI, linkers generate a higher return. If realised inflation is lower than BEI, linkers underperform. When held to maturity, linkers are a perfect hedge against the scenario that realised inflation exceeds the inflation compensation discounted at the time of purchase. Investors with a horizon of ten years should buy ten-year linkers to hedge inflation over their investment horizon, i.e. risk-averse investors should match the maturity of their linker investment with their liabilities.

In the intermediate term, i.e. before maturity, the return of linkers additionally depends on real yield changes. The two-by-two matrix in Table 3 tries to capture in a simplified way the instantaneous price response of linkers and their relative performance versus nominal bonds as a function of real yields and BEI. While real yield movements determine the immediate *absolute* price return of linkers, the change in BEI is crucial for the immediate *relative* performance of indexed to nominal bonds.

Table 3: Instantaneous return sensitivities of linkers vs. nominal bonds

Break-even inflation ↑	Linker + Nominal +/- Linker outperforms Nominal	Linker - Nominal - - Linker outperforms Nominal
Break-even inflation ↓	Linker + Nominal ++ Nominal outperforms Linker	Linker - Nominal +/- Nominal outperforms Linker
	Real Yield ↓	**Real Yield ↑**

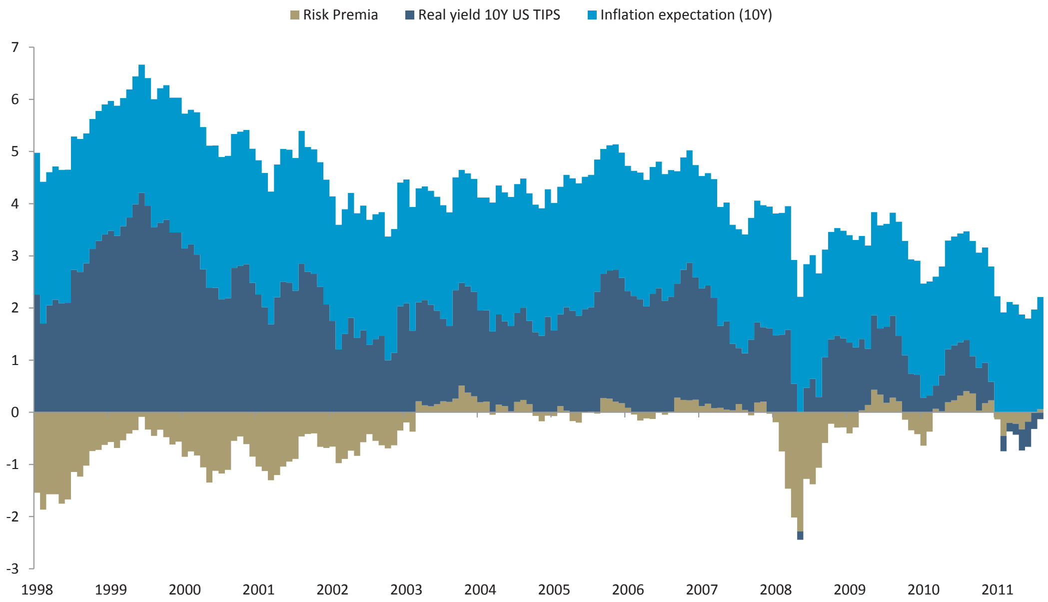
A drop in real yields causes the price of linkers to increase, but nominal bonds can still outperform when BEI decreases at the same time (bottom-left quadrant) because of the greater yield decline and corresponding price impact on nominal bonds. A disinflationary environment with slowing economic growth would be consistent with this scenario. Conversely, when real yields rise, the price of linkers declines. If break-even inflation rises at the same time, however, linkers can outperform nominal bonds (top-right quadrant). This scenario is most consistent with more vigorous economic growth, rising real interest rates and increased inflation risk.

The top-left quadrant describes the case of declining real yields and rising BEI, which can be thought of as a stagflation scenario in which inflation-linked debt experiences price increases and outperforms nominal debt. Finally, the scenario where real yields climb and BEI falls (bottom-right quadrant) can have two interpretations. The benign interpretation is a "Goldilocks" economy with accelerating economic growth and slowing inflation. More worryingly, such a combination could also come about when sovereign credit risk increases and coincides with a drop in inflation risk due to weak economic growth. Inflation-linked bonds of some euro area countries appear to have experienced this scenario as a result of rising public indebtedness that is not offset by loose monetary policy.

3.3 Economic determinants of real yield and break-even inflation

Macroeconomic determinants play an important role in influencing real yields and break-even inflation and interact with the structural and liquidity factors mentioned previously. The real yield of inflation-linked bonds should conceptually be linked to economic factors such as the path of real short rates and economic growth, while break-even inflation is a function of monetary policy credibility. To shed further light on the time variation of these determinants, Chart 2 plots a decomposition of the ten-year US nominal yield into the real TIPS yield, inflation expectations (from long-run Consensus forecasts) and a risk premium component.

Chart 2: Decomposition of yields and break-even inflation

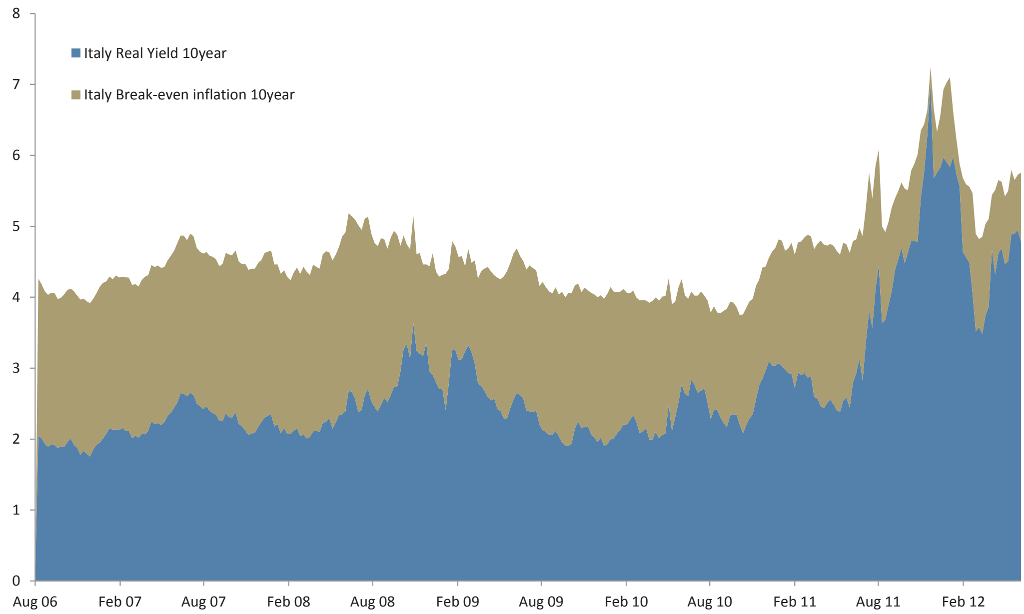


Source: Bloomberg, Consensus Economics

Long-run inflation expectations have been largely stable, reflecting a fairly high degree of monetary policy credibility. The real linkers yield has declined since the start of the financial crisis, coinciding with a new paradigm of low growth ("the new normal") and very low policy rates. The risk premium component contains the inflation risk premium of nominal bonds (with either positive or negative sign) and the liquidity premium of linkers (with negative sign).

A negative net risk premium suggests either that the liquidity premium dominates a positive inflation risk component, or that the inflation risk premium is negative. Between 1997 and 2003, when TIPS were less widely traded, a large liquidity premium could explain the negative risk premium of inflation-linked bonds. The net risk premium also became deeply negative around the bankruptcy of Lehman Brothers when a flight to more liquid nominal bonds occurred. Maybe surprisingly, the net risk premium has never been highly positive, i.e. the expected compensation for holding riskier nominal bonds over linkers has never been ample. This is despite the fact that inflation uncertainty has been considerably elevated after the financial crisis, as suggested by the rising standard deviation of economists' inflation forecasts collected by Consensus Economics. A global disinflationary demand shock and unconventional reflationary central bank policies have come together to increase the range of possible inflation outcomes.

Chart 3: Real yield and break-even inflation for Italian linkers



Source: Bloomberg

A further note of caution when interpreting moves in real linkers yields is that rises in real linkers yields are not always a sign of economic health. In the US, the UK and Japan (all countries which control their own currency), real yields declined after the crisis because of lower growth expectations. In some European countries, for example in the Italian linkers market, real yields climbed not because of improving growth, but on concerns over sovereign creditworthiness (see Chart 3). Because Italy does not control its own currency, default risk is more serious than inflation risk and higher real yields are required to compensate for that default risk.

3.4 Inflation-hedging properties of fixed-income assets

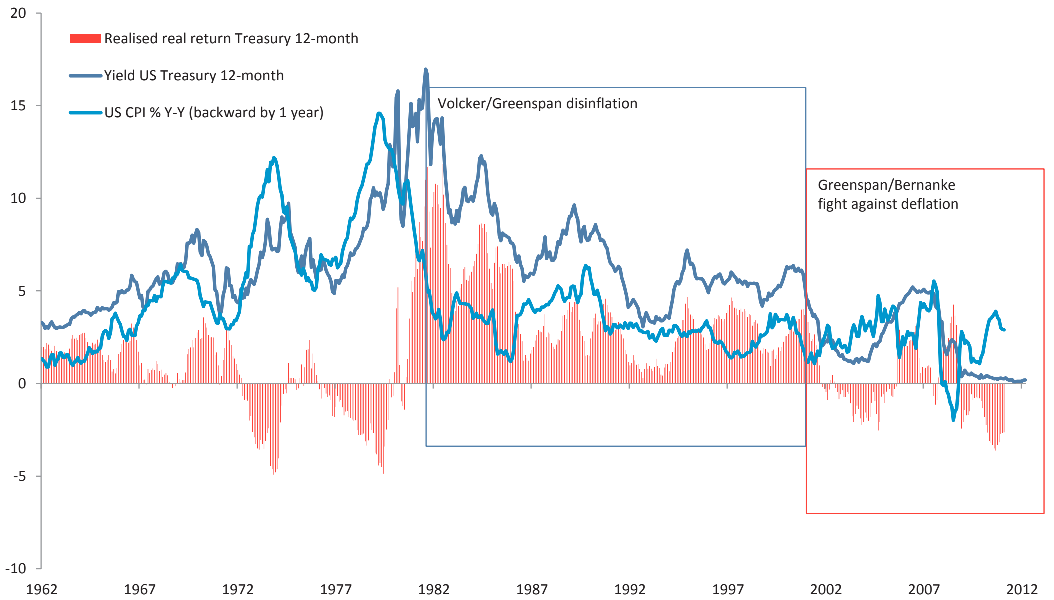
We now compare the inflation-hedging properties of linkers with nominal bonds and T-bills. Campbell, Shiller and Viceira (2009) argue that nominal bonds and T-bills could theoretically perform the function of inflation-linked bonds, but are unlikely to provide safe real returns under realistic conditions.

Nominal bonds are substitutes for linkers only if central banks could achieve perfect credibility, in which case the break-even inflation rate is constant. The events of the recent financial crisis have demonstrated that inflation expectations and the associated inflation risk premium can be highly unstable in the face of unconventional monetary policy measures.

Second, if the ex-ante real interest rate was constant, as argued by Fama (1975), then long-term investors could roll over Treasury bills to achieve almost perfectly certain long-term real returns. As inflation uncertainty is low over short periods such as a month, Treasury bills do not expose investors to a great deal of inflation risk. In general, they do expose investors to the risk of persistent variation in the real interest rate, but this risk is absent if the real interest rate is constant over time.

However, short-term yields are anchored by policy rates, and we illustrate with Chart 4 that the inflation-hedging properties of bills may strongly depend on the monetary policy regime. The chart shows US Treasury one-year yields and realised US inflation, and the red columns signify the real return from buying one-year debt and holding it to maturity (i.e. realised inflation in the holding period is deducted from the yield). It is evident that real ex-post returns are highly variable and that their levels appear to be dependent on the policy regime.

Chart 4: Realised T-bill returns



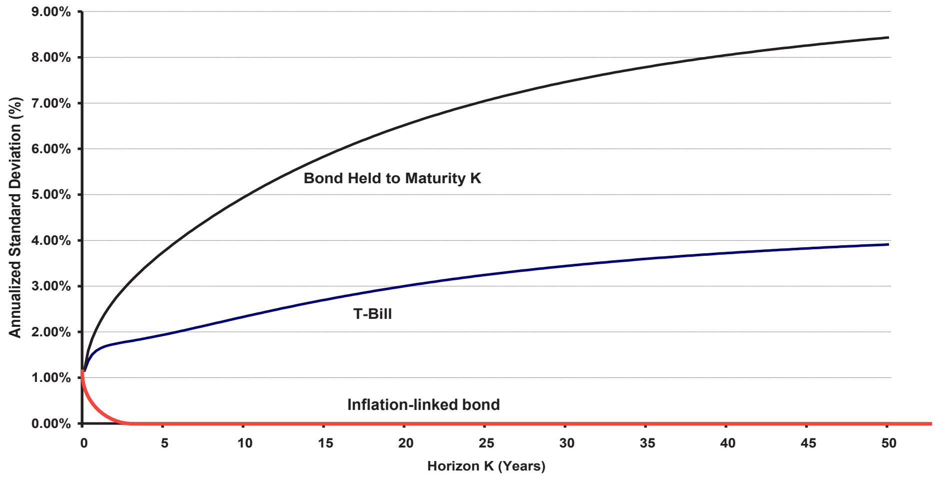
Source: Factset Economics

Real returns are mostly positive before the 1970s and they are highly positive in the disinflationary period under Volcker and Greenspan in the 1980s and 1990s. However, during the 1970s and in the 2000s, short-dated debt did not protect against inflation. Real returns were negative over prolonged spells with the worst real returns reaching -5 percent. Arguably, the oil shock and policy mistakes played their part in the 1970s. In the 2000s, major central banks were concerned about deflation and the financial crisis and kept short-term rates low for very long periods. Therefore, shifts in monetary policy emphasis can change the inflation-hedging properties of bills.

To further illustrate the point that linkers are safer in real return terms, we show in Chart 5 the real return standard deviations of nominal bonds, T-bills and linkers over investment horizons up to 50 years derived from a vector-autoregressive model by Campbell and Viceira (2005). While the nominal return of conventional bonds held to maturity is certain, their risk in real return terms stems from the effects of cumulative unexpected inflation over the term of the securities, which increases with the investment horizon. The same applies to the standard deviation of real T-bill returns, which is caused by persistent variation in the real interest rate in the post-war period. When Treasury bills are reinvested over long horizons, the variation in real rates amplifies the volatility of returns.

In contrast, the risk of inflation-indexed bonds in terms of real returns is zero when the term of the instrument is matched with the investment horizon. The unique role of linkers arises from the fact that they are the only instruments that allow investors to lock in real returns and protect against inflation over longer horizons (even if the real linker yield is currently mildly negative for some important markets).

Chart 5: Annualised standard deviations of real returns implied by VAR(1) model



Source: Viceira (2012)

However, the inflation-hedging ability of linkers may be undermined by two risks. First, the reference index may not accurately reflect the true cost of living. For example, there is evidence that official price statistics in some markets understate the economic rate of inflation (Cavallo 2012). Second, changes to the way the reference index is computed may put investors at a disadvantage. The UK discussion of switching the calculation of the RPI, the relevant index for UK index-linked Gilts, from arithmetic to geometric aggregation is a case in point. Doing so may lower the rate of measured inflation by a substantial amount and reduce the expected returns to indexed debt as the RPI has been higher by around 70 basis points than a similar price index based on geometric aggregation (Johnson 2012).

4 The role of inflation-linked bonds in diversified portfolios

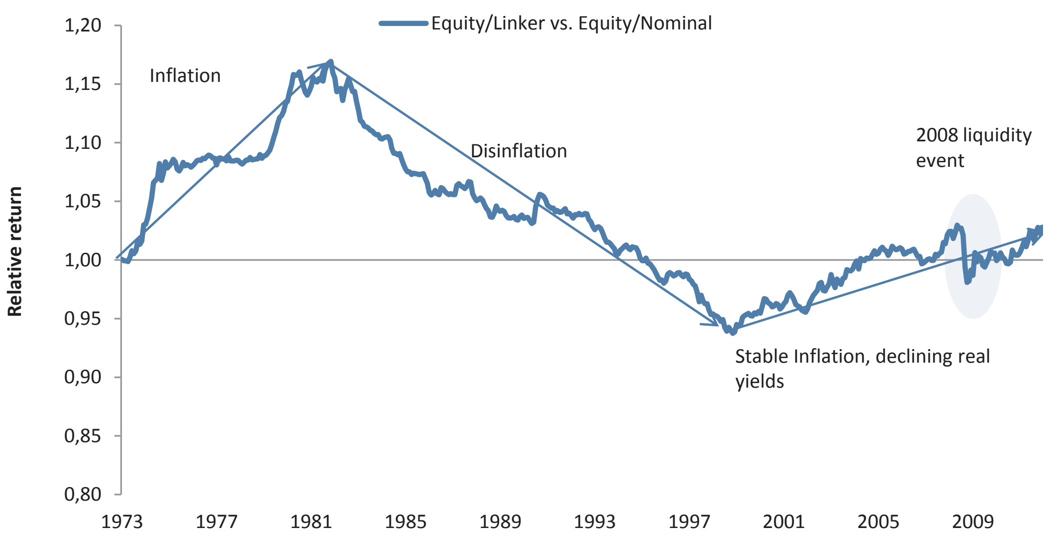
We now turn to studying the role of linkers in a portfolio context, using two methods: historical back-test and Black-Litterman portfolio optimisation.

4.1 Historical back-test

The first approach we use to gain insight into this question is by historical back-test. The starting point is a portfolio of financial assets, here applied to the US market, consisting of 60 percent of the S&P 500 equity index and 40 percent of the US Government & Credit bond index. We ask how the portfolio behaves if we replace the 40 percent nominal fixed income with linkers.

The challenge in this exercise is that US linkers were only introduced in 1997, but the 1970s and 1980s are particularly interesting periods to study. To do so, we need to construct a synthetic inflation-linked return series. We take the approach suggested by Barclays Capital (Pond and Mirani 2009) and model real yields as a function of macroeconomic variables first. We then compute break-even inflation and infer the linker returns. Chart 6 shows the relative performance of the portfolio with linkers versus the one with nominal bonds.

Chart 6: Relative return of diversified portfolios with linkers vs. nominal bonds (US)



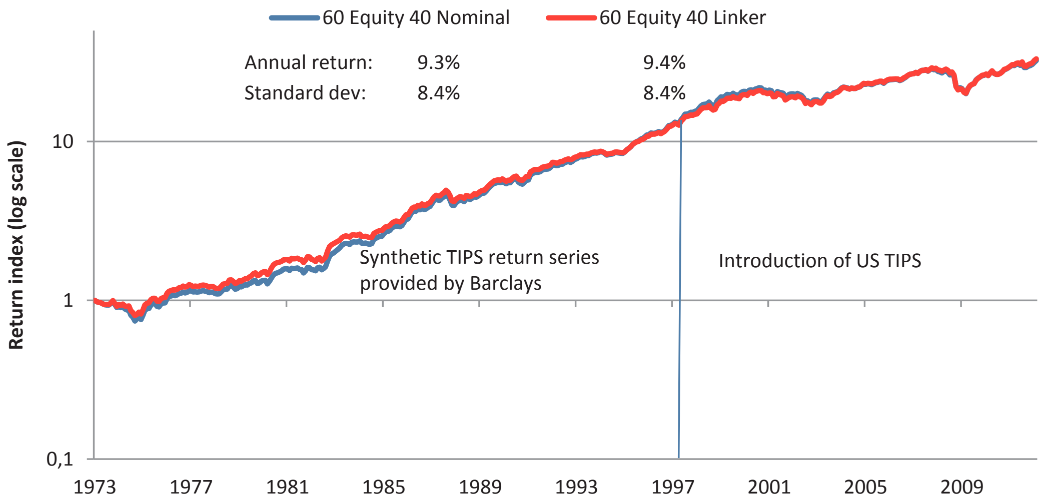
Source: Barclays, Factset Economics, Bloomberg

This relative return goes through some pronounced and long cycles. In the 1970s, when inflation arguably surprised market participants and central banks, linkers would have outperformed strongly and so would a diversified portfolio with linkers. They then more than gave up that outperformance against nominal bonds during the disinflation of the 1980s and early 1990s.

Since the introduction of US TIPS in 1997, inflation-linked bonds have achieved a higher return than nominal bonds despite a broadly stable inflation environment. The decline in real yields and the higher duration of linkers have contributed to that superior return.

While we have seen that there are prolonged cycles of out- and underperformance in linkers versus nominal bonds, the return and standard deviation of both portfolios over the entire sample are virtually the same, as Chart 7 shows.

Chart 7: Long-run return and risk of portfolios with linkers vs. nominal bonds (US)



Source: Barclays, Factset Economics, Bloomberg

There are two explanations for this. First, the Fisher equation holds in the long run when yields are market-determined. While the market may sometimes underestimate and sometimes overestimate inflation, such errors tend to cancel out, and the returns of linkers and nominals are close to each other over the full sample period. Second, with regard to portfolio return volatility, it is the equity component that drives portfolio risk. Both equities and nominal bonds suffer during inflationary periods, but even replacing all nominal bonds with linkers has no substantial impact on portfolio volatility in the long run because the latter is driven by the equity component.

4.2 Forward-looking portfolio choice

Historical back-tests are useful, but have their limitations. We therefore use a second approach to shed light on the possible role of linkers in a portfolio context, a more forward-looking method based on mean-variance optimisation following Markowitz. It is well-known in the literature that the traditional Markowitz method, especially when it uses historical data for expected returns, produces counterintuitive and extremely concentrated portfolios that perform poorly out of sample.

The Black-Litterman method of portfolio optimisation overcomes some of the shortcomings while retaining the rigour of Markowitz approach. First, it takes the market capitalisation weights of asset classes as the starting point, which is usually a well-balanced portfolio, and infers so-called equilibrium expected returns. The equilibrium returns are the expected returns that make the market capitalisation portfolio optimal in the Markowitz sense. Then, in a second step, we specify where we think expected returns could deviate from the equilibrium. These are called "views" and allow us to incorporate returns that are different from equilibrium under different economic scenarios. Finally, we derive the asset class weights that are Markowitz-optimal, i.e. that maximise return for given levels of risk, for each of the scenarios.

In Table 4, we show the inputs of our portfolio construction exercise with four asset classes: global equities, Treasuries, corporate bonds and inflation-linked bonds. The data sample for the covariance matrix is from 1997 to 2011. The market weights and the implied equilibrium excess returns are given in the first two columns on the left. The derived equilibrium returns seem to make intuitive sense. For example, the implicit equity risk premium is about 5 percent, which is within a range that is plausible.

Then we define three scenarios. One is a recovery scenario, one is an inflation scenario and one a deflation scenario. (Here, inflation and deflation are mild.) Since we have a holding period in mind that is roughly equal to the maturity of the fixed-income portfolio, the nominal returns of nominal

Treasuries and corporate bonds are assumed to be independent of the scenario. We anchor the expected excess returns of Treasuries at the equilibrium return of 0 percent. We obtain an excess return of 1.5 percent for corporates (derived from a 2 percent credit spread minus 0.5 percent credit losses – which is a conservatively high assumption for losses) and assume that defaults do not vary substantially across scenarios.

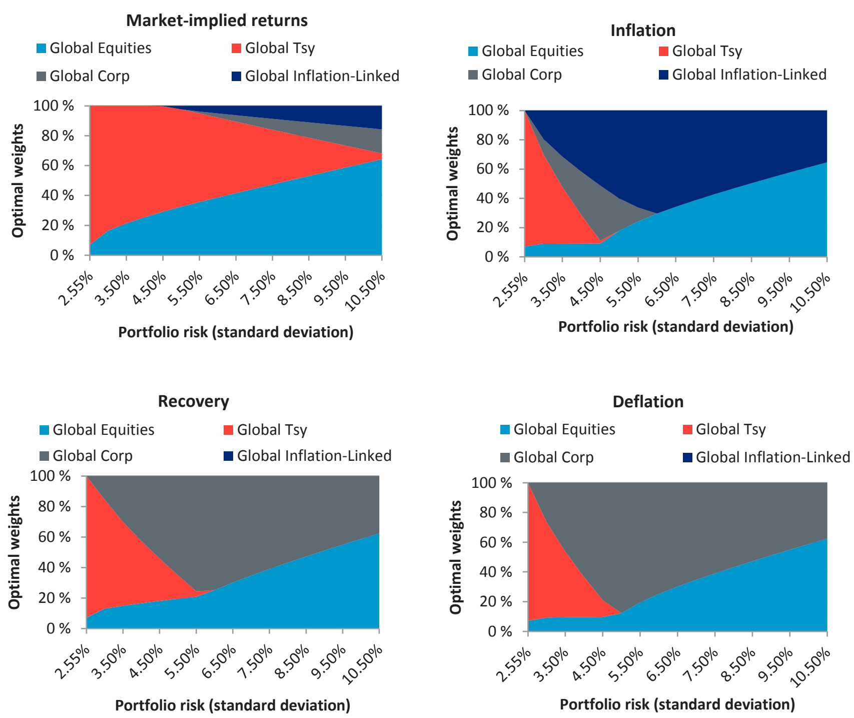
We assume that equities achieve the equilibrium excess of 5 percent under recovery, but suffer slightly under either inflation or deflation, which is consistent with empirical patterns. The most important assumptions in this analysis concern the inflation-linked bonds. We assume that they obtain roughly the equilibrium return of 0.5 percent under the recovery scenario, but that they generate a 1.5 percent nominal excess return under the inflation scenario and a negative 0.5 percent under the deflation scenario.

Table 4: Market weights, equilibrium and scenario returns for Black-Litterman optimisation

Asset class	Market weights	Implied excess returns from market weights	Excess returns, scenario 1 (recovery)	Excess returns, scenario 2 (inflation)	Excess returns, scenario 3 (deflation)
Global equities	49%	4.9%	4.9%	3.0%	3.0%
Global Treasuries	37%	0.0%	0.0%	0.0%	0.0%
Global corporate bonds	11%	0.6%	1.5%	1.5%	1.5%
Global inflation-linked bonds	3%	0.4%	0.5%	1.5%	-0.5%

In Chart 8, we show the Markowitz-optimal allocations for the equilibrium and scenario returns for different levels of portfolio risk. As investors get less risk-averse, they substitute Treasuries for equities in all four cases. To varying degrees, they also substitute Treasuries for corporate bonds and linkers. In the recovery and deflation scenarios, corporate bonds dominate linkers. (Under those scenarios, they have higher expected returns at similar volatility). In the inflation scenario, however, as one would expect, linkers take a very important role and at higher risk levels the optimal portfolio would consist of equities and linkers only.

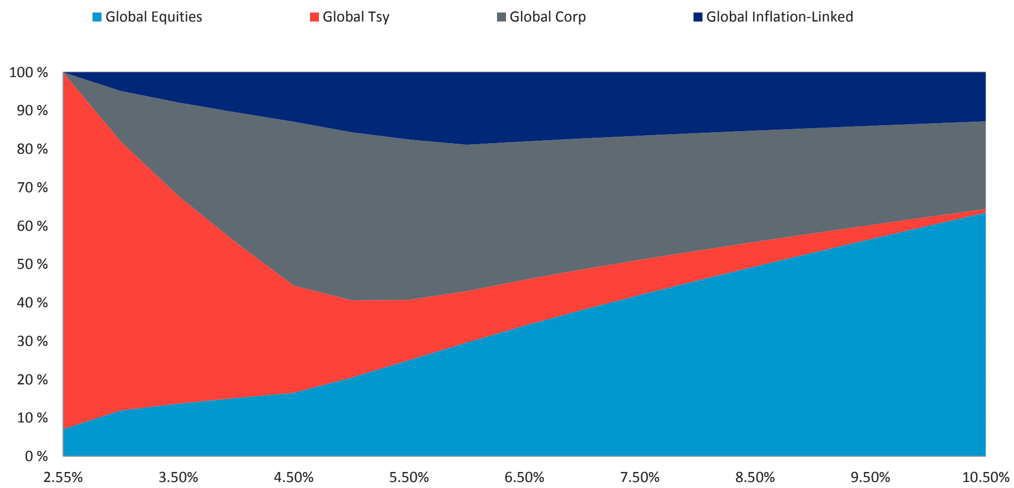
Chart 8: Optimal allocations by return scenario



The analysis shows that inflation-linked bonds are attractive under the inflation scenario such that they dominate Treasuries and corporate bonds in mean-variance optimal portfolios. In our recovery and deflation scenarios, they are dominated by corporate bonds and play no role.

Linkers have a different strategic role from nominal bonds in that they can be expected to perform well in different economic scenarios. Chart 9 below plots optimal portfolio weights for a simple average of the three scenarios. A substantial weight is given to inflation-linked bonds as a consequence of their importance in the inflation case.

Chart 9: Optimal portfolio weights for average of three scenarios



Source: Barclays, Factset Economics, Bloomberg

Finally, we outline avenues for future work on the inflation sensitivity of diversified portfolios, and whether and how that sensitivity should be addressed. While the Black-Litterman method is an improvement over conventional mean-variance optimisation, it still has some of the latter's limitations. Importantly, it focuses on the period-by-period (for example monthly) volatility of nominal portfolio returns. As a long-term investor, this is not necessarily the most suitable measure of "risk". Instead, the distribution of real returns at longer horizons may be more important. For example, we may be interested in the probability that ten- or 20-year real returns fall below an acceptable level. In future work, we therefore intend to broaden this research project on inflation-linked bonds into a wider study of long-term inflation sensitivity and real assets.

To study risk at longer horizons, we intend to conduct follow-up analyses using an approach advocated in Campbell and Viceira's (2005) book on long-term portfolio choice, which relies on modelling asset returns in a vector autoregressive (VAR) framework. We also intend to study inflation-linked bonds in the context of other real assets, such as real estate and alternative real assets such as commodities and farmland.

4.3 The role of inflation-linked versus nominal bonds: a literature survey

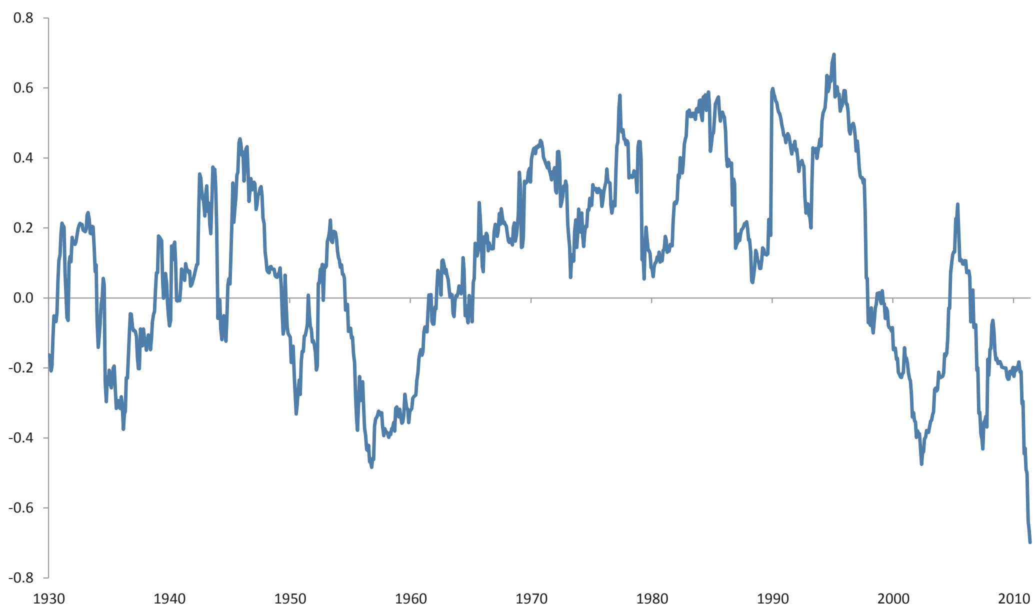
Recent research into portfolio choice, which explicitly models the long horizon of investors, points to the important role that inflation-linked bonds play. In particular, Campbell and Viceira (2001) show that a linker that matches an investor's consumption plan can be considered *the* risk-free asset, not short-term T-bills as in the one-period mean-variance framework. In the absence of default risk, an inflation-linked bond provides a certain real return when its term is matched with the investor's horizon. On the other hand, T-bills that do not match the timing and horizon of investors' consumption should be considered risky when real interest rates vary over time.

Nominal long-term government bonds are also risky because they expose investors to inflation risk. However, Campbell, Sunderam and Viceira (2012) point out that the inflation risk premium can be positive or negative, depending on the correlation of inflation with economic conditions. In a "stagflationary" scenario where the real return of nominal bonds declines when economic growth is poor, risk-averse investors demand a positive inflation risk premium for holding nominal bonds. On the other hand, the inflation risk premium may be negative when inflation and growth move together because nominal bonds will provide a hedge to risk-averse investors.

This hedging property of nominal bonds, which is related to their ability to hedge against fluctuations in equity returns, can be seen as one of their key strategic functions. However, it is likely that the diversification benefits of nominal bonds are not constant. For example, the belief in the hedging ability of nominal bonds for equity risk may be conditioned on the experience of the last decade when there was a strong negative correlation between equity and bond returns. Campbell, Sunderam and Viceira (2012) point out that the covariances between bond returns and equity returns are unstable over time. Traditional asset allocation exercises, for example mean-variance optimisation, assume that the structure of risk between asset classes is constant over time. According to Campbell, Sunderam and Viceira (2012), such an assumption may lead to over-reliance on the diversification benefits of nominal bonds.

The covariance between stock and bond returns can be seen to be regime-dependent. A state when the covariance is positive, and thus the hedging ability of bonds is low, may correspond to an environment in which the Phillips curve is unstable, perhaps because supply shocks are hitting the economy or the central bank lacks anti-inflationary credibility. The stagflationary environment of the 1970s could be characterised this way. On the other hand, a negative covariance could reflect a stable Phillips curve and high monetary policy credibility, which was arguably the regime in the 1990s and 2000s (see Chart 10).

Chart 10: Three-year rolling correlation of ten-year Treasury and S&P 500 returns

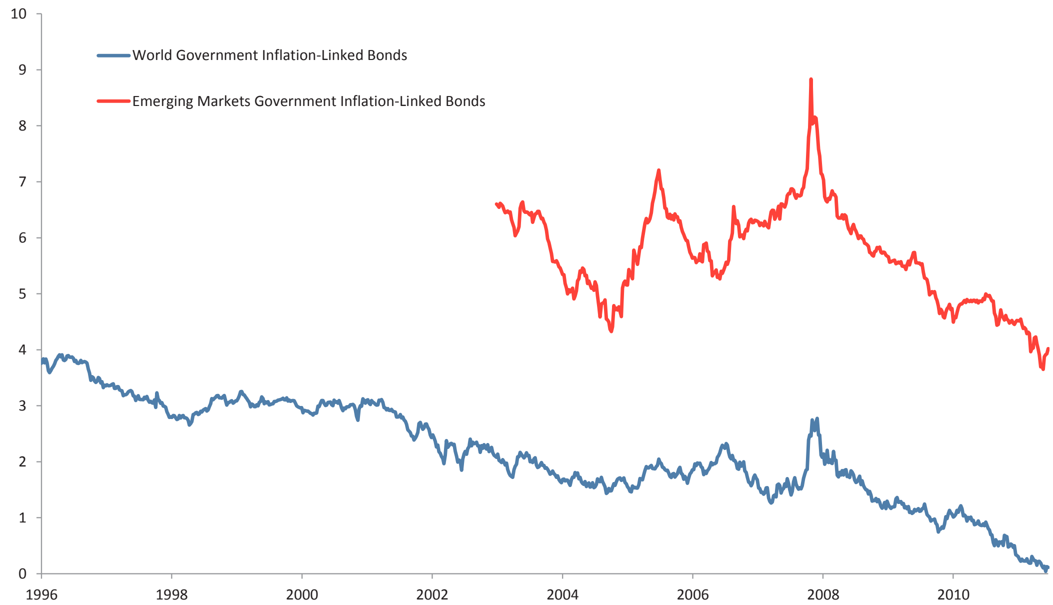


Source: http://www.econ.yale.edu/~shiller/data/ie_data.xls, NBIM calculations

In related research, Brière and Signori (2011) study the relationships between asset classes (including TIPS, but also real assets such as precious metals and real estate) and inflation in a vector-autoregressive model. They derive the optimal strategic asset allocation for investors seeking to hedge inflation risk in two different types of macroeconomic regime. In a volatile macroeconomic environment marked by countercyclical supply shocks (akin to the 1970s), the optimal allocation emphasises cash, inflation-linked bonds and precious metals. In a stable environment corresponding to the "Great Moderation", cash and nominal bonds play important roles, followed by precious metals, real estate and equities. This result is similar to the findings of our Black-Litterman study in Section 4.2 where the value of inflation-linked bonds crucially depends on the macroeconomic scenario. Brière and Signori (2012) point out that an investor who requires greater real returns should have a larger weighting in equities, real estate and precious metals.

The latter point indicates that the great effectiveness of inflation-linked bonds as long-horizon inflation hedges, especially when a stagflationary scenario takes hold, may come at the cost of a lower long-term real return. The real yield on the Barclays World Government Inflation-Linked Bond Index (WGILB) shown in Chart 11 suggests that this is currently the case. Having held around 3 percent until the turn of the century, real linkers yields have continuously declined, with the exception of the 2008 spike in the aftermath of the Lehman Brothers bankruptcy, to reach a level barely above zero. Given that the sovereign creditworthiness of the index constituents worsened over the period, the decline in expected returns is arguably even more dramatic.

Chart 11: Annual real yield of the WGILB and EMGILB



Source: Barclays

However, nominal bonds do not offer ample compensation for the inflation risk that is embedded in them. The work by Campbell, Sunderam and Viceira (2012) suggests that the nominal bond premium has recently been highly negative. Our simple decomposition of break-even inflation into expectations and risk premia components in Chart 2 points in a similar direction. This may be due to the better hedging properties of nominal bonds compared to linkers with regard to equity risk, which is signified by the greater negative correlation of returns shown in Chart 12.

Chart 12: Three-year rolling correlations of returns

Source: Barclays, Factset

Most of the empirical studies on the role of linkers in portfolios concentrate on developed markets, and in particular the US and UK markets. A notable exception is Swinkels (2012) who extends that line of investigation to emerging-market linkers. He studies the added value of inflation-linked bonds in the portfolio context with a set of nine emerging markets. For many of these countries, the inclusion of inflation-linked bonds is found to improve the risk-return characteristics of investment portfolios. Using mean-variance spanning tests, he also finds that US investors who already invest in emerging-market nominal bonds and emerging-market equities would benefit from adding emerging-market inflation-linked bonds to their investment portfolio. As shown in Chart 11 , the real yield of emerging-market linkers is still substantially positive at around 4 percent although it too is at a historical low.

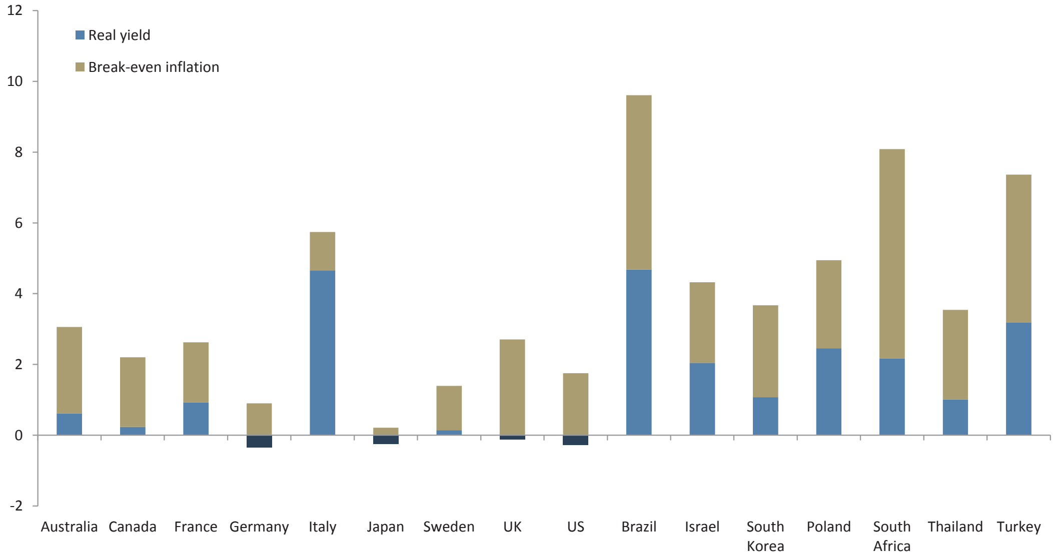
4.4 Summary

In recent years, the returns of nominal bonds have been negatively correlated with equity markets, making them a valuable hedge for long-term investors. Due to this hedging function, the inflation risk premium embedded in nominal bonds could well be negative, as recent research by Campbell, Sunderam and Viceira (2012) suggests. The covariances of bond and equity returns are unstable over time and the hedging value of nominal bonds could diminish if a stagflationary scenario as in the 1970s re-emerged.

The purpose of linkers is different from that of nominal bonds. Recent academic research suggests that inflation-linked bonds of the highest credit quality should be considered the risk-free asset if their cash flow and term match the consumption profile of investors. Their strategic purpose in long-term investors' portfolios is to provide a certain real return and hedge against unexpected inflation. The appeal of inflation-indexed bonds to long-term investors currently comes at a high cost in terms of expected returns, as real yields have declined over the last decade and are around zero for an index of developed-country linkers.

In some markets, such as the US and Germany, the real yield on certain maturities of inflation-indexed bonds has even turned negative. Investors accept a guaranteed negative real return to maturity because recently issued linkers in the aforementioned markets offer inflation and deflation insurance during a time when uncertainty around the inflation outlook is arguably higher than usual. In addition, inflation-indexed debt of highly creditworthy issuers is desirable due to its potentially strong negative correlation with other elements of investors' wealth.

Chart 13: Real yields and break-even inflation, WGILB and EMGILB country indices



Source: Barclays, Bloomberg, as at 19 June 2012

While inflation-linked bonds can provide the desirable certainty of real returns, linkers yields in developed markets could be too low to satisfy the return requirements of most institutional investors, although they are somewhat higher in emerging markets (see Chart 13). Furthermore, inflation-linked markets are only about one-fifteenth of the size of nominal bond markets[1], which may prevent large investors from achieving a desired level of inflation hedging solely through linkers.

1 Further analysis of the evolution, size and structure of linkers markets is contained in a separate NBIM discussion note on "The Structure of Inflation-Linked Bond Markets".

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