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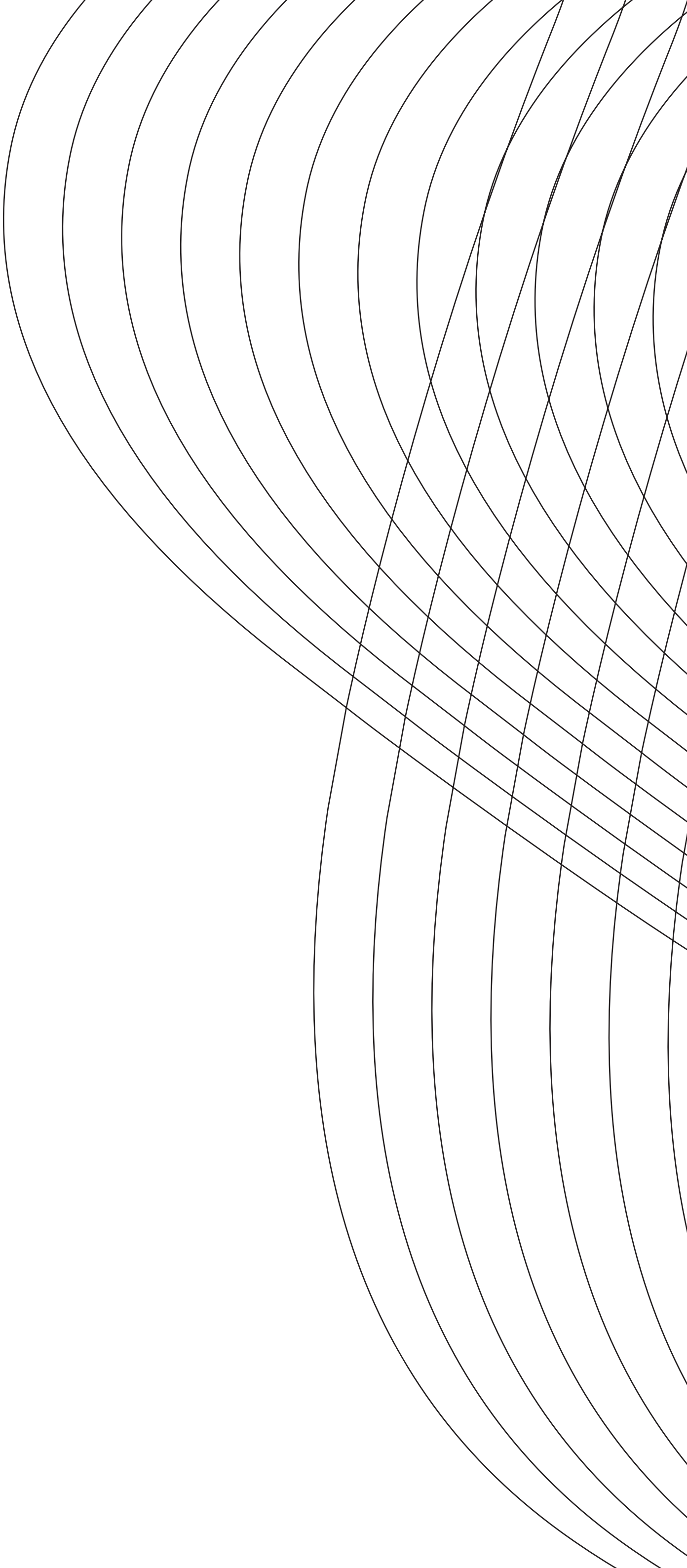
Inflation Risk and the Inflation Risk Premium



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Inflation Risk and the Inflation Risk Premium

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INHOUD

VOORWOORD

Netspar stimuleert debat over de gevolgen van vergrijzing voor het (spaar-)gedrag van mensen, de houdbaarheid van hun pensioenen en het overheidsbeleid. Doordat veel van de babyboomers met pensioen gaan, zal het aantal 65-plussers in de komende decennia snel toenemen. Meer in het algemeen leven mensen gezonder en langer en krijgen gezinnen steeds minder kinderen. Vergrijzing staat vaak in een negatief daglicht, want ten opzichte van de bevolking tussen 20 en 65 jaar zou het aantal 65-plussers wel eens kunnen verdubbelen. Kan de werkende beroepsbevolking dan nog wel het geld opbrengen voor een groeiend aantal gepensioneerden? Moeten mensen meer uren maken tijdens hun werkzame periode en later met pensioen gaan? Of moeten de pensioenen worden gekort of de premies worden verhoogd om het collectieve pensioen betaalbaar te houden? Moeten mensen worden aangemoedigd zelf veel meer verantwoordelijkheid te nemen voor het eigen pensioen? En wat is dan nog de rol van de sociale partners in het organiseren van een collectief pensioen? Kunnen en willen mensen eigenlijk wel zelf gaan beleggen voor hun pensioen of zijn ze graag bereid dat aan pensioenfondsen over te laten? Van wie zijn de pensioengelden eigenlijk? En hoe kan een helder en eerlijk speelveld voor pensioenfondsen en verzekeraars worden gedefinieerd? Hoe kunnen collectieve doelstellingen als solidariteit en meer individuele wensen worden verzoend? Maar vooral: hoe kunnen de voordelen van langer en gezonder leven worden benut voor een meer gelukkige en welvarende samenleving?

Om een aantal redenen is er behoefte aan debat over de gevolgen van vergrijzing. We weten niet altijd precies wat de gevolgen van vergrijzing zijn. En de gevolgen die wel wel goed kunnen inschatten, verdienen het om bekend te worden bij een groter publiek. Belangrijker is natuurlijk dat veel van de keuzen die moeten worden gemaakt een politieke dimensie hebben en daarover is debat hard nodig. Het gaat immers om maatschappelijk zeer relevante en actuele vraagstukken waar, in de

meest letterlijke zin oud en jong mee worden geconfronteerd. Om die redenen heeft Netspar de NEA Papers ingesteld. In een NEA Paper neemt de auteur gemotiveerd stelling over een beleidsrelevant onderwerp.
De naam NEA Papers heeft twee betekenissen. Ten eerste, NEA staat voor Netspar Economische Adviezen. De auteurs adviseren op persoonlijke titel en op verzoek van Netspar over actuele economische kwesties op het gebied van vergrijzing en pensioenen. Ten tweede, NEA klinkt als Nee-Ja en geeft daarmee een wezenskenmerk van elk debat aan.

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INFLATION RISK AND THE INFLATION RISK PREMIUM

Abstract

This article starts by discussing the concept of "inflation hedging" and provides some estimates of "inflation betas" for standard bond and well-diversified equity indices for over 45 countries. I show that such standard securities are poor inflation hedges, motivating an important role for inflation index linked bonds. I then briefly discuss the pros and cons of such bonds, focusing the discussion mostly on the situation in the US, which started to issue Treasury Inflation Protected Securities (TIPS in short) in 1997. I argue that it is hard to negate the benefits of such securities for all relevant parties, unless the market in which they trade is highly deficient, which was actually the case in its early years in the US. Finally, I describe how state-of-the-art term structure research has tried to uncover estimates of the inflation risk premium. Most studies, including very recent ones that actually use inflation-linked bonds and information in surveys to gauge inflation expectations, find the inflation risk premium to be sizable and to substantially vary through time. This implies that governments should normally lower their financing costs through the issuance of index-linked bonds, at least in an ex-ante sense.

Introduction

In an imperfectly indexed monetary world, inflation risk is one of the most important economic risks, faced by consumers and investors alike. Individuals saving for retirement must make sure their wealth finances their expenses in retirement, whatever the inflation scenario. The liabilities of pension funds and endowments are likely to increase in nominal terms with inflation[1]. It is therefore not surprising that a significant amount of research has been devoted to the question whether certain securities are good inflation hedges. In fact, in many countries, governments have issued securities, linked to an inflation index, which makes the hedging more or less perfect. In any case, the existence of a sizable government inflation-linked bond market typically spurs the development of inflation derivative contracts, which could satisfy more complex inflation –linked hedging demands. This development in turn has instigated a debate on the benefits and costs, both for investors and for the government, of inflation-linked securities. A critical element in such a debate is the notion of the inflation risk premium, the compensation demanded by investors, for not being perfectly indexed against inflation, or, put differently the insurance premium investors pay governments to shoulder the inflation risk . There is apparently no consensus about the magnitude of this premium, with some recent articles even suggesting it to be negative (see, e.g., Grishchenko and Huang (2008))! The uncertainty surrounding the inflation risk premium also means that there is uncertainty about critical inputs in any strategic asset allocation, such as the real returns on cash and bonds and their correlation with other asset returns.

This paper accomplishes three things. First, it discusses the concept of "inflation hedging" and provides some estimates of "inflation betas" for standard bond and well-diversified equity indices for over 45 countries. I show that such standard securities are poor inflation hedges, motivating an important role for inflation index linked bonds. Second, I briefly discuss the pros and cons of such bonds, focusing the discussion mostly

1 I will ignore the important issue that official estimates of inflation are unlikely to represent an adequate representation of the relevant price changes for a particular investor. For example, endowments should likely focus on the cost inflation for items dominating their budgets, such as professor's salaries and real estate expenses.

on the situation in the US, which started to issue Treasury Inflation Protected Securities (TIPS in short) in 1997. I argue that it is hard to negate the benefits of such securities for all relevant parties, unless the market in which they trade is highly deficient, which was actually the case in its early years in the US. Finally, I describe how state-of-the-art term structure research has tried to uncover estimates of the inflation risk premium. While I focus primarily on the findings in one study (Ang, Bekaert, Wei (2008)), I end the discussion with a survey of recent results that try to bring more data to the table, both in terms of inflation-linked bonds and survey data on inflation expectations. I provide some recent estimates of the inflation premium in the US, the UK and the euro area. I conclude in the final section.

1 Inflation Hedging

For existing securities to be good inflation hedges, their nominal returns must at the very least be positively correlated with inflation. Nevertheless, there are several ways to define the "inflation hedging capability" of a security. Reilly, Johnson and Smith (1970) examine whether a security protects real purchasing power over time, by calculating the incidence of negative real returns. Clearly, higher yielding assets will almost surely do well on such measure, but may not prove good inflation hedges in the short run, if they fail to generate high returns at times when inflation is high, especially when it is unexpectedly high. Bodie (1976) measures how the variance of the real return of a nominal bond can be reduced using an equity portfolio as a gauge of the hedging capability of equities. In this article, I consider a very simple concept of inflation hedging, namely, the *inflation beta*, computed using a simple regression:

$$\text{Nominal return} = \alpha + \beta \text{ inflation} + \varepsilon \quad (1)$$

Here, ε is the part of the return not explained by inflation. If $\beta = 1$, the security is a perfect hedge against inflation.[2] Note that it is conceivable that even a perfectly indexed security does not generate a perfect coefficient of 1 in the regression in (1). This is true because inflation may be correlated with value-relevant factors that are omitted from the regression. Yet, it is unlikely that a security perfectly indexed against inflation would generate a coefficient that is significantly different from 1.

How do the main asset classes fare in terms of inflation hedging capability? I obtained nominal bond returns, nominal stock returns and inflation data for over 45 countries. A data appendix contains more details, but the sample period for most series ends in March 2006, whereas the starting point varies from country to country, between January 1970 and January 1995. I look at logarithmic annual returns,

2 An imperfect but stable and predictable relation between a security's return and inflation could suffice for hedging (see Schotman and Schweitzer [2000]), as it would be trivial to compute a hedge ratio. However, it is unlikely that the relationship between any non-indexed security and inflation is truly stable and predictable!

computed from monthly data. Using monthly data but a one-year horizon, will result in the residuals of the regression analysis reflected in Equation (1) exhibiting positive serial correlation. I correct the standard errors for this using the standard approach advocated by Hansen and Hodrick (1980).

Exhibit 1 shows the betas from the regression in (1) for bond returns. Dark bars indicate that the beta is statistically significantly different from 1 (at the 10% level). I find that 19 out of 46 inflation betas are indeed significantly below 1, a further 4 countries exhibit negative betas, which are not statistically significantly different from 1. So in about half the countries, bond returns react reliably *negatively* to inflation, earning negative returns in period of high inflation. This should not be surprising. While expected inflation should be priced into the return on bonds, they will be particularly sensitive to shocks to unexpected inflation. I actually examine this further below. Note that in another 8 countries the betas are below 0.5, meaning that real returns react quite negatively to inflation shocks.

But should stocks not fare better? After all, they are real securities, and whereas there are many ways in which inflation could be value relevant for equities it is difficult to argue in favor of a particular bias. There is already a rather voluminous literature on US data showing that equities are not particularly good inflation hedges; in fact the nominal returns of stocks in the US and inflation are mostly *negatively* correlated[3] In Exhibit 2, I extend this evidence to 48 other countries. The inflation beta in the US is indeed negative and statistically significantly below 1, meaning that real returns on stocks and inflation are solidly negatively correlated. However, the US is not the exception but rather the rule. The majority of the inflation betas are negative, and of the ones that are positive, most are way too low. In 37 countries, we observe inflation betas that are significantly below one, and in a further 11 countries the betas are negative but not significant. In only 12 countries is the inflation beta close to one in statistical and economic terms or implausibly high as in Morocco or Hungary.

3 One classic paper is Fama (1981). In fact, bond yields and equity yields (dividend or earnings yields) are surprisingly highly correlated in the US, reflecting the strong negative response of equity returns to inflation; see Bekaert and Engstrom (2009) for more discussion and a potentially rational explanation.

To get a more survey feel for the results, Exhibit 3 presents the results for "pooled regressions." I estimated the inflation beta using all countries, allowing for a country specific intercept, but allowing only one beta per (regional) group.[4] Bonds exhibit inflation betas that are mostly positive but significantly below 1, meaning that their real returns are low when inflation is high. The inflation betas are higher in emerging countries, and lowest in Latin America and Asia. The picture for stocks is depressing. Stock returns are negatively correlated with inflation for all groups except for emerging markets and non-EU Europe. The positive coefficient for emerging markets is driven by the Latin-American countries.

The positive coefficient on nominal bonds may give the impression bonds are "not so bad," but of course it likely reflects the effect of previously expected inflation being priced into bonds and inflation being persistent over time. On the right hand side, I report results from a multi-variate regression, regressing the returns onto two variables, expected inflation the year before and unexpected inflation (the difference between realized and expected). In Fama and Schwert (1977), a classic paper on inflation hedging, they call an asset a complete hedge against inflation if it has coefficients equal to one on both variables in this regression.

Of course this regression requires an estimate of expected inflation! It is impossible to come up with accurate measures of expected inflation for all the countries in this sample, so I use a very simple procedure: I let expected inflation at time t be current year-on-year inflation at t. While this random walk model for inflation may appear inconsistent with the data, I suspect it will be hard to beat by more complex models in out-of-sample forecasting. In fact, for the US, Atkeson and Ohanian (2001) show as much.[5] The table simply reports the coefficient on the second component, unexpected inflation (which is really just the change in inflation). With only a few exceptions, I obtain what was to be expected: the unexpected inflation betas are further removed from 1 than were the "total" inflation betas. This suggests that whatever link with inflation

4 I actually estimated two regressions, one for the developed/emerging split-up, and then another one for all the other groups.

5 As I discuss later, for the US, Ang, Bekaert and Wei (2007) demonstrate that professional surveys do even better. Such surveys are obviously not available for most countries in my sample.

does exist comes through its expected part. For stock returns, all the betas are now negative except for Latin-America (where the beta is still indistinguishable from one), which translates into a similar coefficient for the emerging markets as a whole.

All of our results apply to one-year returns; this is a reasonable horizon to investigate, even when considering long-horizon investors, as portfolios are typically rebalanced at least once a year. However, it is conceivable that the inflation hedging capability of stock returns is more apparent at longer horizons, and, in fact, Boudoukh and Richardson (1993) claim that stocks are a better hedge for inflation at longer horizons. In Exhibits 4 and 5, I examine this issue for my extensive set of countries. I only look at pooled results for the larger groups here, as the longer horizons start exhausting the degrees of freedoms for many countries. I start with the inflation betas in Exhibit 4. For bond returns, the coefficients are nicely increasing with horizon and they are insignificantly different from 1 at the 5 year horizon for developed markets, and well over 1 for emerging markets. Perhaps this is not entirely surprising, as it may simply reflect the accuracy of longer term inflation expectations. The result may also reflect a strong cross-country dimension (bond yields in high inflation countries being reliably higher than bond yields in low inflation countries). For stock returns, the developed market betas increase with horizon but remain significantly below 1, even at the 5 year horizon. For emerging markets, they show little horizon dependence. The unexpected inflation betas, shown in Exhibit 5, tell a different story, however. While the betas for bonds still increase with horizon, they remain significantly below 1 for developed markets, even at the 5-year horizon. For stocks, the betas remain significantly negative for both the EU and developed markets even though they do increase a bit with horizon for developed markets. For emerging markets, the betas show little horizon dependence.

Finally, commodities have recently started to become a popular alternative asset class and may potentially serve as a natural hedge for inflation. If commodity prices are an important driver of inflation movements, it is conceivable that commodity price index changes may be highly correlated with general inflation. However, it is not that obvious that commodities really constitute a great inflation hedge. First, the relationship between commodity prices and actual inflation is complex, and varies through time. For example, in the past, oil price shocks typically passed through powerfully into general inflation, but more recently their effect has been more subdued, perhaps because of increased globalization, or competitive effects through "cheap" Chinese exports abroad. Whatever it may be, the relationship does not appear stable over time. More importantly, exposure to commodities is typically accomplished through commodity futures. However, it is not clear at all that the returns to commodity futures, which are essentially contracts in zero net supply, are highly correlated with inflation. Erb and Harvey (2006) show that while an index of commodity futures returns had a positive and significant unexpected inflation beta, its different components have betas that vary wildly across different commodities, and are often counterintuitive. They suspect that the inflation beta is not stable at all over time. They also note that even a broad-based commodity futures index excludes many items measured in actual consumer price indices, used to compute inflation. Consequently, commodity futures are not likely effective inflation hedges.

2 TIPS to the rescue

a) General Benefits of Inflation Protected Bonds

The whole idea of index-linked bonds is to protect investors against the risk of inflation by indexing the cash flows of the bonds to an inflation index. Given the poor performance of other securities as inflation hedges, such bonds clearly provide an important role in helping investors hedge an important economic risk. Because other securities are so imperfectly correlated with (unexpected) inflation, such bonds truly help financial markets become more complete, in the sense that financial markets should provide the possibility of getting payoffs under as many economic contingencies as possible. Given differences in risk aversion across investors, the co-existence of indexed bonds and of non-indexed bonds with inflation risk (and presumably higher returns), allows for overall better risk sharing (see Campbell and Shiller (1996) for an elaborate discussion). This would make them almost surely overall welfare enhancing. It is also likely that the government is better able to shoulder inflation risk than individual investors (see van Ewijk (2009))[6], and it is even conceivable that indexed bonds would encourage people to save more, thereby potentially affecting the overall savings rate, and therefore economic growth. In addition, and as I will make clear in more detail later, they may potentially help provide market-based information on important economic variables, such as real interest rates over different maturities. Such information is helpful for investors and policy makers alike. Finally, if investors indeed fear inflation risk and demand compensation for taking it when investing in nominal government bonds, the "inflation risk premium" will be positive and an inflation index-linked bond will cost less to issue than a nominal bond of similar maturity, thereby reducing the debt costs of the government. As Campbell and Shiller (1996) point out, from a society's perspective, it is not at all clear that the government should try to minimize its financing costs. Nevertheless, it is quite likely that index-linked bonds may help

6 Of course, the existence of inflation-indexed bonds may even reduce the government's incentives to inflate (see Campbell and Shiller 1996), although Fischer (1981) marshals some evidence that indexed bonds increase an economy's sensitivity to price shocks.

to generate smooth, predictable financing costs in real terms, thereby averting distortionary taxation, which would be welfare enhancing.

Inflation indexed bonds have been issued by many governments over the years, but are a rather recent phenomenon for most developed countries (see Campbell and Shiller (1996)). For example, the UK government has been issuing indexed Gilts since 1981, but France started issuing inflation-linked bonds only in 1998. In the following section, I focus on the TIPS program in the US, which was started in 1997.

b) TIPS

While the TIPS program initially met with some enthusiasm (see Sack and Elsasser (2004)), the program grew rather slowly. Exhibit 6 shows the outstanding amount of TIPS, which grew from around $150 billion at the end of the nineties to close to $500 billion at the end of 2008. The Treasury affirmed its commitment to the program in 2002.

It only gained very slow traction with individual investors. The left-hand side scale of Exhibit 6 shows the growth in assets under management in mutual funds focusing on TIPS, which was very gradual till about 2004, then accelerated to reach over 80 billion at the end of 2008. TIPS were more of a success among institutional investors. In fact, many pension funds and endowments in the US decided to create a new strategic asset class, comprising TIPS. Exhibit 7 shows the asset allocations of a select group of university endowments in June 2000. Only 8 of 19 endowments pictured allocated any money to TIPS, and the average allocation among those was 3.56%. Around that time, one of the largest endowments, Harvard Management Company (HMC henceforth) also introduced TIPS as a new asset class with a 7% strategic asset allocation.[7] It nevertheless made perfect sense to introduce TIPS as a new asset class. Let us think about the properties an asset class should possess to be a suitable strategic asset class:

- The asset class should represent a homogeneous set of securities, which was definitely satisfied by the TIPS securities.
- The returns on the asset class should not replicate something already part of the other asset classes, that is, its returns should be relatively uncorrelated with other asset returns. This was definitely the case

7 See Viceira (2000) for a Harvard case on the introduction of TIPS at HMC.

with TIPS as there does not exist any other security that indexes away inflation risk.
- Preferably, the security should be in "positive supply". By this I mean that the asset class represents actual market capitalization, so that it makes sense for investors to hold the security in equilibrium. Of course, institutional investors do hold assets (hedge funds, commodity futures funds) that may not satisfy this criterion, and are held as alpha generators or diversifiers, but making the case for such assets to constitute an asset class is much harder than for securities that are part of the "market portfolio." Of course, if the world satisfies the assumptions of Barro's (1974) famous article on Ricardian equivalence, investors may view the issuance of Treasury bonds in general as equivalent to higher future taxes (to repay the debt) and TIPS are not necessarily in positive net supply.
- The ultimate test of whether TIPS belong among the strategic asset classes is of course to check whether their addition indeed raises the "utility" of the investor. In the case of many institutional investors using mean variance optimization to determine strategic asset allocations, it would appear that TIPS increase the optimal Sharpe ratio.

But, not all was well with TIPS. An asset class should also have a sufficiently large market capitalization to absorb the demands of institutional and other investors and its market environment should show sufficient liquidity to allow active trading. Both conditions were not likely satisfied in the early years of the TIPS market. I will come back to this important issue below.

As a concrete example, Harvard Management Company, in 2000, introduced TIPS as a new asset class, (allocating 7% into their "policy portfolio" allocation). This seemed good news all around, as the longest maturity TIPS produced a 15.2% average annual return over the next three years. However, studying the excellent case written about this decision by Luis Viceira at Harvard implicitly reveals some interesting problems with the TIPS markets. HMC changed its long-run real interest rate from 2% to 3.5%, primarily because its analysts observed real yields in the TIPS market, substantially higher than 2%, and more of the order of 4%. This decision reflected two important errors in setting capital market assumptions. First, it is not a great idea to estimate a long-run return using only a few years of data. Not only is there much sampling error, but, as I further discuss below, many returns show cyclical patterns, which call for a sample period that "goes through a few cycles." In addition, even in ideal circumstances, real yields will reflect market participants expectations of future inflation which may not be borne out in actual data and inflation forecasting errors cannot be expected to average to zero over such a short period. Second, the TIPS market back then was in its infancy, not very liquid and perhaps even a somewhat "unknown, inefficiently priced" asset, as suggested by Sack and Elsasser (2004). I argue below that in the beginning of the TIPS issuance period, likely up to 2004, real interest rates were much lower than suggested by TIPS data.[8]

The HMC saga also re-iterates the need for set of stylized facts regarding real interest rates, expected inflation and their relation. Of key interest is the inflation risk premium. In the following section, I decompose nominal yields into three economically important components. I then discuss how the recent term structure literature has attempted to identify these components and summarize some concrete estimates.

8 Of course, it is questionable that historical data should be used at all in setting capital market assumptions for expected returns. It may be better to "reverse engineer" them from an equilibrium model such as the CAPM (see Sharpe (1976)). In that case, TIPS should be part of the optimal portfolio proportional to their relative market capitalization.

3 The Inflation Risk Premium

a) Definition and General Identification

The inflation risk premium is the compensation investors demand to protect themselves against inflation risk. It can most easily be identified using yields on nominal Treasury bonds. Consider the following equation:

$$\underbrace{y_t^n}_{\text{nominal rate}} = \underbrace{r_t^n}_{\text{real rate}} + \underbrace{E_t[\pi_{t+n,n}]}_{\text{expected inflation}} + \underbrace{\varphi_{t,n}}_{\text{inflation risk premium}} = r_t^n + \underbrace{\pi_{t,n}^e}_{\text{inflation compensation / break-even inflation rate}} \tag{2}$$

Here, y_t^n is the yield on a nominal zero-coupon bond of maturity n; r_t^n is the yield on a perfectly indexed zero coupon bond of maturity n. The difference between the two is often called "inflation compensation" or sometimes "breakeven inflation rate," as it constitutes the inflation rate that ex-post would make the nominal yields on both bonds equivalent. Inflation compensation economically consists out of two components. The first is simply expected inflation; the second is the inflation risk premium.

A well-known theory of interest rate determination due to Fisher (1930), holds that the inflation risk premium ought to be zero. If true, there is no expected benefit to the government of issuing inflation protected securities. While actual inflation may differ from expected at any given time, unless systematic biases exist, the inflation surprises should cancel out over time, so that there is no expected benefit or cost to issuing TIPS over Treasuries. Most believe there is indeed an inflation risk premium. However, it need not be positive. While it is tempting to conclude that the inflation risk premium is linked to the uncertainty or volatility of inflation, its economic determinants are, in most modern pricing models, in fact a bit more subtle. It is easy to show that the inflation risk premium should be positive if inflation is high in "bad times." If inflation would always occur when agents happen to experience high bond returns, they would not need an inflation risk premium.[9]

9 In the parlance of modern finance, what is required is a positive correlation between the real "pricing kernel" and inflation. The pricing kernel takes on high values in bad states of the world, because risk averse economic agents want to move consumption and wealth into these states, and they are therefore relatively expensive. In alternative models, pure uncertainty about future states of the world may generate risk premiums as well.

How can we identify the different components? At first blush, it looks like an easy task. Indexed bonds would deliver r_t^n; inflation forecasts could deliver the second term, and subtracting both of the obviously observable nominal yields gives us an estimate of the inflation risk premiums, for any horizon we fancy. Unfortunately, it is not that easy. TIPS have only existed for about 10 years, and, as I argue below, the first 7 years are likely not usable in any estimation. Inflation forecasting is at best an imprecise and difficult business. So, we are left with data on nominal yields and actual (not expected) inflation in most cases, although more recent studies have tried to expand the information used (see below). In other words, en econometrician would not view the task as easy but as impossible!

Over the years, a great many approaches have been used to identify the components in Equation (2). It is fair to say that in modern asset pricing, techniques have converged to the following approach:

i. Formulate a no arbitrage term structure model that prices nominal and real bonds. The no arbitrage condition ensures that the pricing is consistent across the curve and across time. The modeling involves a stochastic process for a "pricing kernel" that prices the bond's payoffs and is consistent with a number of economic principles and stochastic processes for a number of "factors," that are deemed relevant for pricing the term structure (TS, henceforth). In some standard models, these factors could be the "level", "slope", and "curvature" of the yield curve.
ii. Formulate an inflation model and link it to the TS model. This model should be consistent with data on inflation and hopefully, in conjunction with term structure data, yield accurate expected inflation numbers.
iii. Estimate the model using as much data as possible, but data on inflation and nominal bond yields are a must.

The estimated model will then imply an inflation risk premium, which immediately reveals a potential problem. The model has to be general enough so as to not impose restrictions on the findings, but it will nonetheless have to be restricted so as to achieve identification of essentially three unobserved components with two sets of information (nominal yields and inflation).

b) Stylized facts regarding real rates and inflation risk premiums in the US

A recent example of the just-described approach is Ang, Bekaert, Wei (2008). They use a no-arbitrage term structure model, that prices real and nominal bonds and make the model quite general. First, the model explicitly allows for the possibility that risk premiums may vary through time, for example, with the business cycle. Second, the model accommodates "regime switches" in interest rates. Many TS studies have shown that the behavior of interest rates can abruptly change, causing regimes in volatilities and persistence. Such changes can be generated by monetary policy changes or reflect business cycle variation, for example. Finally, the model allows arbitrary correlation between real rates and (expected) inflation. They use quarterly inflation and term structure data to estimate the model over a fairly long period, 1952:Q1 – 2004:Q4. This is important, as short samples may give a much distorted view of long-term inflation risk premiums, especially if these premiums vary through time.

The approach of Ang, Bekaert and Wei (2008) (ABW, henceforth) is to consider a large number of different models (24 in total), and to select the model that best fits the data (term structure data, inflation data and their correlation). From this exercise, they can then extract a set of stylized facts regarding real interest rates, expected inflation and the inflation risk premium. I will discuss the most important facts, using a few tables and graphs taken from their study.

I start with discussing the properties of the real interest rate, an important economic variable in its own right. Exhibit 8 shows the mean (average) real rate over the sample, its standard deviation, and the autocorrelation of the real rate process. I show these properties for 4 different maturities, ranging from 1 quarter to 5 years. Unconditionally, the term structure of real rates is in fact hump shaped: it is fairly flat around 1.24%, with a slight hump, peaking at a 1-year maturity. However, there are some regimes in which the real rate curve is downward sloping. Such behavior is totally consistent with an activist monetary policy driving up short rates to fight inflationary forces. This may also explain why real rates are more variable at the short end of the curve and that they show less autocorrelation or persistence there. That is, the monetary policy – induced increases in short-term real rates are not expected to last long. The long rate however is very persistent. In sum, real rates are quite variable at short maturities but smooth and persistent at long maturities. There is no significant real term spread. Exhibit 9 shows both the short and long real rate over time. The shaded areas indicate NBER recessions. Between 1955 and most of the seventies long real rates were very low, barely breaching 1% at times. They rather abruptly increased during the 1979–1982 Volcker period, with the short rate increasing much more than the long rate, and have gradually come down ever since, with many short term movements in either direction.

The so-called Mundell-Tobin effect holds that the short real rate should be negatively correlated with expected inflation. The reasoning is that inflationary shocks would drive investors into real assets, driving up their prices and reducing their expected real returns (the real rate of interest). ABW (2008) indeed find the real short rate to be negatively correlated with both expected and unexpected inflation, but the statistical evidence for a Mundell-Tobin effect is weak.

Since the real rate curve is rather flat[10] and the nominal yield curve in the US is on average upward sloping, there must be, on average, a positive inflation risk premium that is increasing in maturity. Note that this is only true "on average," because then expected inflation cannot have a maturity component, but at any given point of time, inflation expectations can also increase with maturity. Exhibit 10 shows some properties of the inflation risk premium. The fact that the premium is about zero at the one quarter maturity is not a finding of the article, but rather an imposed assumption to help overcome the identification problems imposed by Equation (2). It is clear that the inflation risk premium is generally positive and increases to over 1% at the 5 year horizon. ABW found two "inflation regimes," a "normal" regime where inflation is relatively high and the inflation risk premium substantial, and a regime in which inflation is decreasing (a disinflation regime) and inflation risk premiums are much smaller.

Exhibit 11 graphs the 5-year inflation risk premium over time. In general, the premium rose very gradually from about 75 basis points until the late 70s, before entering a very volatile period during the monetary targeting period from 1979 to the early 1980s. It is then that the premium reached a peak of 2.04%. From then onwards, the trend appears

10 Roll (2003) studies actual data on TIPS and finds the real curve to be flatter than the nominal curve.

downward, but with some rather big swings. During the late 1990s equity bull market, the inflation premium remained relatively stable around 1%, then dropped to a low of 0.15% after the 2001 recession. Fears of deflation were apparent then. At the time of writing, the severe recession has significantly depressed the inflation risk premium. The long history in Exhibit 11 shows that the inflation risk premium has often decreased in recessions but it also shows that this situation may not last!

Because pension funds often have a long-term view, it is of interest to compute inflation risk premiums for bonds with a longer duration. In the ABW model, zero coupon bonds of maturity 10 (20) years carry an inflation risk premium of 112 (84) basis points on average. [11]

The ABW paper has a number of other interesting findings. For example, the decompositions of nominal yields into real yields and expected inflation at various horizons indicate that variation in expected inflation and inflation risks premiums explains about 80% of the variation in nominal rates at both short and long maturities. That is, the folklore wisdom that "inflation is more important in the long run" is not quite true. Inflation is really an important level factor in the term structure that affects both the short and long end of the curve. However, when one focuses on spreads (and essentially eliminate this level factor), the importance of inflation compensation for spreads does increase with maturity and becomes very dominant at the long end of the maturity spectrum.

c) Recent estimates of the inflation risk premium

The disadvantage of the ABW study is that it only uses nominal bond data and data on inflation. It would be obviously useful to test their findings with estimates that are informed by more data, in particular by data on inflation linked bonds. Recent research has tried to resolve the identification problem in Equation (2) by using data in index-linked bonds, and additional, exogenous information on inflation forecasts present in survey data.

Let me first address the use of index-linked bonds. With the exception of the UK, index-linked bonds in most developed countries have a fairly

11 I thank Min Wei for computing these numbers. She also provided longer-duration numbers for the D'Amico, Kim and Wei (2008) article, discussed in the next section.

short history. This by itself limits their usefulness in extracting long-term inflation expectations and risk premiums. It is important, given the tremendous time-variation in inflation risk premiums discussed above, to use a fairly long history in assessing properties of the inflation risk premium. In the US, we now have data on TIPS since 1997, which really does not represent sufficient data by itself, but the actual situation is worse, because of the poor liquidity of the TIPS market in its infancy years. Exhibit 12 shows the secondary market trading in TIPS over time. It increased tenfold, almost twice as much as the amount of TIPS outstanding. Bid-ask spreads in the TIPS market have decreased over time as well; market participation and turnover have generally increased. There is general agreement that the liquidity in the TIPS market has improved dramatically (see Roush, Dudley and Ezer (2008) for a detailed discussion). Moreover, the commitment made by the US government to the TIPS program in 2002 helped resolve market uncertainty about the asset class. Today, the TIPS market is liquid, but still not as liquid as the Treasury bond market. This creates a tremendous problem for the use of TIPS data in uncovering real yields. Denote zero coupon rates derived from TIPS, as $r_t^{n,TIPS}$. They can be thought of as consisting out of two components:

$$r_t^{n,TIPS} = r_t^n + LiQPR_t^n \tag{3}$$

where LiQPR represents a liquidity premium that may vary through time. The literature contains a number of liquidity premium estimates. Exhibit 13 presents a graph of the estimate by D'Amico, Kim and Wei (2008). They compare a term structure model with and without TIPS to infer liquidity premiums. The liquidity premium is very large in the first 4 to 5 years (well over 1%), and then declines to hover below 50 basis points now. Gurkaynak, Sack and Wright (2007) provide an alternative estimate, which shows the same secular decline, with again 2004 the critical year where liquidity premiums become relatively small.[12]

Nevertheless, the difference in liquidity between Treasuries and TIPS remains an issue even to date. When there is a flight to safety, as there is in the current crisis, investors flock to the most liquid security and

12 The Federal Reserve Bank of Cleveland developed its own procedure to compute the liquidity risk premium but acknowledged it was no longer of practical use during the current crisis.

liquidity premiums rise. This means that the most recent TIPS data may again reflect a sizable liquidity premium.

In many countries, there exist surveys of inflation forecasts by professionals and consumers. In the US, there are a number of well-known surveys, with data going back quite a while, including the Livingston survey, the Michigan survey (consumers), and the SPF survey (Survey of Professional Forecasters). Without a lengthy historical record, it is hard to test the accuracy of the forecasts. In a recent article, Ang, Bekaert and Wei (2007) examine in much detail the quality of various forecasting methods for one year ahead annual inflation. In particular, they examine the out-of-sample forecasting performance of four different types of forecasting methods:

1) Time series models. These models use past data on inflation (so called ARIMA models) to forecast future inflation. As indicated above, one of the most successful models here is the random walk model, which simply uses the current inflation rate to forecast future inflation. ABW (2007) also include a non-linear model that embeds regime switches in the inflation process.
2) Phillips curve models: There is a large macro-economic literature that links expected inflation to some measure of the "output gap", a business cycle indicator. A large output gap indicates inflationary forces and should imply relatively high inflation forecasts.
3) Term structure models: As equation (2) indicates, nominal interest rates should have useful information about future expected inflation. ABW consider a large number of both empirical and no arbitrage term structure models to forecast inflation.
4) Surveys: ABW examine the forecasts of all three surveys mentioned above.

ABW use forecasts over both the post 1985 and post 1995 periods to assess the forecasting prowess of the various models, and compare them using the "root mean squared error" criterion. That is, they simply take the square root of the average squared forecasting errors.

ABW's main result is quite simple: Surveys consistently beat other models in terms of "root mean squared error." There are many potential reasons for the superior forecasting performance of the surveys: they may aggregate more information from more sources than is possible in most models, or may reflect information not present in any model (e.g. regarding policy decisions); they can also respond quickly to new information, whereas most models must assume some stability of existing relationships. ABW conjecture that the surveys perform well for all of these reasons: the pooling of large amounts of information, the efficient aggregation of this information and the ability to adapt quickly to major changes in the economic environment such as the drop in real volatility of the mid-eighties known as the Great Moderation, and now perhaps, the crisis conditions. This research suggests that the decomposition in (2) would benefit from using information in the surveys.

With this in mind, I searched the literature for recent studies that provide estimates of the inflation risk premium, using either information in inflation-linked bonds or surveys, or both. Exhibit 14 mentions the studies and the various estimates for different maturities. Studies that use TIPS data *before* 2004 necessarily underestimate the inflation risk premium. That is because the high real interest rates really reflected liquidity premiums, but not true real interest rates. The one US study that reports an average inflation risk premium that is negative (Christensen, Lopez, and Rudebusch (2008)) suffers from this problem. In fact, they report negative inflation premiums before 2004 and positive ones thereafter. The picture emerging from the other 4 studies mentioned, however, is that the inflation risk premium is robustly positive. The magnitude differs, varying between 50 and over 200 basis points at the 10 year horizon. The larger estimates are more in line with previous studies, such as Buraschi and Jiltsov (2005), and Campbell and Viceira (2001).[13]

I also mention a few European studies. Both Hordahl and Tristani (2007) and Garcia and Werner (2008) find a very modest inflation premium of only 25 basis points at the 5 year horizon. However, it is likely that this low estimate reflects the short sample period which was characterized by relatively subdued inflation. My personal estimate of a long-term inflation risk premium for the euro area would be substantially larger. For the UK, I mention a recent study by Joyce, Lundholdt and Sorensen (2008), which does not report an average inflation risk premium, but does graph it over time. The graph confirms

13 The estimate in Buraschi and Jiltsov (2005) is on average 70 basis points; in Campbell and Viceira (2001), albeit using a slightly different but related definition based on holding period returns, the estimate is 110 basis points.

much of what was claimed in this study: the inflation risk premium is mostly positive, can be large, and varies considerably over time. Older studies, such as Evans (1998, 2003), stress the importance of time-varying inflation risk premia in the UK, but surprisingly do not report estimates of their magnitude.

4 Conclusions

This article has made a number of relatively simple points about inflation risk. First, standard securities, such as nominal government bonds and equities are very poor hedges of inflation risk, both in the short and in the long run. I estimated inflation betas for a very large cross-section of countries, showing that this is nearly universally true. As a consequence, index-linked bonds are essential to hedge inflation risk.

With index linked bonds, investors, policymakers and economists can have a better sense of the magnitude of the inflation risk premium, the compensation investors demand to bear inflation risk in nominal bonds. Most studies, including very recent ones that actually use inflation-linked bonds and information in surveys to gauge inflation expectations, find the inflation risk premium to be sizable and to substantially vary through time.

This implies that governments should normally lower their financing costs through the issuance of index-linked bonds, at least in an ex-ante sense. However, some index-linked markets, and in particular the US market, have suffered from poor liquidity driving up real yields, and increasing the cost of issuance. While several measures can be taken to improve liquidity in the index-linked market, recent events demonstrate once again that in volatile market conditions, investors gravitate towards the most liquid securities (typically nominal Treasury bills and benchmark bonds) and liquidity premiums can become extremely large. From an economic perspective, such considerations are actually not terribly important. Having securities that allow the hedging of an important economic risk are almost surely welfare enhancing, and without the government setting a default free benchmark are unlikely to spring up in private markets. Therefore, the case for an index-linked market would appear easy to make.

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TECHNICAL APPENDIX

My basic data are at the monthly level. The inflation data are from the IMF's International Financial Statistics; the stock return data from MSCI and the bond return data from Datastream. For each country i, I compute the following variables:

- Monthly logarithmic stock or bond returns (including dividends and coupons) in month t: $r_{i,t}$
- Returns aggregated over a horizon of h-months:
  $r_{i,t+h,h} = r_{i,t+h} + r_{i,t+h-1} + \ldots + r_{i,t+1}$.
  Ignoring dividends and coupons, this return represents the logarithm of the price at t + h minus the logarithm of the price at time t.
- Year-on-year inflation in month t: $\pi_{i,t} = \ln(CPI_{i,t} / CPI_{i,t-12})$, where CPI is the consumer price index.
- Inflation over a "k-year" horizon:
  $\pi_{i,t+k\times12,k\times12} = \pi_{i,t+k\times12} + \pi_{i,t+(k-1)\times12} + \ldots + \pi_{i,t+1\times12}$
- Expected inflation for a horizon of k years:
  $\pi e_{i,t+k\times12,k\times12} = k\ \pi_{i,t}$
- Unexpected inflation for a horizon of 6 years :
  $\pi u_{i,t+k\times12,k\times12} = \pi_{i,t+k\times12,k\times12} - k\ \pi_{i,t}$

Using these variables, I run both univariate and bivariate regressions. The univariate country-by-country regressions take the following form:

$$r_{i,t+k\times12,k\times12} = \alpha_i + \beta_i\ \pi_{i,t+k\times12,k\times12} + \varepsilon_{i,t+k\times12,k\times12} \quad \text{(A1)}$$

Because I use monthly data, the "overlap" in observations causes the errors to be serially correlated. I therefore adjust the standard errors using the Hansen-Hodrick (1980) method with lag k×12-1.

For the univariate pooled regressions, I run 2 regressions.

$$r_{i,t+k\times12,k\times12} = \alpha_i + \sum_j \beta_j \, \pi^j_{i,t+k\times12,k\times12} + \varepsilon_{i,t+k\times12,k\times12} \qquad \text{(A2)}$$

where:

- $\{\beta_j, j=1,2,\ldots,J\} = \{\beta_{developed}, \beta_{emerging}, J=2\}$, or $\{\beta_{North\ America}, \beta_{Latin\ America}, \beta_{Asia}, \beta_{Africa}, \beta_{Oceania}, \beta_{EU}, \beta_{Non\text{-}EU\ Europe}, J=7\}$
- $\pi^j_{i,t+k\times12,k\times12} = \pi_{i,t+k\times12,k\times12}$ if country i in group j; 0 otherwise.

Standard errors are again adjusted using the Hansen-Hodrick (1980) method, as generalized to panel data by Devarajan, Swaroop and Zou (1996).

Analogous standard errors are used for the bivariate regressions.
The country-by-country regression is:

$$r_{i,t+k\times12,k\times12} = \alpha_i + \gamma_i \, \pi e_{i,t+k\times12,k\times12} + \beta_i \, \pi u_{i,t+k\times12,k\times12} + \varepsilon_{i,t+k\times12,k\times12} \qquad \text{(A3)}$$

The bivariate pooled regression can be represented as:

$$r_{i,t+k\times12,k\times12} = \alpha_i + \sum_j (\gamma_j \, \pi e^j_{i,t+k\times12,k\times12} + \beta_j \, \pi u^j_{i,t+k\times12,k\times12}) + \varepsilon_{i,t+k\times12,k\times12} \qquad \text{(A4)}$$

where

- $\{\gamma_j, \beta_j, j=1,2,\ldots,J\} = \{\gamma_{developed}, \gamma_{emerging}, \beta_{developed}, \beta_{emerging}, J=2\}$, or $\{\gamma_{North\ America}, \gamma_{Latin\ America}, \gamma_{Asia}, \gamma_{Africa}, \gamma_{Oceania}, \gamma_{EU}, \gamma_{Non\text{-}EU\ Europe}, \beta_{North\ America}, \beta_{Latin\ America}, \beta_{Asia}, \beta_{Africa}, \beta_{Oceania}, \beta_{EU}, \beta_{Non\text{-}EU\ Europe}, J=7\}$
- $\pi e^j_{i,t+k\times12,k\times12} = \pi e_{i,t+k\times12,k\times12}$ if country i is in group j; 0 otherwise.
- $\pi u^j_{i,t+k\times12,k\times12} = \pi u_{i,t+k\times12,k\times12}$ if country i is in group j; 0 otherwise.

To describe our estimations more concretely, it is best to distinguish between the country-by-country regressions and the pooled regressions. For the country-by-country regressions, let $y_{t,h} = r_{i,t+k\times12,k\times12}$; $x_t = [1\ \pi_{i,t+k\times12,k\times12}]$ (univariate regression), or $x_t = [1\ \pi e_{i,t+k\times12,k\times12}\ \pi u_{i,t+k\times12,k\times12}]$ (bivariate regression); $\varepsilon_{i,t+k\times12,k\times12} = u_{t,h}$, where we omit the country dimension. Then the regressions become

$$y_{t,h} = x_t\, \beta + u_{t,h} \text{ where } h = k\times12 - 1 \quad \text{(A5)}$$

I estimate the regressions by ordinary least squares (OLS). It can be shown that $\sqrt{T}(\hat{\beta}_{OLS} - \beta)$ converges in distribution to N(0,θ), with:

$$\theta = \left(\frac{1}{T}\sum_{t=1}^{T} x_t' x_t\right)^{-1} \Theta \left(\frac{1}{T}\sum_{t=1}^{T} x_t' x_t\right)^{-1};$$

$$\Theta = \sum_{j=-h+1}^{h-1} \hat{R}_u(j)\hat{R}_x(j);\ \hat{R}_u(j) = \frac{1}{T}\sum_{t=j+1}^{T} \hat{u}_{t,h}\hat{u}_{t-j,h};$$

$$\hat{R}_x(j) = \frac{1}{T}\sum_{t=j+1}^{T} x_t' x_{t-j}$$ where T is the sample size for each country i.

For the pooled regressions, let $y^i_{t,h} = r_{i,t+k\times12,k\times12}$; $x^i_t = [0 \ldots 0\ 1\ 0 \ldots 0\ \pi^1_{i,t+k\times12,k\times12}\ \pi^2_{i,t+k\times12,k\times12} \ldots \pi^J_{i,t+k\times12,k\times12}]$ or $x^i_t = [0 \ldots 0\ 1\ 0 \ldots 0\ \pi e^1_{i,t+k\times12,k\times12}\ \pi e^2_{i,t+k\times12,k\times12} \ldots \pi e^J_{i,t+k\times12,k\times12}\ \pi u^1_{i,t+k\times12,k\times12}\ \pi u^2_{i,t+k\times12,k\times12} \ldots \pi u^J_{i,t+k\times12,k\times12}]$ where the 1 is in the ith position; $\varepsilon_{i,t+k\times12,k\times12} = u^i_{t,h}$.
Then the regressions become

$$y^i_{t,h} = x^i_t\, \beta + u^i_{t,h} \text{ where } h = k\times12 - 1 \quad \text{(A6)}$$

The vector representation is $Y_{NT} = X_{NT}\,\beta + U_{NT}$ and it can be shown that $\sqrt{NT}(\hat{\beta}_{OLS} - \beta)$ converges in distribution to N(0,θ), with:

$$\hat{\theta}_{NT} = \left(X_{NT}' X_{NT}\right)^{-1} X_{NT}' \hat{\Omega}_{NT} X_{NT} \left(X_{NT}' X_{NT}\right)^{-1};$$

$\hat{\Omega}_{NT}$ is symmetric, its lower triangular part can be written as:

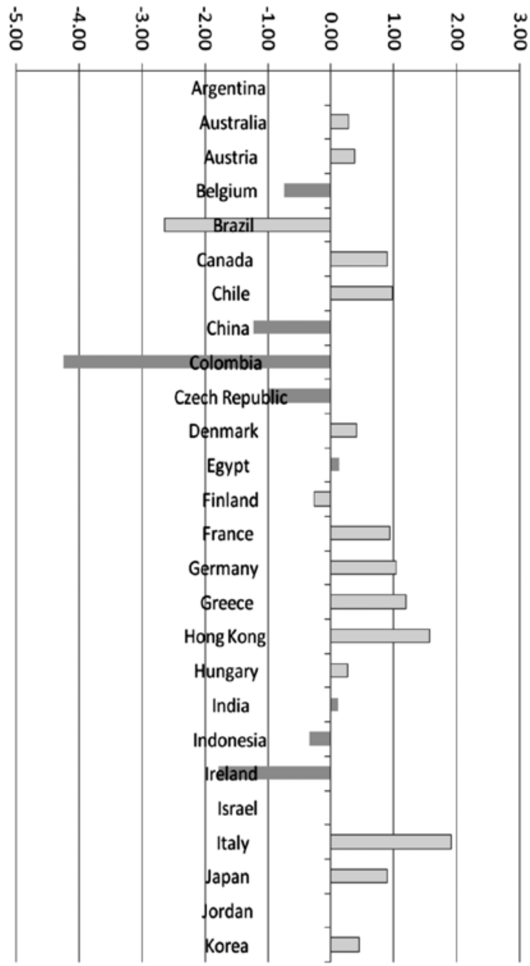
$$a_{t+n,t} = \begin{cases} \hat{R}_u(0), & n = 0, t = 1,2,\ldots,NT \\ \hat{R}_u(n), & n = 1,2,\ldots,h-1, t \neq \lambda T - j + 1 \\ 0, & otherwise \end{cases}$$

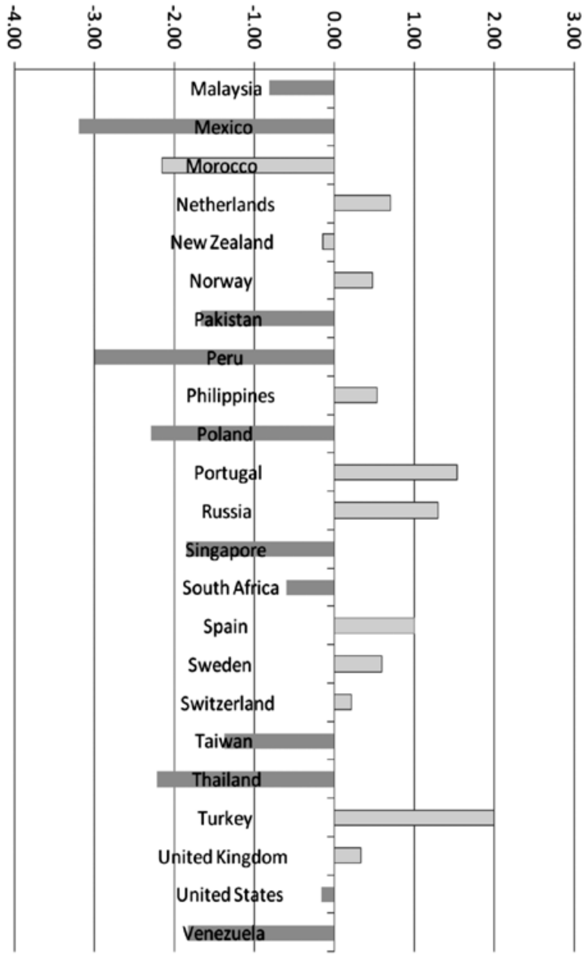
where $\lambda = 1,2,\ldots,N-1,\ j = 1,2,\ldots,n$

and, $\hat{R}_u(j) = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=j+1}^{T}\hat{u}_{t,h}^{i}\hat{u}_{t-j,h}^{i}$.

EXHIBITS

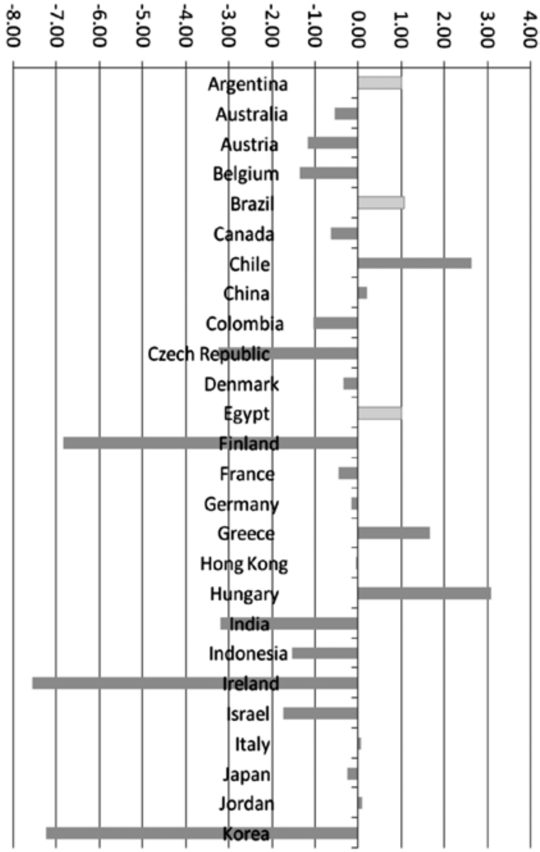
Exhibit 1: Inflation Betas in International Bond Markets

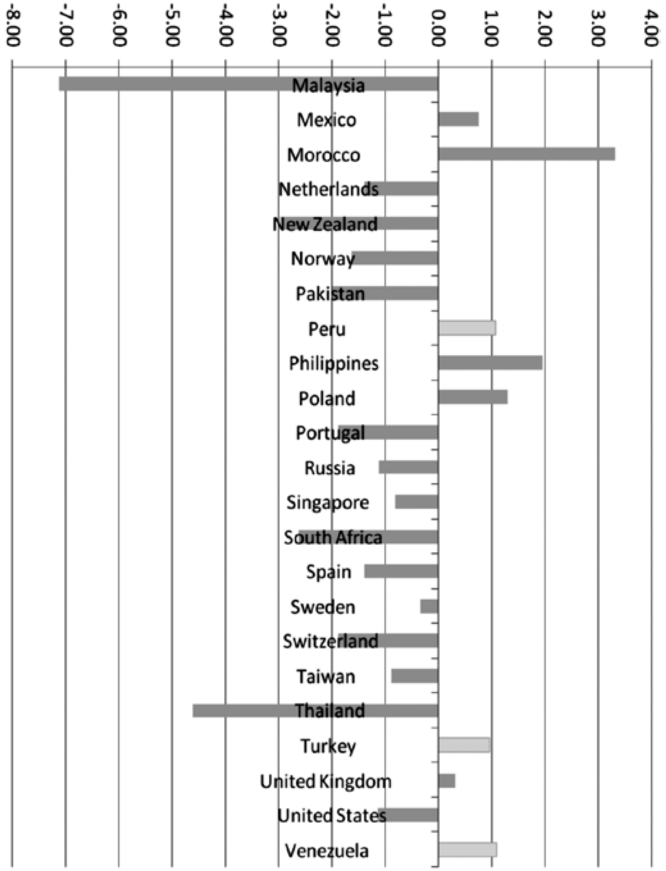




Note: The vertical bars indicate the inflation beta in Equation (1). Dark bars indicate that the beta is statistically significantly different from 1. Note that the data for Argentina, Israel and Jordan are missing.

Exhibit 2: Inflation Betas in International Stock Markets





Note: The vertical bars indicate the inflation beta in Equation (1). Dark bars indicate that the beta is statistically significantly different from 1.

Exhibit 3: Pooled Results for Inflation Betas

	Inflation Beta		Unexpected Inflation Beta	
	Bonds	**Stocks**	**Bonds**	**Stocks**
Developed	0.33 (0.26)	−0.55 (0.28)	−0.78 (0.24)	−1.16 (0.40)
Emerging	0.94 (0.13)	1.00 (0.04)	0.89 (0.10)	0.96 (0.05)
North America	0.21 (0.70)	−0.85 (1.10)	−0.78 (0.69)	−2.06 (1.59)
Latin America	−1.68 (0.66)	1.04 (0.04)	−1.89 (0.52)	1.07 (0.05)
Asia	−0.81 (0.41)	−0.88 (0.32)	−0.77 (0.33)	−0.99 (0.32)
Africa	−0.38 (0.64)	−0.01 (1.27)	−0.38 (0.50)	−0.34 (1.23)
Oceania	0.15 (0.73)	−0.72 (1.15)	−0.72 (0.64)	−1.16 (1.54)
EU	0.34 (0.30)	−0.07 (0.31)	−0.91 (0.28)	−1.30 (0.51)
Non-EU Europe	1.27 (0.14)	0.19 (0.23)	1.17 (0.11)	−0.57 (0.27)

Note: The estimates on the left hand side are from a pooled regression of bond or stock returns on inflation. I run the regression twice, once allowing for different coefficients for developed and emerging markets; once allowing for different coefficients across the different regional groups listed in the table. The estimates on the right hand side for unexpected inflation come from similar but multivariate regressions on expected and unexpected inflation, where only the second coefficient is reported. Standard errors are between parentheses.

Exhibit 4: Inflation Betas over Longer Horizons

	Bonds				
	1-Year Horizon	2-Year Horizon	3-Year Horizon	4-Year Horizon	5-Year Horizon
Developed countries	0.33 (0.26)	0.55 (0.25)	0.79 (0.24)	0.94 (0.21)	1.04 (0.21)
Emerging countries	0.94 (0.13)	1.43 (0.13)	1.66 (0.11)	2.82 (0.14)	3.11 (0.11)
North America	0.21 (0.70)	0.66 (0.66)	1.01 (0.65)	1.06 (0.64)	1.32 (0.62)
European Union	0.34 (0.30)	0.65 (0.27)	0.90 (0.26)	1.03 (0.26)	1.09 (0.25)

	Stocks				
	1-Year Horizon	2-Year Horizon	3-Year Horizon	4-Year Horizon	5-Year Horizon
Developed countries	−0.55 (0.28)	−0.34 (0.26)	−0.20 (0.26)	−0.09 (0.24)	0.05 (0.22)
Emerging countries	1.00 (0.04)	1.01 (0.04)	1.02 (0.04)	1.02 (0.04)	1.00 (0.05)
North America	−0.85 (1.10	−0.65 (1.02)	−0.46 (0.99)	−0.36 (0.94)	−0.24 (0.86)
European Union	−0.07 (0.31	−0.20 (0.29)	−0.22 (0.29)	−0.23 (0.27)	−0.13 (0.25)

Note: I repeat the pooled regressions from Exhibit 3 but also perform them over longer multi-year horizons, up till 5 years. The standard errors correct for the overlap in the observations using Hansen-Hodrick (1980) standard errors.

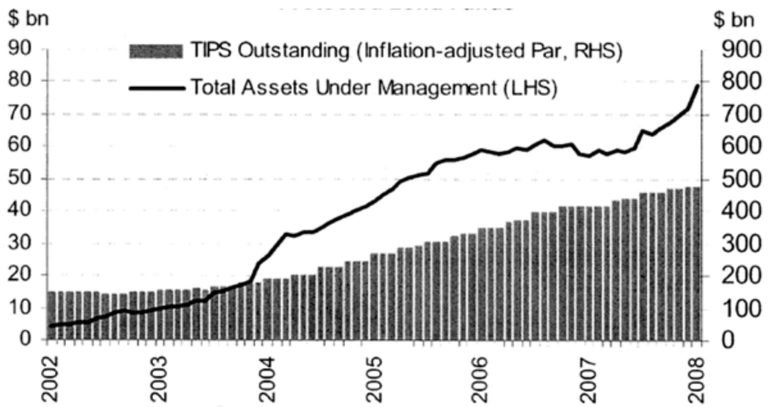
Exhibit 5: Unexpected Inflation Betas over Longer Horizons

	Bonds				
	1-Year Horizon	2-Year Horizon	3-Year Horizon	4-Year Horizon	5-Year Horizon
Developed countries	−0.78 (0.24)	−0.76 (0.24)	−0.29 (0.22)	0.08 (0.18)	0.31 (0.18)
Emerging countries	0.89 (0.10)	1.22 (0.10)	1.50 (0.09)	2.84 (0.11)	3.01 (0.08)
North America	−0.78 (0.69)	−0.69 (0.64)	0.01 (0.63)	0.15 (0.62)	0.40 (0.59)
European Union	−0.91 (0.28)	−0.57 (0.23)	−0.18 (0.23)	0.17 (0.23)	0.40 (0.23)

	Stocks				
	1-Year Horizon	2-Year Horizon	3-Year Horizon	4-Year Horizon	5-Year Horizon
Developed countries	−1.16 (0.40)	−0.79 (0.34)	−0.70 (0.31)	−0.72 (0.29)	−0.60 (0.26)
Emerging countries	0.96 (0.05)	0.97 (0.05)	1.03 (0.04)	1.04 (0.05)	1.03 (0.05)
North America	−2.06 (1.59)	−1.35 (1.31)	−0.90 (1.15)	−0.85 (1.05)	−0.89 (0.96)
European Union	−1.30 (0.51)	−1.26 (0.45)	−1.33 (0.41)	−1.43 (0.37)	−1.24 (0.33)

Note: I repeat the pooled regressions from Exhibit 3 but also perform them over longer multi-year horizons, up till 5 years. The standard errors correct for the overlap in the observations using Hansen-Hodrick (1980) standard errors .

Exhibit 6: TIPS: Assets under Management and Outstanding Amount



Source: Taken from Graph 3 in Roush, Dudley and Ezer and (2008).

Exhibit 7: Asset Allocations of a Selected Group of University Endowments in June 2000 (all numbers in %)

University	U.S. Equity	Foreign Equity	Emerging Markets	Private Equities	Absolute	Commodities	Real Estate	Bonds	TIPS	Cash
A	34.2	14.2	2.0	11.2	7.3	4.7	3.3	17.3	0.0	5.8
B	14.6	4.4	4.8	25.9	19.8	4.0	10.2	9.5	0.0	6.8
C	15.8	6.0	6.9	17.7	24.6	1.3	8.0	11.7	0.0	8.0
D	22.2	11.8	5.6	27.6	1.5	5.7	15.2	4.1	4.3	2.0
E	58.1	1.2	8.5	9.2	5.8	1.6	4.5	7.3	0.0	3.8
F	53.2	6.0	1.0	6.5	0.0	0.0	0.8	29.5	1.5	1.5
G	39.8	8.9	NA	29.5	6.1	0.0	1.6	10.6	0.0	3.5
H	56.3	17.8	NA	1.9	0.0	0.0	1.4	11.3	10.1	1.2
I	21.7	5.8	5.5	20.1	20.6	1.1	4.9	10.0	2.6	7.7
J	41.8	10.8	7.0	0.9	3.6	0.0	5.4	27.5	0.0	3.0
K	49.4	10.3	1.0	12.4	6.1	4.7	2.1	11.6	0.0	2.4
L	37.1	9.8	0.9	10.1	19.1	0.0	3.2	19.8	0.0	0.0
M	34.8	9.1	4.2	25.7	2.2	0.9	3.2	17.9	0.0	2.0
N	27.8	8.1	2.9	21.4	14.4	3.4	6.2	13.2	1.3	1.3
O	25.0	10.0	NA	25.0	10.0	3.5	6.5	20.0	0.0	0.0
P	22.4	14.9	3.1	32.8	7.1	3.3	3.8	11.3	0.9	0.4
Q	28.4	11.5	7.3	21.9	10.5	0.8	2.9	13.9	0.0	2.8
R	26.0	9.4	2.7	24.2	6.7	1.3	6.5	16.6	3.3	3.3
S	21.0	9.0	3.5	21.5	18.5	2.5	4.0	12.0	4.5	3.5
LOW	14.6	1.2	0.9	0.8	0.0	0.0	0.8	4.1	0.0	0.0
MEDIUM	32.5	9.7	4.4	18.1	9.4	2.3	5.0	14.5	1.8	3.0
HIGH	58.1	17.8	8.5	25.3	14.6	5.7	15.2	29.5	10.1	8.0

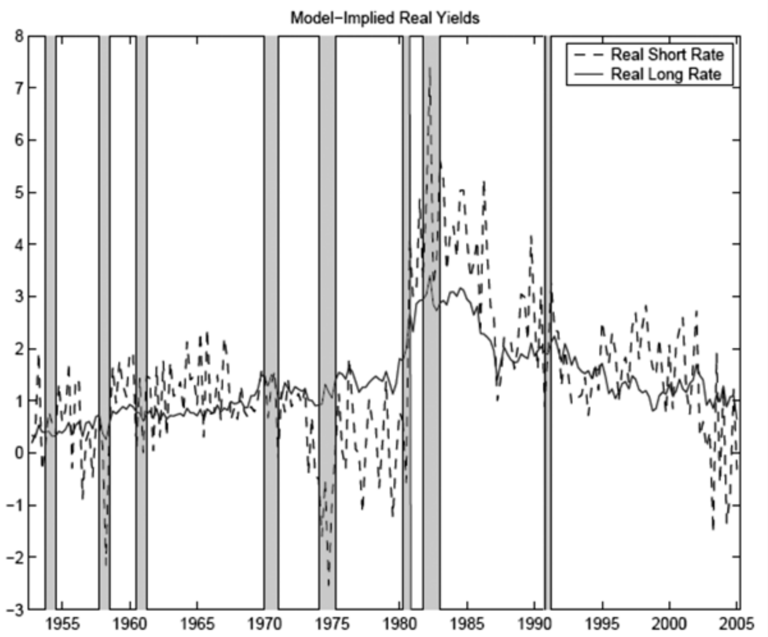
Source: Harvard Management Company, case study. See Viceira (2000).

Exhibit 8: Properties of U.S. Real Rates

Maturity Qtrs.	Mean	Stdev.	Auto
1	1.24 (0.38)	1.46 (0.23)	0.60 (0.08)
4	1.41 (0.38)	0.88 (0.25)	0.73 (0.13)
12	1.37 (0.39)	0.61 (0.30)	0.90 (0.09)
20	1.32 (0.40)	0.55 (0.32)	0.94 (0.05)
Spread 20–1	0.07 (0.28)	1.19 (0.18)	0.52 (0.06)

Source: Ang, Bekaert, Wei (2008).

Exhibit 9: Real Yields and NBER Recessions



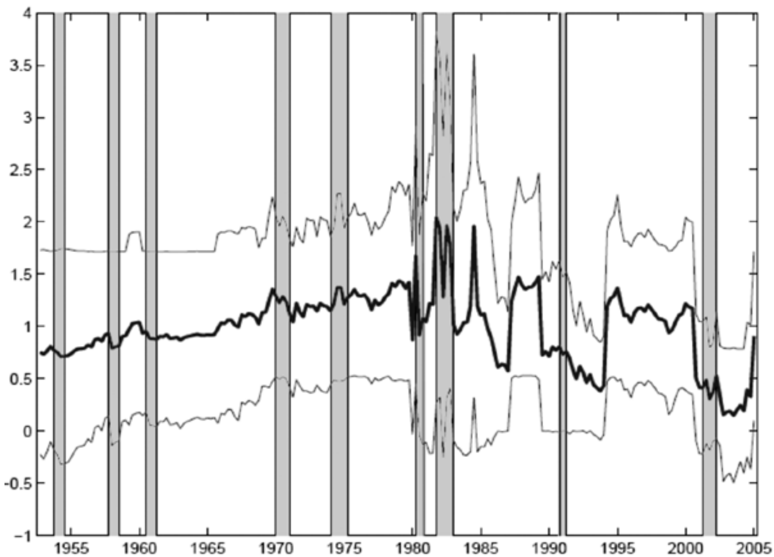
Source: Ang, Bekaert, and Wei (2008).

Exhibit 10: Properties of the Inflation Risk Premium in the U.S.

	Inflation Regimes		
QTRS	1	2	Unconditional
1	−0.01 (0.01)	−0.01 (0.00)	−0.01 (0.01)
4	0.34 (0.11)	−0.14 (0.07)	0.31 (0.10)
12	0.98 (0.30)	0.12 (0.18)	0.91 (0.28)
20	1.19 (0.37)	0.48 (0.26)	1.14 (0.36)
	[normal]	[disinflation]	

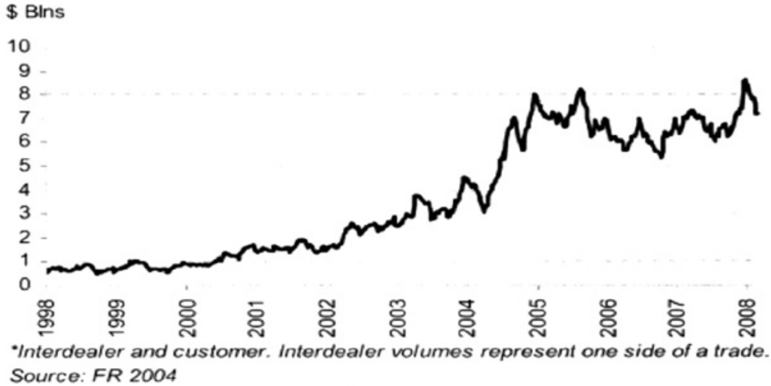
Source: Ang, Bekaert and Wei (2008).

Exhibit 11: The Inflation Risk Premium Over Time



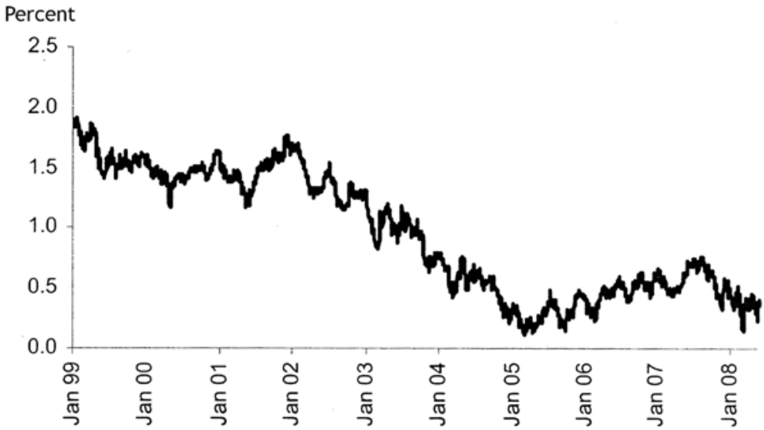
Source: Ang, Bekaert and Wei (2008). The dark line represents the inflation risk premium and the lighter lines a 90% confidence interval around the premium estimate.

Exhibit 12: Treasury Volume in the TIPS Market



Source: Taken from Roush, Dudley, and Ezer (2008), Graph 2, Average Daily Secondary Market Trading Volume in TIPS. They used a 12 week moving average of the actual data.

Exhibit 13: The Illiquidity Premium in the 10-Year TIPS Yield



Source: D'Amico, Kim and Wei (2008).

Exhibit 14: Recent Inflation Risk Premium Estimates

	U.S.					Euro		UK
Maturity in years	**HPR**	**DKW**	**CM**	**GH**	**CLR**	**HT**	**GW**	**JLS**
1	NA	35	19	NA	NA	NA	7	NA
5	27	36	NA	25	−5	25	25	[0,200]
10	51	64	216	50	−5	0	NA	NA
20	82	NA	NA	NA	NA	NA	NA	NA
30	101	NA	NA	NA	NA	NA	NA	NA
TIPS Problem					X	X		

Notes: Full references for the studies mentioned here can be found in the reference list. The line "TIPS problem" refers to the fact that TIPS were used without accounting for the liquidity premium.

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INFLATION RISK AND THE INFLATION RISK PREMIUM

In een imperfect geïndexeerde monetaire wereld is inflatierisico een van de belangrijkste economische risico's van zowel consumenten als investeerders. Individuen die hun pensioen opbouwen moeten zeker weten, dat ze voldoende geld hebben voor ná hun arbeidzame leven. Welk inflatiescenario ook speelt.

In dit paper bediscussieert Geert Bekaert (Columbia Business School) het concept van 'inflation hedging'. Hij laat zien dat standaard zekerheden het inflatierisico slecht afdekken en ziet daarom een belangrijke rol voor indexleningen. Hij beschrijft ook hoe state-of-the-art onderzoek mogelijkheden biedt om de hoogte van de inflatierisicopremies in te schatten. Bekaert eindigt met een overzicht van recente resultaten, en meer gegevens, zowel in termen van indexleningen en onderzoeksgegevens over de verwachte inflatie.

Dit NEA paper is in het Engels.

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