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Stocks, bonds, T-bills and inflation hedging: From great moderation to great recession

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ABSTRACT

Inflation hedging is an important issue for long-term investors, even during prolonged periods of relatively low inflation. This study analyzes the inflation-hedging properties of US stocks, bonds, and T-bills at the subindex level during the years 1983–2012. Our analysis provides only partial confirmation of the hypothesis that, during the post-1980 period, the returns of cyclical stocks exhibit a more positive long-run relation with inflation than the returns of non-cyclical stocks. Stocks in both cyclical and non-cyclical industries have virtually no hedging ability until the fall of Lehman Brothers in September 2008. From that moment on, equity subindices particularly in the cyclical industries start to develop statistically significant but economically modest hedging ability, even in the short run. In contrast to T-bills, long positions in bonds turn out poor inflation hedges during the entire sample period, regardless of maturity, issuer, risk rating and investment horizon. Only short positions in long-term bond indices including Treasury bonds (with maturities of 10 years and longer) may have some long-run inflation hedging capacity.

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1. Introduction

“Investors often see inflation risk primarily as a rapid inflationary spike to 4% or higher, rather than a long-term challenge that can hurt portfolios. However, the more common scenario is a low inflationary environment accompanied by a bear market – an environment that often results in negative real returns.” This statement is taken from a recent report on inflation hedging published by [J.P. Morgan AssetManagement \(2012, p. 4\)](#). Indeed inflation hedging may only seem relevant in periods of high inflation. Yet even in the absence of high inflation rates, it is important for long-term investors to immunize their real portfolio returns against the long-run effects of an increase in the price level. Although the short-run effects of a relatively modest annual inflation rate of say 2% look small and negligible, the long-run erosive effects of this level of inflation on real portfolio returns may turn out substantial (especially in the presence of low nominal returns). For example, in terms of in today's prices the value of \$100 dollar drops to \$76 dollars in 30 years. Consequently, even during prolonged periods of low inflation long-term investors prefer to invest in assets that provide protection against an increase in the general price level. This holds particularly true for pension funds, whose liabilities usually rise with the price level.

A vast literature investigates the inflation-hedging potential of various asset classes, including stocks, bonds, T-bills, commodities, and real estate (e.g. [Bekaert & Wang, 2010](#); [Bruno & Chincarini, 2010](#); [Engsted & Tanggaard, 2002](#); [Gorton & Rouwenhorst, 2006](#); [Hoevenaars, Molenaar, Schotman, & Steenkamp, 2008](#); [Worthington & Pahlavani, 2007](#)). To our best knowledge, only one study analyzes the inflation-hedging capacity of stocks at the industry level. [Boudoukh, Richardson, and Whitelaw \(1994\)](#) point out that to the extent that (expected) inflation is correlated with the economy's aggregate output, the correlation between asset returns and inflation should vary between cyclical and non-cyclical industries. In line with this theory, [Boudoukh et al. \(1994\)](#) find a more positive long-run relation between stock returns and expected inflation for stocks in non-cyclical industries.

[Boudoukh et al. \(1994\)](#) analyze the inflation-hedging properties of various assets during the 1953–1990 period. These years contain the oil crises of the 1970s and generally feature a relatively high macroeconomic volatility and a dominance of countercyclical supply shocks. Many other inflation-hedging studies consider similar periods of high macroeconomic volatility, whereas the inflation-hedging properties of assets during the post-1980 period have been studied in less detail. The post-1980 period is generally characterized by relatively low macroeconomic volatility and procyclical demand shocks.² Moreover, during the post-1980 period monetary policy has explicitly focused on maintaining the average inflation rate around a level of about 2% (‘inflation-targeting’). Although US inflation rates tend to be lower during the post-1980 period than during the preceding era, inflation hedging is also important with a relatively modest inflation rate as explained above. Furthermore, whereas the post-1980 period is not representative for all possible inflationary regimes, this period is representative for the current inflationary era. Hence, the post-1980 period is the relevant sample period if one is interested in the current inflation-hedging properties of stocks, bonds and T-bills.

The study by [Brière and Signori \(2012\)](#) is of particular relevance in the context of inflation hedging during different economic regimes. The authors compare the hedging properties of various asset classes during the 1973–1990 and 1991–2009 periods. The former period is dominated by countercyclical supply shocks, whereas the latter period is characterized by procyclical demand shocks. Several studies have shown that the difference in economic conditions between the two periods partly explains the change of correlation sign between stock and bond returns (see e.g. [Campbell, 2009](#)). [Brière and Signori \(2012\)](#) additionally show that stocks and bonds have better hedging ability during the former period.

By considering aggregate indices only, [Brière and Signori \(2012\)](#) do not investigate stocks' inflation-hedging properties across cyclical and non-cyclical industries. Yet according to [Boudoukh et al. \(1994\)](#), we would expect different hedging properties for cyclical and non-cyclical stocks. During the post-1980 period low inflation rates tend to go hand in hand with low stock returns (and vice versa) in

² During a period of procyclical demand shocks, positive inflation shocks tend to occur during improving macroeconomic conditions. By contrast, with countercyclical supply shocks, positive inflation shocks tend to occur during declining macroeconomic circumstances.

particularly the cyclical industries. We would therefore expect to find a more positive long-run correlation between the returns of cyclical stocks and inflation rates during this period.

The present study extends the literature by connecting the studies of [Boudoukh et al. \(1994\)](#) and [Brière and Signori \(2012\)](#). We analyze the inflation-hedging ability of stocks at the subindex level during the years 1983–2012. This period covers the Great Moderation and the Great Recession.³ On the basis of [Boudoukh et al. \(1994\)](#), we formulate the hypothesis that, during the post-1980 period, the returns of cyclical stocks exhibit a more positive long-run relation with inflation than the returns of non-cyclical stocks. Hence, where the sample period analyzed by [Boudoukh et al. \(1994\)](#) exhibits a more positive long-run relation between stock returns and inflation rates for stocks in non-cyclical industries, we expect that cyclical stocks turn out better hedges against inflation during our sample period. The empirical part of this paper tests this hypothesis.

In addition to equity, this study also analyzes the long-run hedging ability of T-bills (with maturities of at most one year) and bonds (with maturities of at least one year) during the post-1980 period. Existing studies assess the hedging ability of 3-month T-bills and longer-maturity bonds using samples that usually start in the 1970s or earlier. These studies generally find positive hedging ability for 3-month T-bills, whereas the outcomes for longer-maturity bonds are rather mixed ([Attié & Roache, 2009](#); [Bekaert & Wang, 2010](#); [Brière & Signori, 2012](#); [Engsted & Tanggaard, 2002](#); [Hoevenaars et al., 2008](#)). In Section 2 we will explain that the inflation-hedging ability of fixed-income securities is likely to depend on the security's maturity, risk rating and issuer. However, the total effect of the latter factors during the post-1980 period is not clear on forehand. Our empirical analysis will reveal how the hedging properties of fixed-income securities vary across the aforementioned dimensions during the 1983–2012 period.

By definition an inflation-linked bond is a hedge against inflation, as exemplified by the Treasury inflation-protected securities issued by the US government. However, it is less clear for other assets if and to what extent they act as inflation hedges. This study uses the correlation between inflation rates and asset returns as the main hedging measure ([Bodie, 1976](#); [Brière & Signori, 2012](#); [Hoevenaars et al., 2008](#)), but we perform robustness checks involving alternative measures such as the widely used Fisher coefficient, which will turn out to confirm our results based on the correlation. Because of the possible trade-off between the hedging capacity of an asset and its expected real return, we also quantify the costs of hedging ([Bodie, 1976](#)).

We use a vector autoregressive (VAR) model to specify the relation between inflation rates and asset returns and to estimate the multi-period hedging measures. The VAR approach allows us to assess the long-horizon properties of assets without the use of overlapping returns (see [Hoevenaars et al., 2008](#)). Several recent studies have found evidence for multiple regimes in asset return dynamics ([Brière & Signori, 2012](#); [Goetzmann, Li, & Rouwenhorst, 2005](#); [Goetzmann & Valaitis, 2006](#); [Guidolin & Timmermann, 2007](#)). Although we analyze a relatively stable period in terms of macroeconomic regimes, a VAR model applied to the full sample can be misspecified due to a changing correlation structure in the asset return dynamics. We therefore apply rolling-window and subsample analyses to assess the hedging properties of stocks, bonds, and T-bills over time. We explicitly analyze the inflation-hedging behavior of these assets during the Great Recession and the global financial crisis that started with the fall of Lehman Brothers in September 2008.

Our analysis provides only partial confirmation of the hypothesis that, during the post-1980 period, the returns of cyclical stocks exhibit a more positive long-run correlation with inflation than the returns of non-cyclical stocks. Stocks in both cyclical and non-cyclical industries had no significantly positive correlation with inflation until the fall of Lehman Brothers in September 2008. But from that moment on, equity subindices particularly in the cyclical industries developed significantly positive correlation with inflation, even in the short run. Especially the returns on stocks in (sub)sectors related to oil and gas, utilities, basic materials, industrials, and financials have a relatively high correlation

³ According to [Clark \(2009\)](#), the Great Moderation started in the mid-1980s and was interrupted by the Great Recession that ran from December 2007 until June 2009. The Great Recession coincided with the US subprime mortgage crisis. In his empirical analysis [Clark \(2009\)](#) shows that, as of mid-2009, macroeconomic volatility has returned to levels before the Great Recession, suggesting that this period was a temporary interruption of the Great Moderation. Of course, only the future can tell whether the Great Moderation is set to continue or not.

with inflation when the months after September 2008 are taken into account. However, although the positive correlations that we find for these stocks are statistically significant, their economic relevance is at best modest. In contrast to T-bills, long positions in bonds (with maturities of one year and longer) turn out poor inflation hedges during the entire sample period, regardless of maturity, issuer, risk rating and investment horizon. Only short positions in long-term bond indices including Treasury bonds (with maturities of 10 years and longer) may have some long-run inflation hedging capacity.

The remainder of this paper is organized as follows. Section 2 reviews the literature on the inflation-hedging properties of stocks, bonds, and T-bills. Section 3 describes the methodology, followed by a data description in Section 4. The empirical results for the full sample are discussed in Section 5, while Section 6 analyzes the changes in the hedging capacity over time using rolling-window and subsample analyses. Some robustness checks follow in Section 7. Finally, Section 8 concludes.

2. Theoretical framework

This section starts with a discussion of the Fisher hypothesis, after which we review relevant literature about the inflation-hedging properties of stocks, bonds, and T-bills. We formulate various hypotheses regarding the inflation-hedging behavior of stocks, bonds and T-bills that will be tested in the empirical part of this study.

2.1. Fisher hypothesis

A substantial part of the literature on inflation hedging defines a good inflation hedge as an asset for which the Fisher hypothesis holds. Fisher (1930) postulated that the nominal k -period interest rate on a k -period nominally risk-free bond is equal to the sum of the expected real interest rate and the expected inflation rate for the same period. According to Fisher (1930), the real and monetary sectors in an economy are largely independent, which means that expected real rates and expected inflation are unrelated. Consequently, the Fisher hypothesis is equivalent to saying that nominal interest rates move in parallel with expected inflation – often formulated by stating that expected real interest rates are statistically uncorrelated with expected inflation. The proposition that *ex ante* nominal returns contain the market's perception of expected inflation rates can be applied to all assets. The Fisher hypothesis assumes that there is no inflation risk premium.

2.2. Stocks

Stocks are by far the most widely studied asset class in the literature about inflation hedging. Using the argument that stocks are claims to real assets, the Fisher hypothesis was widely believed to hold for returns on common stocks until the early seventies. Assuming rational expectations about future inflation, stocks were considered to be a good inflation hedge. Holders of common stock would be, on average, compensated for price level movements. This 'accepted dogma' was subjected to serious empirical scrutiny only after the subsequent episode of soaring inflation rates and poor stock market performance. Instead of being an inflation hedge, stock returns turned out to be negatively correlated with expected inflation in the short run; only for long-run investment horizons there was evidence for a Fisher effect.⁴

The literature has provided various explanations for the negative effect of inflation rates on stock returns that several studies report for short-term investment horizons. Among these explanations are the proxy effect (Fama, 1981; Kaul, 1987), money illusion (Modigliani & Cohn, 1979), and informational frictions (Barnes et al., 1999). The proxy hypothesis is based on the assumption that stock prices are driven by a company's future earnings potential. If the inflation rate is negatively correlated with the

⁴ See e.g. Fama and Schwert (1977), Solnik (1983), and Gultekin (1983) for evidence of a negative Fisher effect in the short run and Boudoukh and Richardson (1993), Barnes, Boyd, and Smith (1999), Schotman and Schweitzer (2000), Campbell and Vuolteenaho (2004), Hoevenaars et al. (2008), and Amenc, Martellini, and Ziemann (2009) for evidence of a positive Fisher effect in the long run.

economy's expected future output (and thereby with the company's expected future growth rate), then the inflation rate will act as a proxy for future real output. This results in a spurious negative relation between stock returns and inflation rates. The money-illusion hypothesis postulates that stock market investors incorrectly discount real cash flows with nominal discount rates. Consequently, the resulting future equity premium deviates from the rational expectations value. If inflation is high, the equity premium is too low (and vice versa). This effect could account for the negative correlation between inflation rates and equity returns established by several studies. According to the frictions hypothesis, an increase in inflation exacerbates credit market frictions. As a result, and increase in inflation does not only lower real returns on money, but on all other assets.

The inflation-hedging capacity of stocks is usually analyzed on the basis of equity indices that represent the aggregate stock market. Boudoukh et al. (1994) – a notable exception – analyze the hedging capacity of US stocks at the industry level during the 1953–1990 period. Accounting for differences across industries is important in the light of the aforementioned proxy hypothesis (Fama, 1981; Kaul, 1987). To the extent that expected inflation is correlated with the economy's aggregate output, the correlation should vary between cyclical and non-cyclical industries. Boudoukh et al. (1994) analyze the relation between stock returns and expected inflation rates on an industry basis. They find a more positive long-run relation between stock returns and expected inflation for stocks in non-cyclical industries.

The analysis of Boudoukh et al. (1994) illustrates that the hedging properties of cyclical and non-cyclical stocks may differ. At the same time, the study by Brière and Signori (2012) establishes differences in the hedging properties of various assets (among which stocks) during two different economic regimes: high macroeconomic volatility with countercyclical supply shocks (particularly the 1970s) versus low macroeconomic volatility with procyclical demand shocks (as of the mid-1980s). Combining Boudoukh et al. (1994) and Brière and Signori (2012) results in the hypothesis that, during the post-1980 period, the returns of cyclical stocks exhibit a more positive long-run relation with inflation than the returns of non-cyclical stocks. The present paper tests this hypothesis empirically using 146 US stock indices (145 subindices and one aggregate index) observed during the 1983–2012 period. We will henceforth refer to this hypothesis as **HS**.

2.3. Fixed-income securities

The hedging properties of fixed-income securities have been studied in much less detail than those of stocks. A few studies assess the hedging ability of 3-month T-bills and longer-maturity bonds, using samples that usually start in the 1970s or earlier. These studies tend to establish positive hedging ability for 3-month T-bills, whereas the results for longer-maturity bonds are mixed (Attié & Roache, 2009; Bekaert & Wang, 2010; Brière & Signori, 2012; Engsted & Tanggaard, 2002; Hoevenaars et al., 2008). It is important to mention that the latter studies are not only heterogenous with respect to the sample period and the hedging measures used, but also in terms of the chosen bond index, which may partly account for the observed differences in hedging ability.

This study will use the time series correlation between inflation rates and the total returns on various bond indices to assess the hedging ability of bonds. The latter correlation depends on the correlation between the inflation rate and the three determinants of bond total returns (yield-to-maturity, capital return, and reinvestment return). Appendix A discusses these components of the bond total return and their contribution to the latter correlation coefficient. The overall conclusion is that there is ambiguity about the sign of the correlation between inflation rates and bond total returns. Despite this ambiguity, we can formulate several testable hypotheses for T-bills, government bonds, corporate bonds and bonds in general.

We expect to find a relatively low correlation between inflation rates and total returns for long-term bond indices. The price effect (as defined in Appendix A) is stronger for bonds with a longer term to maturity. Especially in periods of low interest rates the price effect is likely to be a more important determinant of the bond's total return than its yield-to-maturity (YTM) or the reinvestment return. These considerations leads to the hypothesis that the correlation between inflation rates and total returns is lower for bond indices consisting of bonds with a longer term to maturity. We will henceforth refer to this hypothesis as **HB1**.

The relevant T-bill indices in our study are 3-month, 6-month and 1-year T-bill indices, which will be discussed in detail in Section 4. These indices are constructed by buying T-bills at the start of the month, selling them at the end of the month and rolling them over into newly selected T-bills as of the new month. Because the zero-coupon bonds are sold before maturity, they pay no interest during the month. Hence, the relevant determinants of the total return (and its correlation with inflation) are the YTM and any capital gains and losses.

A 3-month T-bill has a relatively short term to maturity, due to which the price effect will be relatively small. Consequently, when a 3-month T-bill is sold after one month, the resulting total return will be close to the YTM on a 3-month T-bill – even in the presence of changing interest rates.⁵ In a time series sample, this strategy will therefore result in an average monthly total return that is close to the average monthly YTM on 3-month T-bills. If instead 1-year T-bills were rolled over after one month, the price effect would be more substantial. This leads to the hypothesis that the total returns on the 3-month and 6-month T-bill indices exhibit a relatively high correlation with inflation relative to the 1-year T-bill index. This hypothesis is referred to as **HTB** and is a special case of hypothesis **HB1**.

The hedging ability of T-bills is influenced by monetary policy, as explained by Attié and Roache (2009). During a period of procyclical demand shocks, an increase in interest rates serves as an instrument to lower high inflation rates. By contrast, in the presence of countercyclical supply shocks, lower interest rates can contribute to lower inflation rates. The effect of monetary policy on the time series correlation between inflation rates and T-bill total returns is ambiguous, though. It depends on the effect of the change in interest rates on inflation. For example, if T-bill rates are kept at a relatively low and constant level to boost the economy, total returns on T-bill indices will be low as well. The correlation between inflation rates and total returns on T-bills will be close to zero when inflation rates keep moving. On the other hand, if decreasing T-bill rates and T-bill total returns go hand in hand with decreasing inflation rates, the correlation could even turn out positive provided that the price effect remains limited. In such a scenario a positive correlation is more likely for the 3-month and 6-month T-bill indices than for the 1-year T-bill index. For the 1-year T-bill index the price effect is expected to be more substantial.

Also government bonds deserve some special attention. Following the start of the global financial crisis, interest rates were lowered to boost the economy, resulting in an increase in the prices of especially long-term government bonds. Furthermore, due to the flight into safe investments, the prices of long-term government bonds rose even further. In combination with low inflation rates (due to the weakening of the global economic and the associated negative demand shock), we therefore expect a relatively low (and maybe even negative) correlation between inflation rates and total returns on long-term government bond indices as of the start of the global financial crisis. This leads to the hypothesis that, after the onset of the global financial crisis, the total returns on especially long-term government bond indices exhibit a relatively low correlation with inflation. We will refer to this hypothesis as **HB2**.

Besides changes in expected inflation, also bond risk premia account for an important part of the variation in nominal bond yields (Campbell & Ammer, 1993). Risk-premia are particularly relevant for corporate bonds. Kang and Pflueger (2014) show both theoretically and empirically that long-term corporate bond risk premia are driven by inflation volatility and procyclicality of inflation. More volatile inflation increases the ex-ante risk that firms will default due to high real liabilities, while inflation procyclicality can cause low inflation recessions during which low real cash flows go hand in hand with high real liabilities. These effects are shown to be most relevant for long-term corporate bonds. Inflation cyclicality can also increase the default risk premium when investors are risk averse. Kang and Pflueger (2014) show both theoretically and empirically that inflation volatility has a particularly large effect on long-term corporate bond risk premia during crises. The implications for the time series correlation between inflation rates and corporate bond returns are ambiguous though, because the

⁵ This intuition is confirmed by the correlations between official YTM on T-bills (Datastream) and the total returns on the corresponding T-bill indices (the Merrill Lynch and Citigroup T-bill indices, which are discussed in more detail in Section 4). For 3-month T-bills, this correlation equals 0.95, while it is 0.81 and 0.49 for 6-months and 1-year T-bills (period July 2001–April 2012).

theoretical model of [Kang and Pflueger \(2014\)](#) relates inflation volatility and procyclicality of inflation to corporate bond risk premia rather than the level of inflation.

We can, nevertheless, make some predictions about the correlation between inflation rates and corporate bond returns during the global financial crisis that started with the fall of Lehman Brothers in September 2008. As of this period we expect low inflation rates (due to the weakening of the global economic and the associated negative demand shock) to go hand in hand with low total returns on existing corporate bonds (due to the increase in risk premia and the corresponding drop in corporate bond prices), resulting in a relatively high correlation between inflation rates and corporate bond returns, especially for long-term corporate bonds. This leads to the hypothesis that, after the onset of the global financial crisis, the total returns on especially long-term corporate bond indices exhibit a relatively high correlation with inflation rates. We will refer to this hypothesis as **HB3**. A refinement of hypothesis **HB3** is based on [Chen \(2010\)](#) and states that the effect described in hypothesis **HB3** is stronger for lower-rated bonds. We will refer to this hypothesis as **HB3'**.

Although we have formulated four specific hypotheses about the correlation between inflation rates and bond total returns, we emphasize that the total effect of several relevant factors (including investment horizon, risk rating and issuer) on this correlation is largely ambiguous. This is an empirical question that our paper will also attempt to resolve. In total, we will investigate 95 US bond and T-bill indices (91 bond subindices, one aggregate bond index and three T-bill indices).

3. Methodology

This section discusses the hedging measures that we use to assess the inflation-hedging properties of stock, bonds, and T-bills. We also explain how we estimate the multi-period hedging measures and corresponding confidence intervals.

3.1. Hedging measures

Apart from the Fisher coefficient ([Fama & Schwert, 1977](#)) as discussed in Section 2, several other hedging measures have been proposed in the literature. [Bodie \(1976\)](#) introduces the hedge ratio and the associated costs of hedging. In a later study, he adopts the equivalent Pearson correlation between inflation rates and asset returns as an inflation-hedging measure ([Bodie, 1982](#)). [Schotman and Schweitzer \(2000\)](#) propose the hedging demand, which is closely related to the inflation-tracking approach proposed by [Lamont \(2001\)](#). Both the Fisher coefficient and the hedging demand can be written as the product of a positive scalar and the correlation coefficient and therefore have the same sign as the latter hedging measure. The four hedging measures have in common that they assess the hedging capacity of an asset on a stand-alone basis; i.e., using only asset returns and inflation rates (and possibly some additional predictor variables). They have been used in the literature as a tool for doing a quick scan of an asset's hedging ability. Their popularity can be explained from their relative simplicity and modest data requirements.

The advantage of the correlation as a hedging measure is twofold. As explained in [Bodie \(1982\)](#), this measure is grounded in mean-variance investment theory. The squared correlation coefficient reflects the maximum possible decrease in the k -period real-return variance of a portfolio consisting of k -period nominally risk-free bonds, realized by adding the risky asset to the nominal bonds.⁶ Moreover, the correlation coefficient is scale free and can be used to compare the hedging capacity across assets, sample periods, and investment horizons. Other hedging measures are scale dependent and do not allow for a comparison of the hedging ability across different dimensions. Because of the possible trade-off between the hedging capacity of an asset and its expected real return, [Bodie \(1976\)](#) also

⁶ In case of a negative correlation between asset returns and inflation rates, investors can benefit from the asset's hedging ability by going short in the asset [Bodie \(1982\)](#).

considers the costs of hedging C . These costs reflect the minimum possible decrease in expected real return incurred by adding the risky asset to a portfolio consisting of nominal bonds only.⁷

We follow Bodie (1982) and use the correlation between k -period nominal asset returns and inflation rates as a measure for the hedging capacity of a risky asset. The correlation has also been used in more recent work (see e.g. Brière & Signori, 2012; Hoevenaars et al., 2008). We consider the correlation jointly with Bodie (1976) costs of hedging. Assets are considered better hedges against inflation the higher the correlation of their returns with inflation and the lower their costs of hedging. In a later stage, we will calculate the Fisher coefficient and the hedging demand as a robustness check on our results. The latter inflation-hedging measures will turn out to confirm our findings based on the correlation.

Our data sample (to be discussed in Section 4) covers almost 30 years of monthly data. It thus contains too few non-overlapping long-horizon returns to reliably estimate long-term hedging measures. We therefore opt for a VAR-based approach to estimate the hedging measures. As explained in Hodrick (1992), VAR models are a convenient tool for long-horizon measurement and inference. Motivated by Wold's decomposition theorem, these models provide a flexible way to model the relation between inflation rates and asset returns and avoid the statistical difficulties related to using overlapping returns. VAR models have been used widely in other studies to obtain multi-period hedging measures (see e.g. Brière & Signori, 2012; Hoevenaars et al., 2008; Schotman & Schweitzer, 2000).

3.2. VAR model

We use a reduced-form VAR(p, q) model to specify the dynamics between one-period inflation rates (π_{t+1}) and nominal one-period simple asset returns (R_{t+1}):

$$\begin{aligned}\pi_{t+1} &= \mu_1 + \sum_{i=0}^p \beta_{1i} R_{t-i} + \sum_{j=0}^q \gamma_{1j} \pi_{t-j} + \varepsilon_{1,t+1}; \\ R_{t+1} &= \mu_2 + \sum_{i=0}^p \beta_{2i} R_{t-i} + \sum_{j=0}^q \gamma_{2j} \pi_{t-j} + \varepsilon_{2,t+1}.\end{aligned}\tag{1}$$

Thus ($\varepsilon_{1,t}$) and ($\varepsilon_{2,t}$) are mutually and serially uncorrelated error terms, with $IE[\varepsilon_{1,t}] = IE[\varepsilon_{2,t}] = 0$ and contemporaneous covariance matrix $\Sigma = IE[\varepsilon_{1,t} \varepsilon_{2,t}]$. Consistent (OLS) estimation of the VAR model does not require any assumptions about conditional heteroskedasticity. We will come back to this issue in Section 3.3.

It is possible to extend the VAR model with additional predictor variables to improve the goodness of fit (see e.g. Campbell & Viceira, 2005). We confine the present analysis to the bivariate VAR model in (1), but will run some robustness checks with additional predictor variables in Section 7.3.

3.3. Estimation of hedging measures and confidence bounds

We use the estimated VAR model to calculate the (multi-period) hedging measures of Section 3 in the following way. We estimate a bivariate VAR model for monthly asset returns and inflation rates. Subsequently, we recursively simulate long series of monthly asset returns and inflation rates under specific distributional assumptions regarding the VAR errors (while maintaining the contemporaneous correlation between the errors of the return and inflation equations). We use the simulated series to construct non-overlapping multi-period asset returns and inflation rates. Subsequently, we calculate the multi-period correlations between the returns and inflation rates, as well as the costs of hedging. Because we find similar results regardless of the (homoskedastic or heteroskedastic) distributional

⁷ That is, Bodie (1976) calculates the costs of hedging associated to a risky asset as $C = (\text{expected } k\text{-period real return on a nominally risk-free } k\text{-period bond}) - (\text{expected } k\text{-period real return on the global minimum variance portfolio consisting of the risky asset and the nominally risk-free } k\text{-period bonds})$.

assumptions about the VAR residuals, we estimate the hedging measures under the assumption that the VAR errors follow the empirical distribution of the VAR residuals.⁸ Simulation is a convenient way to calculate the (multi-period) hedging measures, because the latter measures are highly non-linear functions of the model parameters.⁹

It is evident that particularly long-horizon hedging measures may be subject to substantial estimation uncertainty. We quantify this uncertainty by providing confidence intervals in addition to the point estimates of the hedging measures. These confidence intervals are used to assess the statistical significance of an asset's hedging capacity. We quantify two sources of estimation uncertainty. Because the simulated asset returns and inflation rates are based on an estimated VAR model, the resulting estimates of the multi-period correlations are subject to parameter uncertainty. They are also subject to sampling uncertainty, because we estimate the correlation using simulation (see above). We estimate 95% confidence intervals for parameter and sampling uncertainty for the multi-period correlations by means of a bootstrap. Each of the $B = 1,000$ bootstrap runs consists of the following steps. We generate VAR model residuals according to a wild bootstrap (Mammen, 1993), which we use to recursively generate new series of monthly asset returns and inflation rates with the same series length as the original sample. Next, we estimate the VAR model by means of OLS per equation, using the newly generated asset returns and inflation rates. We use the estimated VAR model to calculate the multi-period correlations as described above. The wild bootstrap is robust against heteroskedasticity of unknown form, including conditional heteroskedasticity of the GARCH type Gonçalves and Kilian (2004). Finally, we use the percentile method to obtain the 95% confidence intervals.

The first part of our analysis focuses on the hedging ability of stocks, bonds, and T-bills with respect to total (ex-post) inflation. Section 5 presents an additional analysis that distinguishes between expected and unexpected inflation using a simple proxy of expected inflation.

4. Data

We use monthly total return indices for all asset classes. As explained in the introduction, our goal is to assess the hedging properties of stocks, bonds and T-bills during the post-1980 period. Several considerations play a role in selecting the exact sample period. In particular, there is a trade-off between the length of the sample period and the number of return series available for analysis. The period running from January 1983 until February 2012 offers a fairly large amount of US stock, bond, and T-bill indices available for analysis.

4.1. Stocks and fixed-income securities

Apart from an aggregate equity index, we also consider the 145 equity subindices available in Datastream. The details of the stock data used in this study are provided in Appendix B.

There is a wide array of investment options available for investing in fixed-income securities. These investments can be classified in terms of risk rating, term to maturity, and issuer. We use 93 Citigroup indices to analyze the hedging capacity of bonds. The bonds included in these indices are US Treasury, government agency, corporate, and mortgage-backed securities. They have a term to maturity between 1 and 30 years and a risk rating of at least BBB or Baa3 (i.e., investment grade only). The broadest bond index available from Citigroup is the overall investment grade bond index, to which we refer for simplicity as the aggregate bond index. In 2012 US Treasury Bonds constituted about 36.6% of the aggregate bond index in terms of market capitalization, while its effective duration was 5.45

⁸ We notice that the correlation coefficient is scale free, which explains why this measure is insensitive to the assumptions about the presence or lack of heteroskedasticity (Goetzmann et al., 2005).

⁹ For the square of the correlation coefficient to be interpreted as the reduction in real return variance realized by adding the asset to a portfolio of nominal bonds only, we have to use simple (instead of continuously compounded) asset returns and inflation rates. The gross multi-period asset returns and inflation rates are obtained as the product of the one-period gross returns and inflation rates. Because the multi-period returns arise as a product, they are non-linear functions of the model parameters.

years.¹⁰ Because the Citigroup subindices are not available for bond maturities less than one year, we also use the BofA Merrill Lynch US 3-month and 6-month T-bill indices.¹¹ Appendix B provides the details of the various T-bill and bond indices used in the present analysis.¹²

4.2. Investment horizon, inflation and yield curve

During a period of relatively low inflation the long-run inflation-hedging properties obviously have the highest relevance. To allow for a detailed comparison with previous studies, we also investigate the short-run and medium-run hedging behavior by considering investment horizons of 1 and 6 months and of 1, 2, 3, 4, 5, and 10 years.

The inflation rate is based on the US seasonally corrected all urban consumer price index (CPI), provided by the Bureau of Labor Statistics. This series has also been downloaded from Datastream.¹³ To calculate the costs of hedging, we need the average yields during the sample period for nominally risk-free bills and bonds with maturities between 1 month and 10 years. For this purpose we use average T-bill rates (for maturities of 1 and 6 months) and average Treasury Constant Maturity rates (for maturities between 1 and 10 years).¹⁴ Of course, the costs of hedging will crucially depend on the presumed yield curve. Because the average yield on nominally risk-free bills and bonds shows a decreasing trend during the sample, the resulting costs of hedging will turn out higher than they would have been in the current period (with historically low risk-free yields).

4.3. Sample statistics

The left panel of Table 1 provides sample statistics for monthly inflation rates and nominal asset returns on the aggregate stock, bond, and T-bill indices. Table 1 also provides sample statistics for the Merrill Lynch 3-month and 6-month T-bill indices, as well as the Citigroup USBIG Treasury Benchmark 1-year index.

The return volatility of the aggregate bond index is low relative to its mean. The return volatility of the 1-year T-bill index is high in comparison with the other two T-bill indices, reflecting that longer maturity T-bills are more sensitive to changes in interest rates. The skewness and kurtosis of the 1-year T-bill index is very high. This is due to a couple of positive total return outliers that we cannot further explain. We emphasize that these outliers do not affect the remaining analysis; leaving them out or replacing them by the sample mean leads to very similar results throughout.

Augmented Dickey–Fuller and Phillips–Perron unit root tests reject the null hypothesis that the log of the CPI has a unit root at a 10% significance level. If we run Johansen cointegration tests anyhow, these tests indicate no cointegration between asset prices and the CPI at the 5% level. These results legitimate our use of VAR models to capture the dynamics between asset returns and inflation rates.

¹⁰ For more details about the Citigroup investment grade bond indices that we use, see <https://www.yieldbook.com/f/m/pdf/index.catalog.2012.pdf>. For information about the current composition of the USBIG aggregate bond index, see <https://www.yieldbook.com/x/ixFactSheet/factsheet.monthly.usbig.pdf>.

¹¹ Investors can invest in the various bond indices by means of Exchange Traded Funds (ETFs).

¹² We notice that there is some overlap in the bond indices in terms of e.g. maturity. For example, Treasury bonds with maturities of 1–5 years are aggregated in a subindex (mnemonic: SBGT15I), but also Treasury bonds with maturities between 3 and 7 years have their own subindex (mnemonic: SBGT37I). For completeness, we analyze the hedging ability of all 95 bond (sub)indices available in Datastream.

¹³ Its mnemonic is USCONPRCE.

¹⁴ We take average nominal yields from <http://research.stlouisfed.org/fred2/categories/22>. We use the series with mnemonics TB4WK, TB6MS, GS1, GS2, GS3, GS5, and GS10. We calculate the four-year yield as the average of the three-year and five-year yields. The series TB4WK is not available during the full sample period that starts in 1983. We therefore calculate the average yield for this maturity during the available time period, which starts in 2001. Moreover, the 4-year yield is obtained as the average of the 3-year and 5-year yields. This results in the following (annualized) 'average' yield curve: 1.9% (1 month), 4.5% (6 months), 4.9% (1 year), 5.3% (2 years), 5.5% (3 years), 5.7 (4 years), 5.9% (5 years), 6.3% (10 years). These percentages have been obtained under the assumption that annual interest payments are reinvested against the average annual yield.

Table 1
Sample statistics.

	CPI	Stocks	Bonds	3-M T-bill	6-M T-bill	1-Y T-bill
Mean	0.24	0.90	0.66	0.39	0.41	0.44
Std. dev.	0.26	4.56	1.27	0.24	0.26	0.56
Skewness	−1.66	−1.01	0.01	0.11	0.46	5.12
Kurtosis	14.04	3.13	0.76	−0.51	0.31	41.64
Q1%	−0.53	−10.76	−2.49	0.00	0.00	−0.16
Q5%	−0.06	−7.66	−1.43	0.01	0.02	−0.02
Q10%	0.00	−4.55	−0.89	0.02	0.05	0.00
Q50%	0.25	1.36	0.74	0.42	0.42	0.35
Q90%	0.49	6.26	2.08	0.70	0.72	0.94
Q95%	0.59	7.37	2.73	0.80	0.86	1.13
Q99%	0.83	9.94	3.91	0.92	1.10	1.80

Notes: This table displays sample statistics for the inflation rate and the nominal returns on the aggregate stock, bond, and T-bill indices. Returns and inflation rates are expressed in percentages. Sample quantiles are denoted Q1% etc. All sample statistics are based on monthly data covering the period January 1983–February 2012.

5. Empirical results

This section reports and interprets the estimated hedging measures for the various indices under consideration.

5.1. VAR models

For each return series, we estimate the bivariate VAR model of Eq. (1) by means of OLS per equation. We use a lag length of 2 on the basis of the Akaike criterion.¹⁵ Table 2 displays the estimation results for the aggregate stock, bond, and T-bill total return indices. The equation for the inflation rate has a relatively high adjusted R^2 of around 0.20. Only for the 3-month and 6-month T-bills the adjusted R^2 of the return equation is relatively high. For the latter assets, both autoregressive terms are highly significant and return persistence is high. The low adjusted R^2 for the other return equations indicates that the returns on these assets are to a large extent unpredictable from past returns and inflation rates, which emphasizes once more the importance of quantifying the amount of estimation uncertainty in the hedging measures by means of confidence intervals.¹⁶

5.2. Stocks

Throughout, we report the hedging measures together with 95% bootstrap-based confidence intervals. We use the confidence intervals to assess the significance of the hedging measures. If 0 lies in the confidence interval, then the hedging measure does not significantly differ from 0 at a 5% significance level.

The first panel of Table 3 shows that the correlation between the returns on the aggregate stock index and the inflation rate is not significant, regardless of the investment horizon. For example, for a 10-year investment horizon the correlation equals 0.21 with 95% confidence interval [−0.03, 0.46]. Because 0 is contained in this interval, the correlation is not significantly different from 0 at a 5% significance level. Hence, despite generally lower and less volatile inflation rates than in the 1970s, we do not establish positive inflation-hedging properties for the aggregate stock index during the 1983–2012 period.

Hence, we find that the returns on the aggregate stock index are not significantly positively correlated with inflation regardless of the investment horizon. This result is not in line with a number of

¹⁵ We varied the lag length of the VAR model, but this did not have significant impact on the results.

¹⁶ In line with e.g. Boudoukh and Richardson (1993) and Schotman and Schweitzer (2000) we calculate all hedging measures in terms of their non-annualized multi-period returns.

Table 2
Estimation results for the VAR models.

	coeff.	std.dev.	t-value	p-value	coeff.	std.dev.	t-value	p-value	coeff.	std.dev.	t-value	p-value
	Stocks				Bonds				3-M T-bill			
dep.var.: π_t												
Intercept	0.154	0.019	8.328	0.000	0.164	0.021	7.699	0.000	0.122	0.026	4.777	0.000
π_{t-1}	0.517	0.052	9.892	0.000	0.507	0.053	9.479	0.000	0.485	0.053	9.074	0.000
π_{t-2}	-0.173	0.053	-3.280	0.001	-0.176	0.054	-3.285	0.001	-0.190	0.053	-3.554	0.000
R_{t-1}	0.008	0.003	3.088	0.002	0.006	0.010	0.570	0.569	0.130	0.163	0.797	0.426
R_{t-2}	0.001	0.003	0.316	0.752	-0.006	0.010	-0.656	0.512	-0.003	0.162	-0.019	0.985
adj. R^2	0.221				0.200				0.212			
dep.var.: R_t												
Intercept	0.743	0.368	2.017	0.044	0.597	0.116	5.138	0.000	0.001	0.008	0.102	0.919
π_{t-1}	-0.372	1.056	-0.352	0.725	-0.507	0.292	-1.736	0.083	0.000	0.016	-0.012	0.990
π_{t-2}	1.234	1.046	1.180	0.239	0.567	0.292	1.940	0.053	0.050	0.016	3.123	0.002
R_{t-1}	0.075	0.054	1.389	0.166	0.151	0.054	2.817	0.005	0.556	0.049	11.420	0.000
R_{t-2}	-0.034	0.055	-0.621	0.535	-0.068	0.054	-1.259	0.209	0.405	0.049	8.326	0.000
adj. R^2	-0.001				0.030				0.912			
	6-M T-Bill				1-Y T-Bill							
	coeff.	std.dev.	t-value	p-value	coeff.	std.dev.	t-value	p-value				
dep.var.: π_t												
Intercept	0.137	0.026	5.178	0.000	0.158	0.022	7.156	0.000				
π_{t-1}	0.500	0.053	9.381	0.000	0.503	0.053	9.457	0.000				
π_{t-2}	-0.182	0.053	-3.402	0.001	-0.174	0.053	-3.277	0.001				
R_{t-1}	-0.018	0.084	-0.208	0.836	0.020	0.022	0.927	0.355				
R_{t-2}	0.089	0.084	1.050	0.295	-0.006	0.022	-0.268	0.789				
adj. R^2	0.204				0.201							
dep.var.: R_t												
Intercept	0.022	0.015	1.417	0.157	0.279	0.054	5.215	0.000				
π_{t-1}	0.002	0.031	0.062	0.950	-0.022	0.129	-0.167	0.867				
π_{t-2}	0.110	0.031	3.566	0.000	0.268	0.129	2.072	0.039				
R_{t-1}	0.487	0.049	9.990	0.000	0.135	0.053	2.522	0.012				
R_{t-2}	0.389	0.049	8.007	0.000	0.097	0.053	1.821	0.070				
adj. R^2	0.736				0.002							

Notes: This table displays the estimation results for the VAR model in (1), applied to the returns on the aggregate stock, bond, and T-bill indices. Estimation of the VAR models relies on OLS per equation. The standard errors are based on White's heteroskedasticity robust covariance matrix.

studies that analyze stocks' hedging ability during long periods dominated by high macroeconomic volatility and countercyclical supply shocks, such as Boudoukh and Richardson (1993), Barnes et al. (1999), Schotman and Schweitzer (2000), Campbell and Vuolteenaho (2004), Hoevenaars et al. (2008), and Amenc et al. (2009). These studies all establish positive long-run hedging ability for stocks.

Also Brière and Signori (2012) establish a positive long-run correlation between the returns on an aggregate stock index and inflation, for the 1991–2009 period. Their sample period has substantial overlap with ours. Also our aggregate stock index returns are positively correlated with inflation. However, this correlation is not statistically significant. Hence, the positive correlation found by Brière and Signori (2012) for the 1991–2009 period does not necessarily contradict our conclusion about the aggregate stock index' hedging ability. Yet because Brière and Signori (2012) do not report confidence intervals, we cannot draw any conclusions about the significance of their correlations.

Table 4 lists the equity subindices whose returns exhibit significantly positive long-run correlation with inflation. Particularly stocks in cyclical industries related to oil and gas, utilities, basic materials, industrials, and financials (including real estate) turn out to have good hedging properties. Most subindices with significant hedging ability are of level IV or V, which indicates the sector and subsector level of the Industry Classification Benchmark (see Appendix B). Indices not listed in Table 4 do

Table 3

Hedging measures for the aggregate stock, bond, and T-bill indices.

	Stocks		Bonds		3-M T-bill		6-M T-bill		1-Y T-bill	
	ρ	C	ρ	C	ρ	C	ρ	C	ρ	C
1 M	−0.01	0.00	−0.11	0.01	0.22	−0.03	0.15	−0.04	0.03	0.00
L	−0.07	0.00	−0.19	0.01	0.05	−0.11	0.02	−0.07	−0.01	−0.01
U	0.06	0.00	−0.07	0.02	0.35	0.02	0.27	−0.01	0.07	0.00
6 M	0.17	−0.03	−0.09	0.04	0.40	0.19	0.32	0.04	0.16	−0.02
L	−0.04	−0.06	−0.26	−0.03	0.08	−0.20	0.06	−0.11	0.04	−0.06
U	0.38	0.05	0.08	0.19	0.60	0.66	0.52	0.26	0.27	0.03
12 M	0.20	−0.04	−0.08	0.07	0.52	0.71	0.43	0.30	0.19	0.00
L	−0.03	−0.12	−0.28	−0.09	0.11	−0.19	0.11	−0.08	0.05	−0.08
U	0.44	0.16	0.12	0.38	0.73	1.97	0.64	1.00	0.32	0.15
24 M	0.23	−0.06	−0.07	0.12	0.64	2.49	0.52	1.16	0.20	0.10
L	−0.02	−0.20	−0.28	−0.17	0.14	−0.05	0.14	0.01	0.06	−0.08
U	0.48	0.45	0.14	0.77	0.82	6.60	0.74	3.52	0.34	0.48
36 M	0.23	−0.05	−0.07	0.17	0.70	5.15	0.56	2.35	0.20	0.22
L	−0.01	−0.25	−0.28	−0.24	0.17	0.11	0.15	0.07	0.06	−0.07
U	0.48	0.79	0.15	1.14	0.87	14.15	0.77	6.93	0.35	0.92
48 M	0.25	0.00	−0.07	0.21	0.74	8.93	0.59	3.91	0.22	0.48
L	−0.01	−0.29	−0.29	−0.30	0.17	0.34	0.16	0.23	0.06	−0.02
U	0.51	1.21	0.15	1.48	0.89	24.71	0.80	11.25	0.35	1.53
60 M	0.24	0.02	−0.07	0.29	0.77	13.39	0.60	5.69	0.22	0.72
L	−0.02	−0.31	−0.28	−0.36	0.19	0.58	0.16	0.29	0.06	0.01
U	0.49	1.68	0.15	2.00	0.90	38.53	0.81	16.40	0.36	2.16
120 M	0.21	0.30	−0.05	0.39	0.82	48.61	0.63	17.59	0.25	2.91
L	−0.03	−0.33	−0.28	−0.54	0.21	2.93	0.17	1.47	0.06	0.26
U	0.46	5.03	0.16	4.27	0.93	155.92	0.83	53.09	0.36	6.68

Notes: This table displays the correlation (ρ) between the inflation rate and the returns on the aggregate stock, bond, and T-bill indices. The investment horizon ranges from 1 month until 10 years. Also the costs of hedging (C) are provided and expressed in percentages. Apart from point estimates, we report lower (L) and upper (U) bounds of 95% confidence intervals, which are based on $B = 1,000$ bootstrap runs.

not have significant hedging capacity. The highest correlation is found for the Marin Transportation (MARIN) subindex for a 2-year investment horizon. This correlation equals 0.45 and corresponds to a modest but significant 20% reduction in real-return variance when this subindex is added to a portfolio of nominally risk-free bonds. More detailed estimation results – including estimated costs of hedging and associated confidence intervals for the individual equity subindices – can be found in Tables I and II in the Appendix with Supplementary material.¹⁷

Until so far our findings confirm hypothesis **HS** stating that, during the 1983–2012 period, the returns of cyclical stocks exhibit a more positive long-run relation with inflation than the returns of non-cyclical stocks. However, Section 6 will provide some additional empirical evidence that will force us to narrow down the aforementioned conclusion.

As expected, our results for stocks at the industry level are not in line with Boudoukh et al. (1994), who document that stocks in non-cyclical industries have better inflation-hedging properties than stocks in cyclical industries. We consider the 1983–2012 period (a period of relatively low macroeconomic volatility, dominated by procyclical demand shocks), whereas Boudoukh et al. (1994) analyze the years 1953–1990; a period of high macroeconomic volatility with countercyclical supply shocks such as the two oil crises during the 1970s. During the 1983–2012 period, low inflation rates tend to go hand in hand with low stock returns (and vice versa) in particularly the cyclical industries. This explains why we find a significantly positive correlation between the returns of cyclical stocks and inflation rates. By contrast, during the 1953–1990 period, high inflation rates are generally associated with low stock returns in particularly the cyclical industries. It therefore comes as no surprise that

¹⁷ For completeness we notice that several non-cyclical stock indices exhibit significantly negative (but economically negligible) correlation with inflation at a 1-month investment horizon, but not at longer (and more relevant) investment horizons. For the latter investment horizons the correlations are insignificant.

Table 4
Stock subindices with significant hedging capacity.

Mnemonic	12 M	L	U	24 M	L	U	36 M	L	U	48 M	L	U	60 M	L	U	120 M	L	U
ALUMNUS	0.38	0.13	0.57	0.40	0.14	0.58	0.39	0.13	0.56	0.40	0.14	0.55	0.37	0.13	0.53	0.31	0.11	0.46
AUPRTUS	0.25	0.01	0.48	0.29	0.01	0.50	0.29	0.02	0.50	0.31	0.02	0.50	0.29	0.02	0.50	0.30	0.02	0.47
BMATRUS	0.28	0.01	0.51	0.30	0.00	0.53	0.30	0.01	0.53	0.32	0.01	0.52	0.30	0.01	0.52	0.28	0.02	0.49
BRESRUS	0.30	0.04	0.52	0.32	0.05	0.53	0.32	0.04	0.53	0.33	0.04	0.53	0.32	0.04	0.52	0.27	0.03	0.48
CHMSPUS	0.27	0.02	0.55	0.29	0.02	0.57	0.28	0.02	0.57	0.31	0.02	0.57	0.28	0.01	0.57	0.28	0.02	0.54
COALMUS	0.40	0.20	0.56	0.40	0.19	0.55	0.38	0.18	0.53	0.37	0.18	0.51	0.36	0.17	0.49	0.19	0.13	0.41
DIVINUS	0.29	0.04	0.51	0.32	0.04	0.53	0.32	0.04	0.53	0.34	0.05	0.53	0.33	0.04	0.53	0.32	0.04	0.51
ELECTUS	0.24	0.01	0.45	0.26	0.01	0.48	0.26	0.02	0.49	0.27	0.02	0.48	0.26	0.02	0.48	0.25	0.02	0.46
ELEQPUS	0.26	0.02	0.48	0.29	0.03	0.51	0.30	0.03	0.51	0.31	0.04	0.51	0.29	0.04	0.50	0.27	0.04	0.48
FSTPAUS	0.32	0.08	0.53	0.34	0.09	0.54	0.33	0.09	0.54	0.36	0.10	0.53	0.33	0.09	0.51	0.31	0.08	0.46
GAMNGUS	0.28	0.05	0.49	0.30	0.07	0.49	0.29	0.07	0.47	0.29	0.07	0.45	0.25	0.07	0.44	0.23	0.06	0.36
GASDSUS	0.41	0.22	0.57	0.44	0.22	0.58	0.43	0.22	0.58	0.43	0.22	0.57	0.41	0.22	0.57	0.38	0.19	0.53
GNINDUS	0.28	0.03	0.50	0.31	0.03	0.52	0.31	0.03	0.53	0.33	0.04	0.53	0.32	0.03	0.52	0.31	0.04	0.50
GWMUTUS	0.37	0.19	0.53	0.40	0.19	0.55	0.40	0.19	0.55	0.40	0.19	0.54	0.38	0.19	0.55	0.36	0.17	0.51
HVYCNUM	0.24	0.00	0.44	0.26	0.01	0.46	0.25	0.00	0.45	0.27	0.00	0.45	0.25	0.00	0.44	0.23	0.00	0.39
IMACHUS	0.24	0.00	0.46	0.27	0.00	0.49	0.27	0.00	0.49	0.29	0.00	0.49	0.28	0.00	0.49	0.26	0.01	0.47
INDGSUS	0.24	0.00	0.46	0.27	0.00	0.49	0.27	0.00	0.49	0.29	0.00	0.49	0.28	0.00	0.49	0.26	0.01	0.47
INDMTUS	0.29	0.03	0.50	0.31	0.03	0.51	0.30	0.04	0.51	0.31	0.04	0.50	0.30	0.04	0.49	0.24	0.03	0.44
INDTRUS	0.26	0.03	0.46	0.29	0.04	0.49	0.29	0.05	0.49	0.31	0.05	0.50	0.30	0.04	0.49	0.31	0.04	0.47
INDUSUS	0.24	0.00	0.47	0.27	0.00	0.49	0.27	−0.01	0.49	0.29	0.00	0.49	0.28	0.00	0.49	0.26	0.01	0.47
LFINSUS	0.30	0.05	0.54	0.33	0.05	0.57	0.32	0.05	0.57	0.34	0.06	0.56	0.33	0.06	0.55	0.33	0.06	0.51
MARINUS	0.44	0.26	0.60	0.45	0.26	0.60	0.44	0.25	0.58	0.43	0.25	0.56	0.41	0.24	0.53	0.36	0.19	0.46
MNINGUS	0.34	0.15	0.49	0.34	0.15	0.51	0.34	0.14	0.50	0.34	0.14	0.49	0.32	0.13	0.48	0.27	0.12	0.44
MTUTLUS	0.27	0.06	0.45	0.29	0.05	0.47	0.28	0.05	0.47	0.29	0.05	0.48	0.28	0.05	0.48	0.26	0.04	0.48
OILEPUS	0.40	0.20	0.55	0.42	0.21	0.57	0.42	0.21	0.57	0.42	0.20	0.57	0.41	0.20	0.56	0.38	0.19	0.54
OILESUS	0.38	0.18	0.56	0.39	0.18	0.57	0.39	0.18	0.56	0.38	0.18	0.55	0.36	0.17	0.54	0.33	0.15	0.48
OILGPUS	0.30	0.10	0.48	0.32	0.11	0.50	0.33	0.11	0.50	0.33	0.11	0.51	0.32	0.10	0.51	0.31	0.11	0.50
OILGSUS	0.36	0.16	0.54	0.38	0.17	0.57	0.38	0.16	0.57	0.39	0.17	0.57	0.38	0.16	0.57	0.36	0.15	0.55
OILINUS	0.22	0.02	0.40	0.23	0.02	0.42	0.24	0.02	0.42	0.25	0.02	0.43	0.24	0.02	0.43	0.23	0.02	0.42
OILSVUS	0.39	0.19	0.56	0.40	0.19	0.57	0.40	0.18	0.56	0.38	0.18	0.55	0.36	0.18	0.53	0.34	0.15	0.47
PAPERUS	0.34	0.10	0.55	0.37	0.11	0.56	0.36	0.11	0.55	0.39	0.11	0.54	0.36	0.11	0.53	0.33	0.10	0.48
RAILSUS	0.36	0.15	0.54	0.39	0.15	0.56	0.39	0.16	0.56	0.41	0.16	0.56	0.40	0.16	0.55	0.39	0.15	0.52
RITRSUS	0.30	0.05	0.52	0.33	0.06	0.55	0.32	0.06	0.55	0.34	0.06	0.55	0.32	0.06	0.54	0.31	0.06	0.52
RITRTUS	0.36	0.05	0.60	0.39	0.06	0.62	0.39	0.07	0.62	0.40	0.07	0.61	0.40	0.08	0.61	0.39	0.07	0.57
RLDEVUS	0.41	0.18	0.57	0.42	0.19	0.58	0.42	0.19	0.57	0.42	0.18	0.55	0.41	0.18	0.53	0.37	0.16	0.47

SPFINUS	0.25	−0.01	0.48	0.28	0.01	0.51	0.29	0.01	0.52	0.32	0.01	0.52	0.30	0.01	0.51	0.29	0.01	0.49
STEELUS	0.26	0.02	0.48	0.28	0.03	0.50	0.27	0.03	0.49	0.28	0.03	0.47	0.26	0.03	0.47	0.22	0.02	0.40
UTILSUS	0.29	0.07	0.48	0.31	0.07	0.51	0.31	0.06	0.51	0.32	0.07	0.51	0.30	0.06	0.51	0.29	0.06	0.50

Notes: This table displays the mnemonics of the stock subindices whose returns are significantly positively correlated with inflation at longer investment horizons, reflecting significant hedging capacity. Apart from point estimates of the correlations (in bold face), we report lower (L) and upper (U) bounds of 95% confidence intervals, which are based on $B = 1,000$ bootstrap runs. To save space we only report correlations for the longer (and most relevant) investment horizons. The index names corresponding with the Datastream mnemonics can be found in [Table B.1](#) in [Appendix B](#).

during the latter period only the returns of stocks in non-cyclical exhibit a positive correlation with inflation.

Our hypothesis that, during the 1983–2012 period, the returns of cyclical stocks exhibit a more positive relation with inflation than the returns of non-cyclical stocks turns out to hold even in the short and medium run. By contrast, [Boudoukh et al. \(1994\)](#) report significant hedging ability for stocks in the long run only. However, we emphasize that there is a difference between statistically significant and economically relevant hedging ability. For example, there are equity subindices with significant hedging ability for a 1-month investment horizon. Nevertheless, the economic relevance of such statistically significant hedging ability is minor. For example, the Gas Distributors (GASDS) subindex has a correlation of 0.11 for a 1-month investment horizon (see Table I of the Appendix with Supplementary material), corresponding to a maximum possible reduction in real-return variance of slightly more than 1%. Of course, the economic relevance of the variance reduction depends on investor preferences. But a 1% reduction in real-return variance seems modest in comparison with the reductions that are achieved for longer investment horizons or other assets such as 3-month T-bills.

5.3. Bonds

The aggregate bond index exhibits significantly negative correlation with inflation at a 1-month investment horizon, as shown in the second panel of [Table 3](#). The correlations at the other investment horizons are insignificant though.

The Citigroup aggregate bond index only contains bonds whose term to maturity is between 1 and 30 years. The relatively long maturities of the constituents bonds are likely to explain why we do not find a positive correlation between the returns on this bond index and the inflation rate. The low correlation for the aggregate bond index is likely to reflect a relatively large price effect that drives down the correlation between bond returns and inflation rates.

Almost all bond subindices exhibit significantly negative correlations with inflation at a 1-month investment horizon. More interestingly, most bond indices are not significantly correlated with inflation in both the medium and long run. The bonds constituting the Citigroup bond indices have a term to maturity between 1 and 30 years. These relatively long maturities are likely to account for the many insignificant correlations that we encounter throughout, which are likely to reflect a relatively large price effect that drives down the correlations to levels that are not significantly different from 0.

At higher investment horizons there is a lot of estimation uncertainty, so the price effect has to be strong enough to realize significantly negative correlations in these cases. Only bond indices containing Treasury bonds with a term to maturity of at least 10 years (in combination with either long-term agency or government-sponsored bonds) exhibit significantly negative correlations with inflation at long investment horizons; see the first panel of [Table 5](#) for the resulting correlations and the associated confidence intervals. The price effect for these bonds is likely to drive down the correlations between inflation rates and total bond returns. Hence, for Treasury Bonds, we confirm hypothesis **HB1** stating that the correlation between inflation rates and total returns is lower for bond indices consisting of bonds with a longer term to maturity. Long-term bond indices that do not contain Treasury bonds do not exhibit significantly negative correlations at longer investment horizons. Non-Treasury bonds (especially corporate bonds) are also driven by risk-premia in addition to interest rates, which could explain the differences in the correlation with inflation ([Hasen & Houweling, 2012](#)).

As a side result, we observe that the hedging properties of the aggregate bond index coincide to a large extent with those of the Treasury bond subindex (mnemonic: SBGTIII). The similarities in the hedging behavior come as no surprise given that Treasury bonds constitute a large part of the aggregate bond index in terms of market capitalization.

As explained by [Bodie \(1976\)](#) it is possible to hedge inflation by going short in assets whose returns are negatively correlated with inflation. For a 10-year investment horizon, the highest squared correlation among the bond indices in the first panel of [Table 5](#) equals 9%. This means that at most 8% of the real-return variance can potentially be eliminated by adding a short position in one of the long-term bond indices to a portfolio of nominally risk-free bonds. Hence, the long-term bond indices in [Table 5](#) have statistically significant but economically very modest hedging ability. Some words of caution

Table 5

Bond subindices with negative correlations at longer investment horizons.

Mnemonic	12 M	L	U	24 M	L	U	36 M	L	U	48 M	L	U	60 M	L	U	120 M	L	U
Full sample (January 1983–February 2012)																		
SBGOV10	−0.23	−0.43	−0.03	−0.23	−0.45	−0.02	−0.23	−0.45	−0.01	−0.23	−0.45	0.00	−0.24	−0.44	−0.01	−0.22	−0.44	0.00
SBGT10P	−0.23	−0.44	−0.04	−0.23	−0.45	−0.02	−0.23	−0.45	−0.01	−0.23	−0.45	−0.01	−0.24	−0.44	−0.01	−0.22	−0.45	0.00
SBGT20P	−0.28	−0.50	−0.06	−0.27	−0.51	−0.04	−0.28	−0.51	−0.03	−0.27	−0.51	−0.03	−0.28	−0.51	−0.04	−0.27	−0.51	−0.02
SBGTA10	−0.23	−0.43	−0.03	−0.23	−0.45	−0.02	−0.23	−0.45	−0.01	−0.23	−0.45	0.00	−0.24	−0.44	−0.01	−0.22	−0.44	0.00
SBNLPFT	−0.22	−0.41	−0.03	−0.21	−0.42	−0.01	−0.22	−0.42	0.00	−0.21	−0.43	0.00	−0.22	−0.42	0.00	−0.20	−0.42	0.01
SBTSY10	−0.22	−0.41	−0.04	−0.22	−0.42	−0.02	−0.23	−0.42	−0.01	−0.22	−0.42	−0.02	−0.23	−0.42	−0.01	−0.21	−0.42	−0.01
SBTSY30	−0.30	−0.52	−0.08	−0.30	−0.53	−0.06	−0.30	−0.54	−0.06	−0.30	−0.53	−0.05	−0.30	−0.53	−0.05	−0.28	−0.51	−0.05
Subsample (January 1983–September 2008)																		
SBGOV10	−0.15	−0.34	0.04	−0.17	−0.34	0.04	−0.16	−0.35	0.05	−0.18	−0.35	0.05	−0.18	−0.35	0.05	−0.19	−0.35	0.05
SBGT10P	−0.15	−0.34	0.04	−0.17	−0.34	0.04	−0.16	−0.35	0.05	−0.18	−0.35	0.05	−0.18	−0.35	0.05	−0.19	−0.35	0.05
SBGT20P	−0.19	−0.36	0.00	−0.20	−0.37	0.01	−0.19	−0.37	0.02	−0.21	−0.38	0.02	−0.22	−0.38	0.02	−0.23	−0.37	0.02
SBGTA10	−0.15	−0.33	0.04	−0.17	−0.34	0.04	−0.16	−0.35	0.05	−0.18	−0.35	0.05	−0.18	−0.35	0.05	−0.19	−0.35	0.05
SBNLPFT	−0.14	−0.32	0.05	−0.15	−0.33	0.06	−0.15	−0.34	0.07	−0.16	−0.34	0.07	−0.17	−0.34	0.07	−0.18	−0.34	0.07
SBTSY10	−0.13	−0.32	0.06	−0.14	−0.33	0.07	−0.14	−0.33	0.08	−0.15	−0.34	0.07	−0.16	−0.34	0.08	−0.17	−0.34	0.09
SBTSY30	−0.21	−0.37	−0.02	−0.22	−0.39	−0.01	−0.21	−0.39	−0.01	−0.23	−0.39	−0.01	−0.23	−0.39	−0.01	−0.23	−0.38	−0.01

Notes: This table displays the mnemonics of the bond subindices whose returns are significantly negatively correlated with inflation at longer investment horizons, reflecting significant hedging capacity by going short in these indices (provided that it is possible to replicate short positions in bonds). Apart from point estimates of the correlations (in bold face), we report lower (L) and upper (U) bounds of 95% confidence intervals, which are based on $B = 1,000$ bootstrap runs. To save space we only report correlations for the longer (and most relevant) investment horizons. The index names corresponding with the Datastream mnemonics can be found in [Table B.2](#) in [Appendix B](#).

apply here, though. In practice it will be difficult to perfectly replicate short positions in bonds. The hedging ability reported here can therefore only be achieved under ideal circumstances.¹⁸

We notice that we establish positive correlations with inflation for the total returns of several bonds indices. However, none of these positive correlations turns out statistically significant. This means that the bond subindices possess no significantly positive hedging ability regardless of their maturity, issuer and risk rating. Complete estimation results for a selection of individual bond indices can be found in Table III of the Appendix with Supplementary material.

It is difficult to compare our findings for bonds with the results of previous studies, which show very mixed results. We therefore limit the comparison to the study by Brière and Signori (2012), who establish a positive long-run correlation between long-term bond index returns and inflation rates during the 1991–2009 period.¹⁹ Throughout, we find negative or non-significant correlations for long-term bond indices. Their finding, however, does not necessarily contradict our results, as they do not report the correlation's statistical significance.

5.4. Bills

The 3-month, 6-month, and 1-year T-bill indices possess significant hedging capacity; see Table 3. The returns on these indices are significantly positively correlated with the inflation rate, for investment horizons of 6 months and longer. For the 3-month and 6-month T-bill indices also the 1-month correlation is significantly positive. For each of the three T-bill indices, the correlation tends to increase with the investment horizon. This pattern reflects better hedging ability in the long run. For a 10-year investment horizon, the squared correlation corresponding to the 3-month T-bill index equals almost 70%. This means that about 70% of the real-return variance of the nominally risk-free bond can potentially be eliminated by adding the 3-month T-bill index to a portfolio of nominally risk-free bonds. From Table 3 it becomes clear that T-bills' hedging ability decreases with maturity, confirming hypothesis HTB.²⁰

Table 3 also reports the estimated costs of hedging (assuming the yield curve as described in Section 4), expressed in percentage points. The T-bill indices involve significant costs of hedging.²¹ These costs are particularly substantial for the 3-month T-bill index. The positive costs of hedging indicate that rolling forward T-bills over an k -period horizon leads to a lower expected return than holding a k -period T-bill until maturity. Whether or not investors are willing to sacrifice part of their expected return in exchange for (partial) immunization against inflation risk depends on their risk preferences.

The significantly positive correlation between 3-month T-bill returns and inflation rates during the 1983–2012 period confirms the findings of previous studies that analyze the inflation-hedging properties of 3-month T-bills during long samples that usually start in the 1970s or earlier. The positive short-run, medium-run and long-run correlations that we establish for 3-month T-bills are also in line with Brière and Signori (2012), who analyze the 1991–2009 period. All in all, it seems that 3-month T-bills are good hedges during periods of high macroeconomic volatility and countercyclical supply shocks, as well as during years of low macroeconomic volatility and procyclical demand shocks.

¹⁸ We notice that the bond subindices whose returns exhibit significantly negative long-run correlations with inflation have significant costs of hedging, up to 3% over a 10-year period; see the complete estimation results in Table III of the Appendix with Supplementary material. However, by going short the sign of these costs switches, due to which the costs change into gains.

¹⁹ Brière and Signori (2012) analyze the Morgan Stanley 7–10 year bond index.

²⁰ We notice that the data source for the 3-month and 6-month T-bill index (Citigroup) differs from that of the 1-year T-bill index (BofA Merrill Lynch). This could account for some of the differences in hedging ability between the 1-year T-bill index and the other T-bill indices. However, we expect that it is mostly the price effect that accounts for the difference in hedging ability between the 1-year T-bill index and the other two T-bill indices; see Section 2.3.

²¹ Throughout, we use a quadratic approximation to calculate the simple real return on an asset: $r_t^{(k)} = R_t^{(k)} - \pi_t^{(k)} - \text{Cov}[R_t^{(k)}, \pi_t^{(k)}] + \text{Var}[\pi_t^{(k)}]$. This approximation is based on Ito's lemma and holds exactly in continuous time (Seruc, 1981).

Fig. 1. Rolling window estimates of the correlations between asset returns and inflation rates: stock (sub)indices. *Notes:* This figure displays rolling-window estimates of the correlations between the inflation rate and the returns on the aggregate stock index (mnemonics: TOTMKUS) and the value-weighted level II cyclical and non-cyclical stock indices, for investment horizons ranging from 1 month to 10 years. The rolling window width is equal to 10 years. An investment horizon of 1 month is abbreviated as 1-M etc. The horizontal axis displays the mid-date of the 10-year rolling window interval. The first 10-year interval is 1983–1993 with mid-year 1988 and the last 10-year window is 2002–2012 with mid-year 2007.

6. Rolling-window and subsample estimates

We have analyzed the hedging ability of stocks, bonds, and T-bills during the period January 1983–February 2012. The hedging measures estimated over the full sample period reflect the average hedging ability during this 29-year period. It is likely that the assets' hedging ability has not been constant during the past decades (Brière & Signori, 2012; Goetzmann et al., 2005; Goetzmann & Valaitis, 2006; Guidolin & Timmermann, 2007). We therefore start with a rolling-window approach to explore the changes in the hedging capacity of the aggregate indices over time, followed by a sub-sample analysis.

Throughout, we use a rolling-window width of 10 years, selected by eyeballing. Too small a window results in erratic patterns in the correlation over time, but too large a window yields too little variation over time. Eyeballing makes clear that a window width of 10 years works well.²²

6.1. Stocks

Fig. 1 shows rolling-window estimates of the correlation coefficient for the returns on the aggregate stock index. The rolling-window estimates are plotted against the mid-date of the rolling-window interval. The correlation between the return on the aggregate stock index and the inflation rate exhibits a huge jump around mid-year 2003, when its sign changes from negative into positive. As of this mid-year, the rolling-window estimates contain the observations around the collapse of Lehman Brothers

²² We find qualitatively the same results for rolling-window widths between 5 and 15 years.

in September 2008 (which corresponds with the mid-date November 2003). This event was followed by several months of low stock returns and low inflation rates (occasionally even deflation). The low stock returns and low inflation rates were a direct consequence of the weakening of the global economy and the associated negative demand shock. The parallel movement in stock returns and inflation rates resulted in a substantial increase in the correlation coefficient as measured over a 10-year period.

To get an impression of the changes over time in the hedging ability of cyclical and non-cyclical stocks, we additionally consider two value-weighted stock indices. The first consists of the cyclical level II stock subindices (Oil and Gas; Basic Materials; Industrials; Utilities and Financials), while the second consists of the non-cyclical level II equity subindices (Consumer Goods; Health Care; Consumer Services; Telecommunication; Technology).²³ Fig. 1 displays the rolling-window graphs for the correlations between the returns on these two indices and the inflation rate. Since the early nineties the returns on the cyclical stock index are more positively correlated with inflation than the returns on the non-cyclical stock index. Furthermore, although both correlations peak shortly after the collapse of Lehman Brothers, the peak in the correlation of the cyclical index is much higher. The return on the cyclical index has a maximum correlation with inflation of about 0.63, while the maximum correlation equals only 0.46 for the return on the non-cyclical index. These results are consistent with our earlier finding that the returns of cyclical stocks are more positively correlated with inflation.

To see whether and how the period after the fall of Lehman Brothers affects the full-sample correlations, we run statistical tests for time-varying correlation matrices (Goetzmann et al., 2005). These tests indeed detect a breakpoint around the fall of Lehman Brothers. It turns out that the period prior to the fall of Lehman Brothers is maximally different from the period preceding it in terms of the correlation between aggregate stock returns and inflation rates.²⁴ We subsequently divide the sample into the two subperiods that follow from the correlation test. The first period covers the period prior to the fall of Lehman Brothers (January 1983–September 2008) and the second period applies to the period thereafter (October 2008–February 2012). The stock subindices that have significant hedging ability during the full sample period turn out to have substantially less hedging capacity during the first subperiod, which is consistent with the visual results of the rolling-window analysis. Only four subindices show statistically significant but economically marginal hedging ability during the first subperiod (Mining; Marine Transportation; Gas, Water and Multi-Utilities; Gas Distributors). These results confirm that the observations after the fall of Lehman Brothers have a huge impact on the full-sample correlations.

For the cyclical and non-cyclical stock indices the aforementioned correlation test also detects a breakpoint around the collapse of Lehman Brothers. A subsample analysis indicates that, during the full sample period, the returns on the non-cyclical stock index are not significantly correlated with inflation, while the correlation is significantly positive for the cyclical stock index during this period. Prior to the fall of Lehman Brothers the correlation between the returns on the cyclical index and the inflation rate is insignificant, whereas the correlation is significantly negative during this period for the non-cyclical index. Hence, the returns on the cyclical stock index generally exhibit a higher long-run correlation with inflation than the returns on the non-cyclical stock index.²⁵ Detailed numerical results for the equity subsample analysis are summarized in the first and second panel of Table 6 (see the mnemonics TOTMKUS, CYCL and NON-CYCL).

The rolling-window and subsample analyses make clear that there is only partial confirmation of our hypothesis **H5** that, during the post-1980 period, the returns of cyclical stocks exhibit a more positive long-run relation with inflation than the returns of non-cyclical stocks. Low inflation rates go hand

²³ Unlike the other level II indices that constitute the cyclical stock index, the returns on the Financials stock index do not exhibit significant correlation with the inflation rate (although some of the components of the Financials stock index do so). We therefore include Financials in the cyclical index. The results do hardly change if we include Financials in the non-cyclical index.

²⁴ We calculate the critical values of the correlation test proposed by Goetzmann et al. (2005) using a wild bootstrap.

²⁵ Although this seems to confirm our hypothesis to some extent, we emphasize that the correlation between the returns on the cyclical stock index and the inflation rate is not significantly different from 0 during the period preceding the fall of Lehman Brothers. Hence, cyclical stocks have no hedging ability during the latter period. By going short, however, the non-cyclical stock index does provide significant hedging ability.

Table 6
Subsample analysis.

Mnemonic	12 M	L	U	24 M	L	U	36 M	L	U	48 M	L	U	60 M	L	U	120 M	L	U
Full sample (January 1983–February 2012)																		
TOTMKUS	0.20	−0.03	0.44	0.23	−0.02	0.48	0.23	−0.01	0.48	0.25	−0.01	0.51	0.24	−0.02	0.49	0.21	−0.03	0.46
CYCL	0.31	0.08	0.52	0.34	0.08	0.55	0.34	0.09	0.56	0.36	0.08	0.56	0.34	0.09	0.55	0.33	0.09	0.54
NON-CYCL	0.14	−0.09	0.37	0.17	−0.09	0.40	0.17	−0.10	0.40	0.19	−0.09	0.40	0.18	−0.09	0.40	0.16	−0.08	0.39
USBIGBI	−0.08	−0.28	0.12	−0.07	−0.28	0.14	−0.07	−0.28	0.15	−0.07	−0.29	0.15	−0.07	−0.28	0.15	−0.05	−0.28	0.16
SBCRPPII	0.00	−0.27	0.29	0.02	−0.28	0.32	0.02	−0.28	0.33	0.03	−0.28	0.34	0.02	−0.28	0.34	0.03	−0.28	0.34
SBGSIII	−0.12	−0.32	0.09	−0.11	−0.34	0.10	−0.11	−0.34	0.11	−0.12	−0.34	0.11	−0.12	−0.34	0.12	−0.10	−0.34	0.11
SBGTIII	−0.16	−0.34	0.03	−0.15	−0.35	0.05	−0.15	−0.36	0.06	−0.15	−0.35	0.06	−0.15	−0.36	0.06	−0.13	−0.36	0.06
MLUS3MT	0.52	0.11	0.73	0.64	0.14	0.82	0.70	0.17	0.87	0.74	0.17	0.89	0.77	0.19	0.90	0.82	0.21	0.93
MLUS6MT	0.43	0.11	0.64	0.52	0.14	0.74	0.56	0.15	0.77	0.59	0.16	0.80	0.60	0.16	0.81	0.63	0.17	0.83
SBTSY1B	0.19	0.05	0.32	0.20	0.06	0.34	0.20	0.06	0.35	0.22	0.06	0.35	0.22	0.06	0.36	0.25	0.06	0.36
Subsample (January 1983–September 2008)																		
TOTMKUS	0.12	−0.13	0.37	0.13	−0.14	0.39	0.13	−0.14	0.39	0.13	−0.14	0.40	0.12	−0.14	0.39	0.14	−0.13	0.38
CYCL	−0.13	−0.30	0.06	−0.13	−0.32	0.07	−0.16	−0.32	0.07	−0.14	−0.32	0.08	−0.15	−0.32	0.08	−0.16	−0.32	0.08
NON-CYCL	−0.28	−0.43	−0.11	−0.28	−0.44	−0.11	−0.30	−0.44	−0.11	−0.29	−0.45	−0.11	−0.30	−0.45	−0.10	−0.29	−0.43	−0.09
USBIGBI	−0.03	−0.23	0.16	−0.04	−0.24	0.17	−0.04	−0.24	0.18	−0.05	−0.24	0.18	−0.06	−0.25	0.18	−0.07	−0.25	0.18
SBCRPPII	0.01	−0.23	0.25	0.00	−0.25	0.26	0.00	−0.26	0.27	−0.01	−0.26	0.27	−0.01	−0.26	0.27	−0.03	−0.26	0.27
SBGSIII	−0.06	−0.24	0.13	−0.07	−0.26	0.14	−0.06	−0.26	0.15	−0.07	−0.26	0.14	−0.09	−0.26	0.15	−0.10	−0.27	0.14
SBGTIII	−0.10	−0.28	0.10	−0.11	−0.30	0.10	−0.10	−0.30	0.11	−0.11	−0.30	0.11	−0.12	−0.30	0.11	−0.14	−0.30	0.12
MLUS3MT	0.48	0.08	0.65	0.59	0.09	0.75	0.65	0.10	0.80	0.69	0.10	0.83	0.72	0.11	0.85	0.77	0.12	0.89
MLUS6MT	0.40	0.07	0.61	0.47	0.09	0.69	0.50	0.10	0.72	0.51	0.09	0.74	0.54	0.09	0.74	0.55	0.10	0.76
SBTSY1B	0.15	0.01	0.29	0.16	0.01	0.31	0.17	0.01	0.31	0.16	0.01	0.32	0.16	0.01	0.32	0.14	0.00	0.32

Notes: This table compares the estimated correlations for several stock, bond and T-bill indices estimated over the full sample period (upper panel) and the subsample spanning the period preceding the fall of Lehman Brothers (lower panel). Apart from point estimates of the correlations (in bold face), we report lower (L) and upper (U) bounds of 95% confidence intervals, which are based on $B = 1,000$ bootstrap runs. To save space we only report correlations for the longer (and most relevant) investment horizons. The index names corresponding with the Datastream mnemonics can be found in Tables B.1 and B.2 in Appendix B. CYCL and NON-CYCL refer to the value-weighted indices of cyclical and non-cyclical level II equity subindices, respectively. MLUS3MT and MLUS6MT denote the 3-month and 6-month T-bill indices, respectively.

Fig. 2. Rolling window estimates of the correlations between asset returns and inflation rates: bond (sub)indices. *Notes:* This figure displays rolling-window estimates of the correlation between the inflation rate and the returns on aggregate, corporate, government-sponsored and Treasury bond indices (mnemonics: SBGSI, SBCRP, SBGSI, and SBGT), for investment horizons ranging from 1 month to 10 years. The rolling window width is equal to 10 years. An investment horizon of 1 month is abbreviated as 1-M etc. The horizontal axis displays the mid-date of the 10-year rolling window interval. The first 10-year interval is 1983–1993 with mid-year 1988 and the last 10-year window is 2002–2012 with mid-year 2007.

in hand with low stock returns in particularly the cyclical industries, but only as of September 2008. Prior to 2008 neither cyclical nor non-cyclical stocks indices exhibit significantly positive correlation with inflation. Hence, the significant hedging ability of cyclical stocks turns out to be a relatively recent phenomenon. It may be a transient effect caused by extreme values of stock returns and inflation rates since the fall of Lehman Brothers. Because the positive correlation between stock returns and inflation rates as of September 2008 seems to arise mainly from the combination of low inflation rates and low stocks returns, it is uncertain whether stocks will also be able to protect against high inflation rates.

As a side result, our empirical analysis illustrates that stocks were better long-run hedges against inflation during the period prior to the Great Moderation (Boudoukh et al., 1994) than during the years 1983–2008, despite the higher and more volatile inflation rates during the former period.

6.2. Bonds

In comparison with stocks, the correlation between the inflation rate and the returns on the Citi-group aggregate bond index is relatively stable over time; see Fig. 2. The correlation exhibits a peak when the observations around the fall of Lehman Brothers are included. We explain the temporary rise in the correlation after the fall of Lehman Brothers as follows. After the fall of Lehman Brothers bonds show the same behavior as stocks: low returns accompanied by low inflation rates. We even observe a few months of negative bond returns and negative inflation rates. This results in a peak in the correlation around mid-date November 2003. In contrast to our results for stocks, the peak is relatively small and does not persist; the correlation measured over a 10-year horizon becomes negative again shortly thereafter.

In addition to the aggregate bond index, we also provide rolling-window graphs for the broadest subindices of its main constituents: Treasury, government-sponsored and corporate bonds. The rolling-window graphs for the Treasury and government-sponsored bond indices are similar to the one for the overall bond index; see Fig. 2. In particular, the aggregate bond index shows similar behavior after the onset of the global financial crisis as the Treasury and government-sponsored bond indices, with a negative correlation between inflation rates and bond index returns. The similarities in the rolling-window graphs of the aggregate and Treasury bond indices can be explained from the substantial weight of Treasury bonds in the aggregate bond index.

The hedging behavior of the corporate bond subindex differs from that of the aggregate bond index, though. After the fall of Lehman Brothers (around mid-date November 2003) Fig. 2 reveals a substantial rise in the correlation between corporate bond returns and inflation rates, of which a substantial part persists over time. This finding confirms hypothesis **HB3** in the sense that the correlation between inflation rates and total returns on corporate bond indices is relatively high as of the start of the global financial crisis. Yet we notice that the positive correlation after the fall of Lehman Brothers is not significantly different from 0.

The corporate bond subindices vary across risk rating, sector and maturity. Qualitatively, all subindices show rolling-window graphs with similar dynamics as the one for the broadest corporate bond index. Also the subindices consisting of corporate bonds with an AAA/AA rating (mnemonic: SBC1ACI), A rating (mnemonic: SBC2ACI), or B rating (mnemonic: SBC3BCI) feature such a rolling-window graph. The correlations after the onset of the crisis turn out higher for lower-rated bonds, thus confirming hypothesis **HB3'**. Also the subindices consisting of long-term corporate bonds feature a rolling-window graph similar to the one for the broadest corporate bond index, with a rise in the correlation after the fall of Lehman Brothers. But the overall level of the latter correlation is relatively low, while we expected it to be relatively high for long-term corporate bonds on the basis of Kang and Pflueger (2014); see Section 2.3. We explain this as follows. In addition to changes in the risk premium, corporate bonds are also sensitive to interest rate movements. The price effect is likely to drive down the correlation for the long-term corporate bond subindices.²⁶

The returns of long-term Treasury bond indices exhibit negative long-run correlations with inflation in the full-sample analysis; see Section 5.3. Fig. 3 displays the rolling-window figures of two representative indices. We observe that the hedging ability of these long-term government bond indices tends to be negative, as expected for long-term bond indices due to the price effect. Furthermore, we observe a large and persistent drop in the correlation after the fall of Lehman Brothers. Thus, the rolling-window graphs confirm hypothesis **HB2** in the sense that, after the onset of the global financial crisis, the total returns on long-term government bond indices exhibit a relatively low correlation with inflation.

To assess to what extent the period preceding the fall of Lehman Brother affects the estimated full-sample correlations for the aggregate bond index, we apply the aforementioned correlation test again. We use this test to split up the sample in two subperiods, in such a way that the correlation between bond returns and inflation rates is maximally different across the two subperiods. According to the test the breakpoint is in October 2008, just after the fall of Lehman Brothers. The correlation is not significantly different from 0 during both the first subperiod and the full sample period; see Table 6 (mnemonic: USBIGBI).

Also for the three other broad subindices the correlation tests detects breakpoints around the fall of Lehman Brothers. Again the correlations are not significantly different from zero during both the first subperiod and the full sample period; see Table 6 (mnemonics: SBCRP1I, SBGSIII, and SBGTIII). Hence, the period after the fall of Lehman Brothers has a relatively minor influence on the full-sample correlations.

A subsample analysis of the long-term bond indices' hedging ability shows the following pattern. The correlations for the period prior to the fall of Lehman Brother tend to be negative, but insignificant. Only when the observations after the fall of Lehman Brothers are included, the correlations become significantly negative. The only exception to this rule is the subindex of 30-year Treasury

²⁶ The rolling-window estimation results for the corporate bond subindices are available upon request.

Fig. 3. Rolling window estimates of the correlations between asset returns and inflation rates: long-term bond subindices. *Notes:* This figure displays rolling-window estimates of the correlations between the inflation rate and the returns on the long-term bond indices (mnemonics: SBGOV10 and SBTSY30), for investment horizons ranging from 1 month to 10 years. The rolling window width is equal to 10 years. An investment horizon of 1 month is abbreviated as 1-M etc. The horizontal axis displays the mid-date of the 10-year rolling window interval. The first 10-year interval is 1983–1993 with mid-year 1988 and the last 10-year window is 2002–2012 with mid-year 2007.

bonds (mnemonic: SBTSY30). This bond index has also significantly negative hedging ability prior to the fall of Lehman Brothers, although the rolling-window graph reveals some time variation in this index' hedging capacity. Detailed subsample estimates for the long-term bond indices can be found in the second panel of [Table 5](#).

Fig. 4. Rolling window estimates of the correlations between asset returns and inflation rates: T-bill indices. *Notes:* This figure displays rolling-window estimates of the correlations between the inflation rate and the returns on the 3-month, 6-month and 1-year T-bill indices (mnemonics: MLUS3MT, MLUS6MT and SBTSY1B), for investment horizons ranging from 1 month to 10 years. The rolling window width is equal to 10 years. An investment horizon of 1 month is abbreviated as 1-M etc. The horizontal axis displays the mid-date of the 10-year rolling window interval. The first 10-year interval is 1983–1993 with mid-year 1988 and the last 10-year window is 2002–2012 with mid-year 2007.

6.3. T-bills

To visualize the time variation in the correlations between T-bill returns and inflation rates, Fig. 4 displays the rolling-window estimates of the correlation between the returns on the 3-month T-bill index and the inflation rate. These correlations are mainly positive, emphasizing that the inflation rate and the returns on the T-bill index tend to move in the same direction over time. The correlations in Fig. 4 exhibit more variation over time than the correlations based on the stock and bond returns though. Similar to bonds, there is also something of a peak marking the fall of Lehman Brothers around mid-date November 2003.

During several 10-year periods the T-bill correlation is relatively low (occasionally it even becomes negative), for instance in the early 1990s and 2000s. Both periods are characterized by an economic downturn, during which the Federal Reserve Bank kept the T-bill rates at a low level to stimulate the economy. This results in a relatively low correlation between T-bill returns and inflation, because inflation rates kept moving while T-bill rates were relatively constant.

The rolling-window plot for the 6-month T-bill index is similar, see Fig. 4. The dynamics for the 1-year T-bill in Fig. 4 look somewhat different, with low (and often negative) correlations as of the mid-year 2000. The longer maturity of the 1-year T-bills – making the price effect stronger – is likely to account for this. Hence, once more our analysis confirms hypothesis **HTB**.

To formalize the visual analysis we run the correlation tests again. For each of the three T-bill indices the test detects a breakpoint around the Fall of Lehman Brothers, in such a way that the correlation between the T-bill returns and the inflation rates is maximally different across the two periods. In line with Fig. 4, the estimated correlations for the first subperiod are somewhat higher than for the full sample period. The subsample results for the T-bill subsample analysis are summarized in Table 6 (see the mnemonics MLUS3MT, MLUS6MT, and SBTSY1B).

Table 7
Robustness checks: expected and unexpected inflation.

	Correlation with π_e	Correlation with π_u
Stock (sub)indices		
With significant hedging ability	Not significant	Significant (+)
Without significant hedging ability	Not significant	Not significant
3-month T-bill index	Significant (+)	Significant (+) (4 years and longer)
6-month T-bill index	Significant (+) (up to 5 years)	Significant (+) (2 years and longer)
1-year T-bill index	Significant (+) (6 months and 1 year)	Significant (+) (1 year and longer)
Bond (sub)indices	Not significant	Not significant

Notes: This table summarizes the correlation between the various (sub)index returns and (proxies of) expected inflation (π_e) and unexpected inflation (π_u) as measured over the full sample period 1983–2012. Unless stated otherwise (in parentheses), the results are valid regardless of the investment horizon.

The rolling-window and subsample analyses presented in this section are a first attempt to model the time variation in assets’ hedging ability. More advanced models could be based on e.g. regime-switching models with endogenous states (Guidolin & Timmermann, 2007). We leave this as an important direction for future research.

7. Robustness checks

In this section we run several robustness checks to verify the results obtained in Section 5.

7.1. Alternative hedging measures

We calculate two alternative stand-alone and asset-only measures for the aggregate stock, bond, and T-bill indices. These measures are the Fisher coefficient and Schotman and Schweitzer (2000) hedging demand. According to Fama and Schwert (1977), an asset is a complete hedge against inflation if its Fisher coefficient (denoted β) is not significantly different from 1. Schotman and Schweitzer (2000) argue that an asset provides protection against inflation if the hedging demand (denoted Δ) is significantly different from 0.

We calculate the multi-period versions of the two alternative hedging measures in a similar way as before, using the VAR-model of Section 3. Again we use a wild bootstrap to obtain confidence intervals. The results are reported in Table 8. The general pattern that emerges from this table is the same as before: the aggregate stock and bond indices do not have significant hedging capacity, unlike the T-bill indices that have significant hedging ability.²⁷

7.2. Expected and unexpected inflation

Throughout, we have established the hedging ability of stocks, bonds, and T-bills with respect to actual inflation. Our analysis will benefit from a distinction between expected and unexpected inflation. For example, an asset could have a zero correlation with actual inflation, because its return

²⁷ The interpretation of the aggregate stock index’ Fisher coefficients and the associated confidence intervals is subtle. The null hypothesis that the aggregate stock index has no hedging ability ($H_0 : \beta = 0; H_1 : \beta \neq 0$) is not rejected. But neither can we reject the null hypothesis that the aggregate stock index is a perfect hedge against inflation ($H_0 : \beta = 1; H_1 : \beta \neq 1$), for investment horizons of 6 months and longer. This seems a very odd result, but can be explained from the considerable amount of estimation uncertainty in the aggregate stock index’ Fisher coefficient. This uncertainty is so large that a whole range of values of β cannot be rejected from a statistical point of view. However, the fact that we cannot reject the null hypothesis of a perfect hedge does not mean that the aggregate stock index is a perfect hedge. The estimation uncertainty is so large that the estimate of β is extremely uninformative. The most appropriate overall conclusion is that we cannot say much about the aggregate stock index’ hedging ability on the basis of the estimated Fisher coefficient due to the huge amount of estimation uncertainty.

Table 8

Robustness checks: alternative hedging measures.

	Stocks		Bonds		3-M T-bill		6-M T-bill		1-Y T-bill	
	β	Δ	β	Δ	β	Δ	β	Δ	β	Δ
1 M	−0.25	0.00	−0.56	−0.02	0.21	0.23	0.15	0.15	0.06	0.01
L	−1.25	0.00	−0.92	−0.04	0.03	0.08	0.02	0.02	−0.03	0.00
U	0.90	0.00	−0.34	−0.01	0.41	0.38	0.29	0.27	0.15	0.03
6 M	2.50	0.01	−0.36	−0.02	0.68	0.23	0.54	0.19	0.33	0.08
L	−0.78	0.00	−1.14	−0.07	0.09	0.07	0.09	0.05	0.09	0.02
U	5.57	0.03	0.33	0.02	1.26	0.40	0.97	0.34	0.57	0.13
12 M	3.03	0.01	−0.33	−0.02	1.16	0.23	0.92	0.20	0.41	0.09
L	−0.78	0.00	−1.22	−0.07	0.17	0.07	0.19	0.05	0.13	0.03
U	6.67	0.03	0.49	0.03	1.91	0.41	1.58	0.36	0.69	0.15
24 M	3.83	0.01	−0.32	−0.02	1.79	0.23	1.36	0.20	0.47	0.09
L	−0.85	0.00	−1.33	−0.07	0.27	0.07	0.29	0.05	0.15	0.03
U	7.86	0.03	0.60	0.03	2.61	0.40	2.29	0.36	0.79	0.15
36 M	4.23	0.01	−0.32	−0.01	2.18	0.23	1.62	0.20	0.47	0.09
L	−0.88	0.00	−1.40	−0.07	0.35	0.07	0.32	0.05	0.14	0.02
U	8.90	0.03	0.68	0.03	3.02	0.40	2.68	0.36	0.80	0.16
48 M	4.98	0.01	−0.33	−0.01	2.45	0.22	1.77	0.19	0.52	0.09
L	−0.92	0.00	−1.48	−0.06	0.40	0.07	0.36	0.05	0.18	0.03
U	10.15	0.03	0.75	0.03	3.39	0.40	2.97	0.36	0.87	0.15
60 M	5.11	0.01	−0.37	−0.01	2.62	0.22	1.88	0.19	0.55	0.09
L	−0.97	0.00	−1.57	−0.06	0.45	0.07	0.38	0.05	0.18	0.03
U	11.50	0.02	0.75	0.03	3.62	0.39	3.17	0.35	0.92	0.15
120 M	7.45	0.01	−0.36	−0.01	3.28	0.21	2.26	0.18	0.70	0.09
L	−1.23	0.00	−2.13	−0.05	0.53	0.06	0.46	0.05	0.19	0.02
U	21.04	0.02	0.98	0.02	4.71	0.38	3.87	0.32	1.21	0.15

Notes: This table displays the Fisher coefficient (β) for the aggregate stock, bond, and T-bill indices. The investment horizons range from 1 month until 10 years. Also the hedge ratio (Δ) of [Schotman and Schweitzer \(2000\)](#) is provided. Apart from point estimates, we report lower (L) and upper (U) bounds of 95% confidence intervals, which are based on $B = 1,000$ bootstrap runs.

correlates positively with expected inflation and negatively with unexpected inflation, or vice versa.²⁸ Similarly, when a particular asset has a higher correlation with actual inflation than another asset, we may want to know whether the higher correlation stems from expected or unexpected inflation. In line with [Bekaert and Wang \(2010\)](#), we use the previous period's inflation rate as a simple proxy of expected inflation.²⁹ This choice is motivated by the positive autocorrelation observed in realized inflation rates. We calculate unexpected inflation as the one-period difference in inflation. Instead of focusing on the numerical results based on these proxies, we look at the main pattern in the results, assuming that these proxies are at least able to pick up some trends. We summarize these trends in [Table 7](#); more detailed results are available in Table IV of the Appendix with Supplementary material.

The hedging ability of the relevant stock subindices stems from the correlation between their returns and unexpected inflation. The latter result is opposite to what is found by [Boudoukh et al. \(1994\)](#), which we contribute again to the sample period. The returns on the aggregate stock index do neither correlate significantly with expected inflation, nor with unexpected inflation. The same holds for the aggregate bond index. The returns on the 3-month T-bill index, by contrast, correlate

²⁸ That is, the correlation between asset returns $R_t^{(k)}$ and actual inflation π_t is a weighted sum of the correlation between assets returns and expected inflation $\pi_{e,t}^{(k)}$ and the correlation between asset returns and unexpected inflation $\pi_{u,t}^{(k)}$: $\text{Cor}(R_t^{(k)}, \pi_t^{(k)}) = \text{Cor}(R_t^{(k)}, \pi_{e,t}^{(k)})\sigma(\pi_{e,t}^{(k)})/\sigma(\pi_t^{(k)}) + \text{Cor}(R_t^{(k)}, \pi_{u,t}^{(k)})\sigma(\pi_{u,t}^{(k)})/\sigma(\pi_t^{(k)})$.

²⁹ [Ang, Bekaert, and Wei \(2007\)](#) compare one-year ahead inflation forecasts and show that survey-based forecasts outperform other forecasts. For the US, the Survey of Professional Forecasters provides inflation forecasts, but only on a quarterly frequency. We use monthly data, due to which we cannot use the quarterly forecasts. Apart from the forecast frequency there are also problems related to the sample period and the availability of multi-period forecasts of expected inflation. For this reason we use the simple proxy of expected inflation as outlined in the main text.

significantly with expected inflation regardless of the investment horizon. They also correlate significantly with unexpected inflation for investment horizons of four years and longer. The correlation of T-bill returns with expected inflation particularly decreases with the maturity of the bill and becomes even insignificant for the 1-year T-bill index (with exception of the 6-month and 1-year investment horizons). The return on the 6-month T-bill index correlates significantly with expected inflation in the short and medium run only. [Table 7](#) confirms the intuition that shorter-maturity T-bills are better hedges against expected inflation, while longer-maturity T-bills are better hedges against unexpected inflation.

7.3. Predictor variables

Stock return predictability is one of the most extensively discussed topics in the finance literature; for a recent survey see [Rapach and Zhou \(2013\)](#). Among the potential predictors of stock returns are dividend yields and dividend growth rates, book-to-market ratios, term spreads, credit spreads, and nominal interest rates. Although the literature on the predictability of bond returns is much less extensive, bond returns have been found to be driven by e.g. equity returns, term spreads, credit spreads and yield spreads (see e.g. [Hasen & Houweling, 2012](#); [Silva, Ceu Cortez, & Rocha Armada, 2003](#)).

A complicating factor in assessing the robustness of our results with respect to the inclusion of additional predictor variables in our VAR models is that many of the aforementioned predictors are not stationary during our sample period (according to augmented Dickey-Fuller and Phillips-Perron unit root tests). In fact, only equity returns are found to be stationary, while all other predictors are not stationary during our sample period. The issue of non-stationary predictor variables is well-known in the literature; see e.g. [Jiang and Lee \(2007\)](#). Predictor variables must be stationary because predicting stationary returns with a non-stationary regressor is meaningless ([Lanne, 2002](#)).

To circumvent the problem of predictor variables with a unit root in case of our VAR model for stock returns and inflation rates, we estimate the loglinear cointegration model of [Jiang and Lee \(2007\)](#). This model combines the loglinear dividend yield model of [Campbell and Shiller \(1988\)](#) and the loglinear book-to-market model of [Vuolteenaho \(2002\)](#) into one model and allows for cointegration relations among log dividends, log book values and log market values.³⁰ Together with inflation rates, this approach results in a 5-dimensional Vector Error Correction (VEC) model. In case of bonds and T-bills, we add the stationary return on the overall equity index as a predictor [Illmanen, 1995](#), resulting in 3-dimensional instead of 2-dimensional VAR models.³¹ For 55% of the stock subindices the model with predictors has a higher adjusted R^2 than the model without predictors, indicating an improvement in the goodness-of-fit due to adding the additional predictor variables. For the bond subindices this percentage equals 90%.³²

For a selection of stock, bond and T-bill indices [Table 9](#) displays the estimated correlations based on both the standard VAR model and the extended model including one or more predictor variables as outlined above. We see that the differences in estimated correlations between the standard and extended models are marginal, emphasizing the robustness of our results.³³ Similarly, we establish only marginal differences in the estimated alternative hedging measures between the standard and extended models.

³⁰ These predictor variables have been obtained from Thomson Datastream using the datatypes DY, BP and MV for the stock indices mentioned in [Appendix B](#). For all stock indices the Johansen test establishes 0 cointegration relations. As a result, the VEC model boils down to a VAR model in first differences.

³¹ The aggregate equity index has Datastream mnemonic TOTMKUS.

³² More detailed estimation results are available upon request.

³³ Only for the level II industrial stock subindex (mnemonic: INDUSUS) the model with additional predictor variables leads to a loss of significance. For this index the correlations are not significantly different from 0 according to the model with predictor variables, while they are significantly positive in the model without predictors. However, the two models yield very similar point estimates. Hence, the additional predictors merely increase the amount of parameter uncertainty.

Table 9
Robustness checks: predictor variables.

Mnemonic	12 M	L	U	24 M	L	U	36 M	L	U	48 M	L	U	60 M	L	U	120 M	L	U
With predictors																		
TOTMKUS	0.215	−0.043	0.446	0.248	−0.034	0.470	0.250	−0.035	0.479	0.271	−0.035	0.476	0.254	−0.039	0.473	0.232	−0.040	0.465
BMATRUS	0.283	0.006	0.513	0.300	0.005	0.532	0.293	0.006	0.532	0.317	0.003	0.529	0.295	0.009	0.517	0.277	0.007	0.481
CNSMGUS	0.066	−0.188	0.278	0.087	−0.194	0.305	0.086	−0.191	0.309	0.112	−0.192	0.307	0.100	−0.192	0.302	0.094	−0.182	0.297
CNSMSUS	0.102	−0.146	0.323	0.131	−0.141	0.346	0.133	−0.140	0.354	0.153	−0.139	0.354	0.149	−0.143	0.348	0.135	−0.138	0.339
FINANUS	0.247	−0.022	0.505	0.275	−0.016	0.524	0.276	−0.013	0.522	0.295	−0.013	0.519	0.282	−0.010	0.515	0.267	−0.011	0.482
HLTHCUS	0.149	−0.065	0.384	0.169	−0.068	0.401	0.177	−0.070	0.411	0.186	−0.068	0.412	0.172	−0.073	0.410	0.156	−0.067	0.400
INDUSUS	0.234	−0.026	0.475	0.263	−0.028	0.494	0.264	−0.024	0.498	0.279	−0.029	0.499	0.263	−0.025	0.494	0.246	−0.027	0.474
OILGSUS	0.375	0.181	0.554	0.396	0.185	0.577	0.398	0.185	0.580	0.403	0.188	0.581	0.390	0.180	0.579	0.378	0.172	0.560
TECNOUS	0.064	−0.155	0.263	0.081	−0.170	0.270	0.069	−0.168	0.269	0.089	−0.168	0.268	0.070	−0.172	0.262	0.049	−0.160	0.242
TELCMUS	0.064	−0.143	0.280	0.099	−0.146	0.306	0.101	−0.154	0.313	0.122	−0.153	0.309	0.116	−0.155	0.310	0.103	−0.155	0.301
UTILSUS	0.294	0.062	0.492	0.315	0.065	0.515	0.312	0.061	0.518	0.323	0.060	0.520	0.306	0.058	0.520	0.295	0.063	0.507
USBIGBI	−0.074	−0.271	0.106	−0.071	−0.277	0.124	−0.068	−0.280	0.127	−0.070	−0.280	0.131	−0.070	−0.280	0.133	−0.052	−0.283	0.144
SBCRPPII	0.018	−0.260	0.291	0.031	−0.268	0.325	0.037	−0.275	0.342	0.037	−0.273	0.348	0.031	−0.277	0.339	0.045	−0.280	0.347
SBGSIII	−0.119	−0.311	0.062	−0.120	−0.329	0.080	−0.118	−0.329	0.082	−0.124	−0.329	0.085	−0.123	−0.332	0.084	−0.097	−0.334	0.085
SBGTIII	−0.157	−0.349	0.024	−0.158	−0.353	0.040	−0.158	−0.354	0.046	−0.158	−0.354	0.050	−0.158	−0.355	0.050	−0.137	−0.357	0.056
MLUS3MT	0.518	0.105	0.691	0.640	0.142	0.797	0.700	0.163	0.845	0.740	0.173	0.870	0.764	0.186	0.889	0.825	0.193	0.918
MLUS6MT	0.428	0.095	0.632	0.523	0.128	0.726	0.565	0.143	0.764	0.590	0.147	0.791	0.608	0.142	0.797	0.635	0.150	0.820
SBTSY1B	0.197	0.044	0.328	0.214	0.052	0.353	0.211	0.055	0.364	0.229	0.056	0.363	0.235	0.055	0.367	0.258	0.050	0.375
Without predictors																		
TOTMKUS	0.201	−0.034	0.436	0.233	−0.019	0.485	0.233	−0.014	0.479	0.253	−0.006	0.512	0.236	−0.016	0.489	0.214	−0.033	0.461
BMATRUS	0.280	0.006	0.512	0.302	0.005	0.529	0.299	0.007	0.533	0.321	0.008	0.525	0.303	0.008	0.523	0.282	0.016	0.489
CNSMGUS	0.048	−0.188	0.248	0.067	−0.196	0.266	0.066	−0.194	0.275	0.090	−0.196	0.273	0.081	−0.195	0.270	0.076	−0.189	0.268
CNSMSUS	0.083	−0.149	0.297	0.110	−0.144	0.320	0.111	−0.141	0.323	0.128	−0.152	0.326	0.126	−0.144	0.327	0.113	−0.143	0.322
FINANUS	0.230	−0.029	0.473	0.262	−0.015	0.493	0.265	−0.017	0.503	0.280	−0.015	0.497	0.267	−0.012	0.493	0.261	−0.012	0.466
HLTHCUS	0.138	−0.072	0.360	0.156	−0.073	0.382	0.161	−0.074	0.381	0.171	−0.072	0.387	0.159	−0.069	0.383	0.144	−0.070	0.374
INDUSUS	0.238	−0.002	0.467	0.273	0.001	0.492	0.275	−0.005	0.495	0.293	0.001	0.494	0.277	0.002	0.490	0.260	0.006	0.466
OILGSUS	0.360	0.164	0.542	0.381	0.166	0.569	0.383	0.164	0.570	0.391	0.166	0.570	0.379	0.156	0.575	0.363	0.154	0.545
TECNOUS	0.069	−0.141	0.260	0.087	−0.154	0.268	0.076	−0.149	0.270	0.096	−0.151	0.271	0.078	−0.151	0.267	0.053	−0.139	0.246
TELCMUS	0.053	−0.146	0.264	0.088	−0.148	0.289	0.090	−0.152	0.300	0.104	−0.147	0.299	0.101	−0.148	0.290	0.085	−0.148	0.280
UTILSUS	0.286	0.066	0.484	0.308	0.066	0.506	0.307	0.061	0.509	0.319	0.067	0.509	0.300	0.058	0.508	0.290	0.062	0.498
USBIGBI	−0.079	−0.275	0.122	−0.072	−0.285	0.142	−0.069	−0.284	0.151	−0.069	−0.286	0.154	−0.073	−0.282	0.151	−0.055	−0.284	0.162
SBCRPPII	0.002	−0.267	0.289	0.017	−0.276	0.320	0.022	−0.285	0.334	0.025	−0.279	0.338	0.016	−0.285	0.344	0.030	−0.282	0.343
SBGSIII	−0.119	−0.324	0.085	−0.115	−0.339	0.099	−0.112	−0.338	0.107	−0.118	−0.338	0.106	−0.119	−0.338	0.116	−0.096	−0.342	0.106

Table 9 (Continued)

Mnemonic	12 M	L	U	24 M	L	U	36 M	L	U	48 M	L	U	60 M	L	U	120 M	L	U
SBGTIII	−0.156	−0.344	0.031	−0.152	−0.353	0.051	−0.152	−0.356	0.056	−0.151	−0.355	0.060	−0.153	−0.356	0.062	−0.132	−0.357	0.064
MLUS3MT	0.518	0.112	0.727	0.640	0.143	0.823	0.702	0.170	0.865	0.742	0.174	0.889	0.765	0.191	0.903	0.824	0.208	0.929
MLUS6MT	0.427	0.113	0.645	0.519	0.140	0.736	0.564	0.153	0.774	0.587	0.159	0.798	0.605	0.165	0.811	0.631	0.169	0.832
SBTSY1B	0.189	0.054	0.317	0.204	0.058	0.336	0.202	0.062	0.347	0.219	0.063	0.347	0.224	0.063	0.355	0.250	0.057	0.362

Notes: This table displays the estimated correlations for several stock, bond and T-bill indices based on the models with predictor variables (upper panel) and without predictor variables (lower panel). Apart from point estimates of the correlations (in bold face), we report lower (L) and upper (U) bounds of 95% confidence intervals, which are based on $B = 1,000$ bootstrap runs. To save space we only report correlations for the longer (and most relevant) investment horizons. The index names corresponding with the Datastream mnemonics can be found in Tables B.1 and B.2 in Appendix B. MLUS3MT and MLUS6MT denote the 3-month and 6-month T-bill indices, respectively.

8. Conclusions

Most inflation-hedging studies consider periods dominated by high macroeconomic volatility and countercyclical supply shocks, whereas the inflation-hedging properties of assets during the post-1980 period – a period characterized by relatively low macroeconomic volatility and procyclical demand shocks – have been studied in less detail. US inflation rates tend to be lower during the post-1980 period than during the preceding era. Yet inflation hedging is also important for long-term investors during prolonged periods of low inflation. This study analyzes the inflation-hedging ability of stocks, bonds and T-bills at the subindex level during the 1983–2012 period.

Our empirical results provide only partial confirmation of the hypothesis that, during the post-1980 period, the returns of cyclical stocks exhibit a more positive long-run relation with inflation than the returns of non-cyclical stocks. We find that stocks in both cyclical and non-cyclical industries have no hedging ability until the fall of Lehman Brothers in September 2008. From that moment on, equity subindices particularly in the cyclical industries start to develop statistically significant hedging ability, even in the short run. Especially stocks in (sub)sectors related to oil and gas, utilities, basic materials, industrials, and financials have relatively favorable hedging properties when the months after September 2008 are taken into account.

Do our results imply that stocks in cyclical industries are good hedges against inflation as of September 2008? It is evident that, as of then, stocks have some hedging ability. However, the economic significance of stocks' hedging ability is at best modest in comparison with 3-month T-bills. Moreover, because the positive correlation between stock returns and inflation rates as of September 2008 seems to arise mainly from the combination of low inflation rates and low stocks returns, it is uncertain whether stocks will also be able to provide immunization against higher inflation rates.

The other asset classes analyzed in this paper are T-bills and bonds. Long positions in bonds turn out poor inflation hedges during the entire sample period, regardless of maturity, issuer, risk rating and investment horizon. Only short positions in long-term bond indices including Treasury bonds (with maturities of 10 years and longer) may have some long-run inflation-hedging ability, provided that it is possible to replicate short positions in bonds. We establish much more favorable hedging properties for 3-month T-bills and, to a lesser extent, 6-month and 1-year T-bills. When we combine these findings with the existing literature, we conclude that 3-month T-bills are good long-term hedges against inflation not only during years of low macroeconomic volatility and procyclical demand shocks, but also during periods of high macroeconomic volatility and countercyclical supply shocks.

The T-bill indices involve significant costs of hedging, which are particularly substantial for 3-month T-bills. Rolling forward single-period T-bills over a longer period is favorable in terms of the T-bill's ability to reduce the portfolio's real return variance due to inflation, but it is unfavorable in terms of the expected portfolio return. This is the price investors will have to pay to achieve (partial) immunization against inflation.

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Appendix A. Time-series correlation between bond total returns and inflation rates

This appendix provides some additional details about the expected sign of the time-series correlation between bond total returns and inflation rates.

A.1. Total returns

Bond indices are periodically rebalanced; usually every month. Its constituent bonds can be sold before maturity, potentially leading to capital gains and losses. Capital gains (losses) arise when a bond is sold at a price higher (lower) than it was bought against. Any intra-month cash flows (including not only interest, but also principals and capital gains) are reinvested until the next rebalancing date. The performance measure that captures both capital gains and losses and reinvestment effects over the investment horizon is the total return (Fabozzi, 2001; Johnson, 2010). This study therefore assesses the inflation-hedging ability of bond and T-bill indices in terms of their total returns.

The total return on a bond index, measured over the investment horizon, is defined as the relative difference between the total of funds at the start of the investment horizon and the total of funds at the end of that period. It is calculated under the assumption that, at the end of the investment horizon, any remaining bonds in the index are sold against the market price (if they have not yet reached maturity) or pay back their principal (if they have reached maturity). It is also assumed that any intra-month cash flows are reinvested in newly selected bonds or a floating-rate money market instrument until the next rebalancing date.

The total return on a bond sold before maturity is equal to its yield-to-maturity (YTM) if all intra-period cash flows are reinvested at the YTM and the capital return from selling the bond equals the YTM (Johnson, 2010). Yet interest rates change over time, due to which the capital and reinvestment return – and thereby the total return – will generally differ from the bond's YTM. A *ceteris paribus* increase in interest rates will lead to a decrease in bond prices and cause the capital return to drop below the YTM. This price effect is stronger for bonds with a longer term to maturity, because such bonds are more sensitive to changes in interest rates. Total returns are calculated under the assumption that all intra-month cash flows are reinvested in newly selected bonds or in a floating-rate money market instrument. When interest rates rise, *ceteris paribus*, both will pay a higher interest rate and the reinvestment return will exceed the bond's YTM. *Ceteris paribus*, the total return depends positively on the YTM, capital return and reinvestment return. For a given YTM, the overall effect of a rise in interest rates on a bond's total return is ambiguous, because capital and reinvestment returns change in opposite directions and might partly offset each other.

The bond (sub)indices that we consider in this study are discussed in detail in Section 4. It is convenient to mention here that these bond indices are rebalanced every month. Their total returns are based on the assumption that any intra-month cash flows are reinvested in a floating-rate money market instrument until the next rebalancing date. Furthermore, its constituent bonds are not held until maturity. Bonds remain part of an index as long as they meet the requirements in terms of e.g. risk rating and their term to maturity falls into the required maturity class.

A.2. Bond total returns and its time series correlation with inflation

We use the time series correlation between inflation rates and the total returns on various bond indices to assess the hedging ability of bonds. The latter correlation depends on the correlation between the inflation rate and the three determinants of bond total returns (YTM, capital return, and reinvestment return).

Over time, the bonds in the bond index are rolled over into newly selected issues. When inflation rates rise, interest rates are expected to rise as well. The newly selected bonds will thus feature a higher YTM. In a time series sample, we therefore expect higher inflation rates to go hand in hand with higher YTM on the bonds constituting the bond index. Because bond total returns depend positively on the YTM, higher inflation rates are also expected to go hand in hand with higher bond total returns, *ceteris paribus*.

Typically, a rise in inflation rates goes hand in hand with a rise in interest rates and a drop in bond prices. This price effect will drive down the time series correlation between inflation rates and bond total returns. Because bonds with a longer term to maturity are more sensitive to price changes, we anticipate that this effect is particularly relevant for bonds with a longer term to maturity.

By contrast, we expect the reinvestment effect to contribute positively to the time series correlation between inflation rates and bond total returns. When inflation rates rise, the interest rate on the money

market account is expected to rise as well. This results in a higher reinvestment return and, *ceteris paribus*, in a higher bond total return.

In sum, the time series correlation between inflation rates and bond total returns is expected to be positive in the absence of any price effects. However, due to the possibility of price effects the sign of the correlation between inflation rates and bond total returns is indeterminate. A factor contributing to this ambiguity is that the correlation between inflation rates and bond total returns depends on the pass-through of inflation rates into bond interest rates. For example, short-term bonds can rapidly adjust to changes in expected inflation, but it is unclear to what extent the interest rates on such bonds provide an inflation risk premium. Long-term bonds might turn out better hedges against unexpected inflation.

Appendix B. Data

Tables B.1 and B.2 list the various indices used in this study, along with their Datastream mnemonics. Throughout, the selected data type is 'RI' (total return index).

The Thomson Reuters Datastream equity indices are classified on the basis of the Industry Classification Benchmark (ICB), jointly created by FTSE and Dow Jones. The indices are calculated from a representative sample of stocks, covering at least 75–80% of the total market capitalization. They are divided in six levels. Level I is the complete market index, encompassing all sectors. Level II refers to the ICB industry level and is calculated by dividing the Level I index into ten major industries. Level III–V divide each of the industry level indices into further niche segments at the ICB supersector level, ICB sector level, ICB subsector level, respectively. We calculate the hedging capacity for each of the 146 subindices that constitute the overall stock market index. The indices are displayed in increasing detail, starting with the Level II ICB industry index (bold) and followed by the sectoral indices within that ICB industry index.

We use the Citigroup Overall Broad Investment Grade (CGBIV) Index to proxy the overall bond market (Datastream mnemonic SSBIGBI). We select various subindices to investigate the hedging capacity of bonds across different maturities (short, medium and long term), risk ratings, and issuers (government or corporate). The CGBIV index contains the US investment-grade bond market, including US Treasury, government agency, corporate and mortgage-backed securities. All bonds in this index (and its subindices) are investment grade (rated at least BBB- or Baa3), have a term to maturity of at least 1-year, and a total outstanding value of at least \$ 200 million. Rebalancing is done on a monthly basis. Bonds that have an average remaining life of less than one year from the last calendar day of the month are removed from the (sub-)index upon the next rebalancing. The same holds for bonds that do no longer meet the requirements regarding the amount outstanding or risk rating. All the bond issues meeting the required criteria enter the index (i.e., there is no maximum number of constituents). Bonds remain part of a subindex as long as they fall into the required maturity class and meet the requirements in terms of e.g. risk rating. Notice that a bond's term to maturity is used to decide whether it falls into a specific maturity class. For example, a 30-year bond with an 8-year term to maturity will fall into the 7–10 years maturity class for one year.³⁴

The BofA Merrill Lynch US 3-month T-bill index contains a single issue of T-bills purchased at the beginning of the month and held for a full month. At the end of the month, this issue is sold and rolled into a newly selected issue. The issue selected at each month-end rebalancing is the outstanding T-bill that matures closest to, but not beyond, three months from the rebalancing date. To qualify for selection, an issue must have settled on or before the month-end. While the index will often hold the T-bill issued at the most recent or prior three-month auction, it is also possible for a seasoned 6-month or 1-year T-bill to be selected.³⁵ The Datastream mnemonic is MLUS3MT. The BofA Merrill Lynch US 6-month T-bill index (mnemonic MLUS6MT) is constructed in a similar way. The Citigroup 1-year T-bill index has Datastream mnemonic SBTSY1B.

³⁴ Source: http://www.yieldbook.com/f/m/pdf/index_catalog.2012.pdf.

³⁵ Source: <http://www.bofacapital.com/Publish/Content/application/pdf/GWMOL/UpdatingYourInvestmentPolicyWhitePaper.pdf>.

Table B.1

Datastream equity indices.

Name	Mnemonic	Level	Name	Mnemonic	Level
Aggregate Market	TOTMKUS	I	Personal Products	PRSNLUS	V
Oil and Gas	OILGSUS	II	Tobacco	TOBACUS	IV
Oil and Gas Producers	OILGPUS	IV	Health Care	HLTHCUS	II
Oil Exploration and Production	OILEPUS	V	Health Care Equipment and Services	HCEQSUS	IV
Integrated Oil and Gas	OILINUS	V	Health Care Providers	HCPROUS	V
Oil Equipment, Services and Distribution	OILESUS	IV	Medical Equipment	MEDEQUS	V
Oil Equipment and Services	OILSVUS	IV	Medical Supplies	MEDSPUS	V
Pipelines	PIPELUS	V	Pharmaceuticals and Biotechnology	PHARMUS	IV
Basic Materials	BMATRUS	II	Pharmaceuticals	PHRMCUS	V
Chemicals	CHMCLUS	III	Consumer Services	CNSMSUS	II
Commodity Chemicals	CHEMSUS	V	Retail	RTAILUS	III
Specialised Chemicals	CHMSPUS	V	Food and Drug Retailers	FDRGRUS	IV
Basic Resources	BRESRUS	III	Drug Retailers	DGRETUS	V
Forestry and Paper	FSTPAUS	IV	Food Retailers and Wholesalers	FDRETUS	V
Paper	PAPERUS	V	General Retailers	GNRETUS	IV
Industries Metals and Mines	INDMTUS	IV	Apparel Retail	APRETUS	V
Aluminum	ALUMNUS	V	Broadline Retailers	BDRETUS	V
Nonferrous Metals	NOFMSUS	V	Home Improvements Retailers	HIMPRUS	V
Iron and Steel	STEELUS	V	Specialised Consumer Services	SPCSVUS	V
Mining	MNINGUS	IV	Speciality Retailers	SPRETUS	V
Coal	COALMUS	V	Media	MEDIAUS	III
Gold Mining	GOLDSUS	V	Broadcasting and Entertainment	BRDENUS	V
Industrials	INDUSUS	II	Media Agencies	MEDAGUS	V
Construction and Materials	CNSTMUS	III	Publishing	PUBLSUS	V
Building Materials / Fixtures	BMATSUS	IV	Travel and Leisure	TRLESUS	III
Heavy Construction	HVYCNSUS	IV	Airlines	AIRLNUS	V
Industrial Goods and Services	INDGSUS	III	Gambling	GAMNGUS	V
Aerospace and Defence	AERSPUS	IV	Hotels	HOTELUS	V
Aerospace	AEROSUS	V	Recreational Services	RECSVUS	V
Defense	DEFENUS	V	Restaurants and Bars	RESTSUS	V
General Industrials	GNINDUS	IV	Telecommunications	TELCMUS	II
Containers and Packaging	CONPKUS	V	Fixed Line Telecommunications	TEFLUS	IV
Diversified Industrials	DIVINUS	V	Mobile Telecommunications	TELMBUS	IV
Electronic and Electrical Equipment	ELTNCUS	IV	Utilities	UTILSUS	II
Electrical Components and Equipment	ELEQPUS	V	Electricity	ELECTUS	IV
Electronic Equipment	ELETRUS	V	Construction Electricity	CNVELUS	V
Industrial Engineering	INDENUS	IV	Alternative Electricity	ALTELUS	V
Commercial Vehicles / Truck	COMMVUS	V	Gas, Water and Multi-Utilities	GWMUTUS	IV

Table B.1 (Continued)

Name	Mnemonic	Level	Name	Mnemonic	Level
Industrial Machinery	IMACHUS	IV	V Gas Distributors	GASDSUS	V
Industrial	INDTRUS		V Multiutilities	MTUTLUS	V
Transportation			V Water	WATERUS	V
Delivery Services	DELSVUS		Financials	FINANUS	II
Marine	MARINUS	IV	V Banks	BANKSUS	III
Transportation			V Insurance	INSURUS	III
Railroads	RAILSUS		V Nonlife Insurance	NLINSUS	IV
Transportation	TRNSVUS		V Full Line Insurance	FLINSUS	V
Services		IV	V Insurance Brokers	INSBRUS	V
Trucking	TRUCKUS		V Property / Casualty Insurance	PCINSUS	V
Support Services	SUPSVUS		V Life Insurance	LFINSUS	IV
Business Support	BUSUPUS		V Real Estate	RLESTUS	III
Services		II	Real Estate Investment, Services	RLISVUS	IV
Financial	FINADUS		Real Estate Holding and Development	RLDEVUS	V
Administration			V Real Estate Investment Trusts (REITS)	REITSUS	IV
Industrial Suppliers	INSUPUS		V Retail Real Estate Investment Trusts (REITS)	RITRTUS	V
Waste and Disposal	WASTEUS	III	V Resident Real Estate Investment Trusts (REITS)	RITRSUS	V
Services			V Specialty Real Estate Investment Trusts (REITS)	RITSPUS	V
Consumer Goods	CNSMGUS		V Hotel, Lodging Real Estate Investment Trusts (REITS)	RITHLUS	V
Auto and Parts	AUTMBUS		V Financial Services (3)	FINSVUS	III
Automobiles	AUTOSUS	IV	V Financial Services (4)	FNSVSUS	IV
Auto Parts	AUPRTUS		V Asset Managers	ASSETUS	V
Tires	TYRESUS		V Consumer Finance	CNFINUS	V
Food and Beverages	FDBEVUS		V Speciality Finance	SPFINUS	V
Beverages	BEVESUS	III	V Investment Services	INVSUS	V
Brewers	BREWSUS		V Mortgage Finance	MORTFUS	V
Distillers and Vintners	DISTVUS		Technology	TECNOUS	II
Soft Drinks	SOFTDUS		V Software and Computer Services	SFTCSUS	IV
Food Producers	FOODSUS	IV	V Software	SOFTWUS	V
Food Products	FDPRDUS		V Computer Services	CMPSVUS	V
Personal and Household Goods	PERHHUS		V Technology Hardware and Equipment	TECHDUS	IV
Household Goods, Home Construction	HHOLDUS		V Computer Hardware	COMPUS	V
Durables Household Products	DURHPUS	IV	V Electronic Office Equipment	OFFEQUS	V
Non-Durable Household Products	NDRHPUS		V Semiconductors	SEMICUS	V
Furnishings	FURNSUS		V Telecommunications Equipment	TELEQUS	V
Home Construction	HOMESUS				
Leisure Goods	LEISGUS	IV			
Toys	TOYSGUS				
Personal Goods	PERSGUS				
Footwear	FOOTWUS				
Clothing and Accessories	CLTHGUS				

Table B.2

Citigroup bond indices.

Name	Mnemonic	Name	Mnemonic
AGENCY FHLMC MGE 30Y	SBM30FH	GVT-SPONS AG&SUP	SBGSIII
AGENCY FNMA MGE 30Y	SBM30FN	GVT-SPONS 1-3 Y	SBGS13I
AGENCY GNMA MGE 30Y	SBM30GN	GVT-SPONS 1-5 Y	SBGS15I
COLL. MORTGAGE	SBMTIII	GVT-SPONS 3-7 Y	SBGS37I
COLL. (LPF) MORTGAGE	SBNLPFM	GVT-SPONS 7-10Y	SBGS710
COLL. MORTGAGE FHLMC	SBMFHLM	GVT-SPONS 1-10Y	SBGS110
COLL. MORTGAGE GNMA	SBMGNMA	GVT-SPONS.10+Y	SBGS10P
COLL. MORTGAGE 30Y	SBM30MI	OVERALL BROAD INV.GRADE	SBBIGBI
CORP. ALL MATS. (\$)	SBCRP1I	OVERALL SOVEREIGN/PROVS.	SBCYIII
CORP. 1-10Y	SBCRP11	OVERALL MEDIUM 1-10Y	SBBIGIN
CORP. 1-3Y	SBCRP13	OVERALL LONG 10+Y	SBBIGLN
CORP. 1-5Y	SBCRP15	TRSY BENCHMARK 10 Y.	SBTSY10
CORP. 3-7Y	SBCRP37	TRSY BENCHMARK 30 Y.	SBTSY30
CORP. 7-10Y	SBCRP71	TRSY.	SBGTIII
CORP. 10+Y	SBCRP10	TRSY. MORTGAGE	SBGTMTI
CORP. A SECTOR	SBC1ACI	TRSY. MORTGAGE	SBGMTII
CORP. A 1-10Y	SBC1A11	TRSY CORE 3	SBCORE3
CORP. A 1-3Y	SBC1A13	TRSY CORE 5	SBCORE5
CORP. A 1-5Y	SBC1A15	TRSY. 1-3Y	SBGT13I
CORP. A 3-7Y	SBC1A37	TRSY. 1-5Y	SBGT15I
CORP. A 7-10Y	SBC1A71	TRSY. 1-10Y	SBGT110
CORP. A 10+Y	SBC1A10	TRSY. 3-7Y	SBGT37I
CORP. AAA/AA SECTOR	SBC2ACI	TRSY. 7-10Y	SBGT710
CORP. AAA/AA 1-10Y	SBC2A11	TRSY. 10+Y	SBGT10P
CORP. AAA/AA 1-3Y	SBC2A13	TRSY. 20+Y	SBGT20P
CORP. AAA/AA 1-5Y	SBC2A15	TRSY. BMK 1Y	SBTSY1B
CORP. AAA/AA 3-7Y	SBC2A37	TRSY. BMK 2Y	SBTSY2B
CORP. AAA/AA 7-10Y	SBC2A71	TRSY. BMK 5Y	SBTSY5B
CORP. AAA/AA 10+Y	SBC2A10	TRSY.- GVT-SPONS	SBGOVSI
CORP. BBB SECTOR	SBC3BCI	TRSY.- GVT-SPONS (LPF)	SBNLPFT
CORP. BBB 1-10Y	SBC3B11	TRSY.- GVT.SPONS CORE 3	SBCR3GO
CORP. BBB 1-3Y	SBC3B13	TRSY.- GVT.SPONS CORE 5	SBCR5GO
CORP. BBB 1-5Y	SBC3B15	TRSY/ GVT-SPONS.1-10Y	SBGOV11
CORP. BBB 3-7Y	SBC3B37	TRSY/ GVT-SPONS.1-3Y	SBGOV13
CORP. BBB 7-10Y	SBC3B71	TRSY/ GVT-SPONS.1-5Y	SBGOV15
CORP. BBB 10+Y	SBC3B10	TRSY/ GVT-SPONS.3-7Y	SBGOV37
CORP. FINANCE	SBCFIII	TRSY/ GVT-SPONS.7-10Y	SBGOV71
CORP. INDUSTRIAL	SBCIIII	TRSY/ GVT-SPONS.10+Y	SBGOV10
CORP. UTILITY	SBCUIII	TRSY-AGCY	SBGTAI
CORP. (LPF) BASELINE	SBNLPFI	TRSY-AGCY 1-10Y	SBGTA11
CORP. (LPF)	SBNLPFC	TRSY-AGCY 1-3Y	SBGTA13
GVT-CORP.	SBGCIII	TRSY-AGCY 1-5Y	SBGTA15
GVT-CORP.1-10Y	SBGC110	TRSY-AGCY 3-7Y	SBGTA37
GVT-CORP.1-3Y	SBGC13I	TRSY-AGCY 7-10Y	SBGTA71
GVT-CORP.1-5Y	SBGC15I	TRSY-AGCY 10+Y	SBGTA10
GVT-CORP.3-7Y	SBGC37I		
GVT-CORP.7-10Y	SBGC710		
GVT-CORP.10+Y	SBGC10P		

Notes: FHLMC, federal home loan mortgage corporation; FNMA, federal national mortgage association; GNMA, government national mortgage association; LPF, large pension funds; TRSY, treasury; AGCY, agency; CORP, corporate; GVT, government; SPONS, sponsored; BMK, benchmark. The subindices' maturity class (such as 7–10 years) applies to the required term to maturity of the constituent bonds.

Appendix C. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.jeconbus.2014.12.002>.

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