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Inflation Hedging for Long-Term Investors

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Abstract

Long-term investors face a common problem—how to maintain the purchasing power of their assets over time and achieve a level of real returns consistent with their investment objectives. While inflation-linked bonds and derivatives have been developed to hedge the effects of inflation, their limited supply and liquidity lead many investors to continue to rely on the indirect hedging properties of traditional asset classes. In this paper, we assess these properties over different time horizons, in the context of a diversified portfolio. Using a vector error correction model, we find that effective short-run hedges, such as commodities, may not work over longer horizons and that tactical asset allocation could enhance investment returns following inflation surprises.

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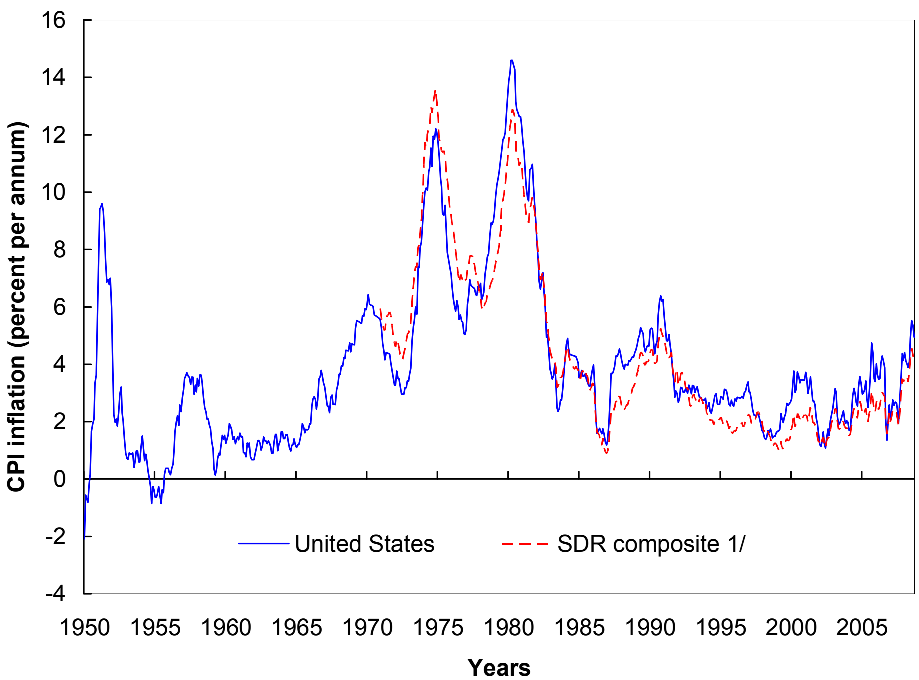
I. Introduction

Long-term investors face a common problem: how to maintain the purchasing power of their assets over time and achieve a level of real returns consistent with their investment objectives. Both dimensions of this problem are often considered together, but there remains an active debate regarding the first, namely which type of assets provide the most effective hedge against inflation. The focus on inflation-hedging properties, naturally, sharpens and fades along with the fluctuations in inflation itself. The most intense burst of activity in this area followed the persistent rise in inflation through the 1970s. So why focus on inflation hedging now?

Up until the emergence of the financial crisis in 2007, inflation had been rising on a global scale. Since then, the economic implications of this crisis, including wider output gaps, have led to an abrupt decline in inflation. If policymakers are successful in their attempt to stabilize output and stave off deflation, then inflation could resume its upward path. Given the policy tools employed through the crisis so far, particularly massive injections of liquidity and quantitative easing, the risks of this outcome remain significant. This implies that inflation hedging should remain an important component of long-run investment policy.

Figure 1. Long-term Consumer Price Inflation, 1950–2008 (annual percent)



Sources: IMF International Financial Statistics, authors' estimates.
1/ We use the International Monetary Fund's Special Drawing Rights (SDR) as a proxy for weighting a global portfolio invested in assets of mature markets. We also rely on the SDR weights to calculate aggregate national inflation rates across these markets. From January 1970 to June 1978, the currency units for the U.S. dollar, Deutsche mark, Japanese yen, French franc, and pound sterling from the inception of the SDR in July 1974 through June 1978, and the actual exchange rates are used to weight the SDR composite. From July 1978 through December 2000, the currency units for these five currencies, reflecting the SDR valuation basket at that time, are used. From January 2001 through September 2008, the euro replaces the Deutsche mark and the French franc.

While inflation-linked bonds and derivatives have been developed to hedge the effects of inflation, their limited supply and liquidity across various markets lead many investors to continue to rely on the indirect hedging properties of traditional asset classes.

In this paper, we measure these properties over different time horizons, in the context of a diversified portfolio. Assessing the stability of these properties over time, we find that they experience large variations. We elucidate the short- and long-run dynamic relationships between asset classes and inflation, which we define in this paper as the rate of change in headline consumer prices. This expands on the earlier literature which has tended to focus on asset classes in isolation using single-equation estimations. We assess those asset classes that have traditionally formed the core of long-term investor portfolios—cash, bonds, equities, and commodities—and we use two distinct methods to shed light on certain aspects of inflation hedging. First, we consider regressions of 12-month returns against inflation, as this is often the frequency over which long-term investors review and report performance. Second, we estimate a multivariate vector error-correction model (VECM) and calculate impulse responses to assess the short- and long-run dynamic impact of inflation shocks.

We proceed as follows: Section II reviews the relevant theoretical and empirical literature; Section III presents the model that assesses the inflation-hedging properties over a 12-month period; Section IV details the long-run approach to assessing inflation sensitivities; Section V concludes, with a focus on the investment implications of our results.

II. Literature Review

In this section, we briefly outline the key theories proposed to explain the relationship between the major asset classes and inflation, and we review the empirical literature, focusing on the most important historically as well as some recent contributions.

A. Cash

Irving Fisher's theory of interest rates, which is the foundation for much of the analysis of the effects of inflation in asset returns, holds that the nominal rate i equals the real rate r plus compensation for expected inflation $E(\pi)$ (Fisher, 1930). Assuming some premium for inflation uncertainty, $\theta(\sigma_\pi)$, where the inflation volatility is denoted by σ_π, this can be approximated as:[2]

$$i_t = r_t + E_{t-1}\{\pi_t\} + \theta(\sigma_\pi) \tag{1}$$

In its purest form, the Fisher hypothesis assumes that the real interest rate is independent of expected inflation and constant over time, a property which, if true, would mean that short-term debt instruments such as treasury bills—commonly referred to as cash in the investment

[2] This is a log-linear approximation of the compound relationship $(1+i) = (1+r) * (1+\pi)$.

industry—would provide a perfect hedge against inflation in the absence of inflationary shocks.[3]

Even before the events of the 1970s and 1980s indicated that real interest rates were far from constant, this hypothesis had been challenged. Mundell (1963) and Tobin (1965) both argued that nominal interest rates should change by less than one-to-one with changes in expected inflation. This is because as inflation rises, the return on real assets increases above the return on nominal monetary assets, which reduces the demand for real money and triggers an investment boom. In turn, this increases capital intensity and lowers real interest rates.[4] By contrast, Taylor's (1993) active monetary policy rule predicts a positive relationship between real interest rates and expected inflation, as the authorities tighten monetary conditions in the face of inflationary pressures.

B. Bonds

There is a strong link between the price and expected return on bonds, short-term interest rates, and inflation. The price of a default risk-free nominal bond, such as a U.S. Treasury, is determined by the present value of its cashflows, discounted by the spot rate for the maturity of each cashflow. Each spot rate may be expressed as the annualized rate of return of a series of forward rates, and these reflect expectations for the path of short-term interest rates over time plus any risk premia. As a result, the Fisher hypothesis predicts a direct link between expected inflation and bond prices. In particular, bonds that pay nominal coupons and principal repayments should be negatively related to expected inflation over the maturity of the bond.

This framework is subject to similar criticisms as the Fisher hypothesis, with additional complications introduced by longer maturities and the typically upward sloped yield curve. A number of theories have been advanced to account for this, including liquidity and risk premia, market segmentation, and preferred investor habitats; for a survey of this literature, see Fabozzi (2001).

Inflation-linked bonds

In a bid to make bond securities more attractive, some issuers sell so-called "inflation-protected" bonds, which index either coupon or principal payments (or both) to a specific measure of inflation. Typically issued with long maturities in excess of 5 years, these securities provide investors an asset with a fixed long-term real yield that is free from the risk of higher-than-anticipated inflation. The potential drawbacks of these instruments include having to specify a particular index which may not match the inflation exposure of an

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[3] Fisher believed that this relationship was more likely to hold over the long run, rather than the short run. However, the Fisher hypothesis is often used to describe the likely behavior of short-term interest rates.

[4] Makin (1983) extends Mundell's IS-LM analysis and finds that inflation uncertainty tends to drive real interest variation.

investor's liabilities, index measurement biases which may understate inflation to the detriment of investors, and indexation lags; see Shen (1998) and Dudley (1996).[5]

Dudley (1996) also suggests that the prevailing monetary policy regime greatly affects the hedging efficiency of inflation-linked bonds. In periods of proactive monetary policy, inflation volatility is kept low while real interest rate volatility is higher, leading to high correlations between inflation-linked and nominal bonds.[6] However, Kothari and Shanken (2004) suggest that inflation-linked bonds can enhance the risk-return tradeoff within a diversified portfolio. Focusing on the US market, they construct a time series of hypothetical inflation-indexed bond returns going back to the 1950s, and show that returns are less volatile than conventional bond returns, and that their correlation with equity returns is lower, thus enabling investors to construct superior mean-variance portfolios.

C. Corporate Equity

Conventional finance theory holds that equities should provide an effective hedge against inflation as they represent a claim on the dividend stream of real assets. In other words, at the aggregate level and in the long run, the corporate sector will pass on inflation in the form of higher prices; see Mishkin (1992) and Boudoukh and Richardson (1993).

The experience of the 1970s, a period during which inflation rose and most of the major equity markets suffered negative real returns, triggered a reappraisal of this view with notable contributions including Bodie (1976), Jaffe and Mandelker (1976), Fama and Schwert (1977) and Solnik (1983). The extent to which these developments came as a surprise is encapsulated by Bodie's remark that "this negative correlation leads to the surprising and somewhat disturbing conclusion that to use common stocks as a hedge against inflation, one must sell them short".[7] A range of competing hypotheses then emerged, attempting to explain these relationships, four of which have endured: tax effects; inflation illusion; the proxy hypothesis; and the equity risk premium.

We also consider recent contributions which indicate that, over the very long run, equities are an effective inflation hedge, as well as other analyses which focus on the causality of inflation.

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[5] Dudley (1996) estimates that the average difference between CPI inflation and the employment cost index (ECI) that best expresses the rise in actual liabilities of a US pension fund was 1.3 percent during the period June 1981–October 1996, or a cumulative 19.3 percent.

[6] Dudley concludes that inflation-linked bonds offer an advantage to investors only when inflation rises while real interest rates fall, a situation that occurred in 1973–1975, or generally in periods of "lax monetary policy and monetary stress."

[7] Bodie (1976), p. 469.

Tax effect
The "tax effects" hypothesis was proposed by Feldstein (1979) and Summers (1981). According to this analysis, rising inflation causes firms to report spuriously high profits due to certain characteristics of the tax code, such as historical cost depreciation of assets and methods of inventory valuation that can increase accounting earnings.[8] This increases the firm's effective tax burden, reduces real profits, and leads to a decline in the valuation of the firm's equity through lower returns. Although Summers (1981) and Poterba and Summers (1984) provide evidence in support of this hypothesis, the subsequently poor empirical performance of the *q*-model of investment has led the literature to focus more on alternative explanations.

Inflation illusion
A more controversial hypothesis that raises doubts regarding market efficiency is "inflation illusion", proposed by Modigliani and Cohn (1979). This theory argues that investors commit two inflation-induced errors: using nominal instead of real interest rates when capitalizing firms' expected real profits; and failing to recognize the implicit real capital gain that accrues as a result of the depreciation in nominal liabilities, even though the decline in reported profits for firms facing higher nominal interest payments is considered.

Proxy hypothesis
The "proxy hypothesis" suggests that the inverse correlation between equities and inflation is spurious because inflation is acting as a proxy for the real driver of equity returns, expectations of future real economic activity, and profits. First proposed by Fama (1981), the argument is based on the money demand-quantity model, which predicts that an anticipated future fall in activity lowers the demand for real money balances which, given an unchanged stock of nominal money and interest rate, is accommodated by a rise in the price level.

Extending this approach, Geske and Roll (1983) and Kaul (1987) suggest a role for countercyclical monetary policy in which a negative output shock leads to lower equity prices, easier monetary policy and, due to the rational agent expectations, a contemporaneous increase in inflation. Hasbrouck (1984) casts some doubt on these assumptions by failing to find a relationship between expected inflation and expected output growth from survey data.

In a recent extension, Pilotte (2003) presents evidence which supports the conclusion that the proxy effect reflects not just a negative correlation between expected output and inflation, but a positive relationship between inflation and excess returns. Other work that posits a link between inflationary expectations and real effects includes Evans and Wachtel (1993) and Holland (1995). Spyrou (2004), however, found a positive relationship between inflation and equities in emerging markets.

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[8] The most well-known example is first-in-first-out (FIFO) inventory valuation. In a period of high inflation, accounting profits will be increased as a result of FIFO because the inventories produced further in the past are recorded as being sold in the current period.

Equity risk premium
The "equity risk premium" hypothesis, was initially outlined by Malkiel (1979) and Pindyck (1994). According to this model, as inflation variability increases, which it often does when the level of inflation rises, the gross marginal return on capital will also experience increased volatility. Assuming risk-averse investors, this should increase the required risk premium from equities which would require an immediate decline in equity prices.

Long-run hedging
A number of studies have indicated that equities may indeed be an effective inflation hedge, but only over very long horizons. Ely and Robinson (1997) find that stocks seem to maintain their values relative to movements in overall price indices over the long horizons. Lothian and McCarthy (2001), using long-run data for OECD countries conclude that equities are, after all, a good inflation hedge, but that it takes "an exceedingly long time for this to happen." Ahmed and Cardinale (2005) conclude that equities have been an effective inflation hedge in the U.S. for horizons of five years or more, although results for the UK and Germany were mixed.

Another branch of the literature tests the Fisher hypothesis for equities using very long sample periods. As Boudoukh and Richardson (1993) note, the hypothesis involves a relationship between returns and expected inflation; the use of ex post inflation measures introduces an error-in-variables problem. Using measures of ex-ante inflation, they present evidence for a positive relationship between the nominal equity returns and both ex ante and ex post inflation, particularly at longer horizons.[9] A consensus has yet to be reached, however. Engsted and Tanggaard (2002) conclude that U.S. equities have not proven to be an effective long-run hedge against either expected or unexpected inflation. In contrast, Luintel and Paudyal (2006) find that the majority of U.K. industry sectors have a long-run inflation elasticity in excess of one.

Equities and monetary inflation
Danthine and Donaldson (1986) and Marshall (1992) argue that equities may provide an effective hedge against inflation caused by monetary fluctuations, but not if it is caused by real output volatility. Graham (1996) also supports this view by noting that equity returns and inflation were positively correlated during the 1976–1982 period in which, he argues, U.S. inflation was driven by monetary factors rather than exogenous supply shocks.

[9] The authors circumvent the errors-in-variables problem by choosing instruments for ex ante inflation, including past inflation rates and short- and long-term interest rates. The estimations used data for the U.S. and the U.K. over the period 1802–1990.

D. Alternatives

Real estate

Real estate may be valued in a similar way to equities and bonds, by discounting the expected future stream of cashflows using a required rate of return.[10] Perhaps even more so than equity, real estate is backed by real assets and, in theory, should provide an effective hedge against inflation.[11]

A number of early papers discovered that both residential and commercial real estate offered favorable inflation-hedging properties. Fama and Schwert (1977) find that residential property provided a complete hedge against both expected and unexpected inflation between 1953 and 1971. Both Rubens, Bond and Webb (1989) and Bond and Seiler (1998) conclude that commercial and residential real estate partially hedged inflation at least since the 1960s. Hoesli, MacGregor, Matysiak and Nanthakumaran (1997) nuanced these findings by highlighting the lag in the property market's response to inflation, suggesting an imperfect hedge even in the long run.[12]

Real estate, however, is a heterogeneous asset class and its inflation-hedging properties are determined by the nature of an investor's exposure. For example, Gyourko and Linneman (1988) showed that securitized Real Estate Investment Trusts (REITs) exhibit the same negative relationship found with equities, while income-producing property indices, such as the U.S. Prudential Property Investment Separate Accounts (PRISA), are positively correlated with inflation.

Commodities

The recent volatility in commodity prices has triggered a flurry of new research, including analysis of inflation-hedging properties. Overall, the research provides quite strong evidence that commodities provide effective short-run protection against inflation. Greer (2000) estimates that the correlation between the 12 month return of the unlevered Chase Physical Commodity Index and annual U.S. inflation was 0.23 between 1970 and 1999.[13] Against the change in inflation, the correlation was 0.59. Erb and Harvey (2006) estimate that from 1969

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[10] There are other valuation measures used in the real estate industry, including cost and market appraisals, that must be applied to investments that do not produce cashflows (Chinloy, 1988). In practical terms, these methods may be more appropriate for many types of properties, but they are less useful for thinking about the potential effects of inflation on fundamental valuation.

[11] At an individual property level, features such as the lease length, indexed escalations, and expense pass-throughs will all influence inflation sensitivity (Miles, Cole, and Guilkey, 1988). At the aggregate level, theory suggests that in the absence of a major shift in relative property values, over the long run both periodic cashflows generated by rents and terminal values will move in line with inflation.

[12] See also Hoesli, Lizieri, and MacGregor (2006).

[13] An unlevered index return means that the total return of the short-term cash instrument used as collateral is included.

to 2003, changes in the rate of U.S. inflation explained about 43 percent of the variance of returns of the Goldman Sachs commodity excess return index (GSCI), with higher inflation leading to higher GSCI returns. However, they stress that the results vary widely across individual commodities. Kat and Oomen (2007) suggest that there are a number of commodities that provide an effective hedge against unexpected U.S. inflation, based on 12 month returns.

Some studies have taken a longer-run perspective. Gorton and Rouwenhorst (2006) find that correlations between commodity futures returns and inflation tend to rise and become statistically significant as the horizon lengthens. Adams, Füss, and Kaiser (2008) also conclude that correlations between commodities, measured using GSCI excess returns, and U.S. inflation rises with the investment horizon, although these positive correlations do not hold consistently for inflation in the euro area and Asia. Worthington and Pahlavlani (2007) present evidence of the long-run hedging properties of gold based on a positive long-run relationship between gold and U.S. inflation in the post-war period.

E. Diversified Portfolios

Few studies have examined the inflation-hedging properties of asset classes in the context of complex and diversified investment portfolios. Strongin and Petsch (1997) include a broad range of asset classes commonly used by institutional investors. They concluded that commodities and cash are the only assets that provide significant protection against global inflation risk. They also noted that international diversification on a currency unhedged basis is likely to hedge local inflation risk in an equity dominated diversified portfolio.

III. Inflation Hedging Over a One-Year Horizon

In this section, we measure the sensitivity of asset class returns to inflation over a one-year horizon. Long-term investors tend to focus on return outcomes over multi-year periods, but many also report their portfolio performance every 12 months. Also, while long-term investors often change their strategic asset allocation only infrequently, some tactically tilt their portfolios based on their own expectations for returns across asset classes over shorter time horizons. In both cases, it would be useful to gain some understanding of how inflation might impact annual returns over a one-year horizon.

Our approach updates and extends earlier research by Strongin and Petsch (1997). We start with a multiple regression which relates the 12-month total return on asset classes (denoted by r^A) to the contemporaneous 12-month inflation rate (π^A), and the change in this inflation rate over the prior 12-month period. This can be written as:

$$r_t^A = \alpha + \beta\pi_t^A + \gamma\left(\pi_t^A - \pi_{t-12}^A\right) + u_t \qquad (2)$$

In a world of perfect inflation foresight and no money illusion, we might expect the Fisher hypothesis to hold. For any asset, total returns would comprise a required real return α and full inflation compensation, which would imply that β=1 and γ=0.[14] Unexpected changes in inflation would cause these coefficient values to be different from their perfect foresight values, as asset values adjust to ensure expected real returns converge to their equilibrium levels. We are consciously using ex post inflation in our simple regressions, since we are interested in the actual effects of inflation on returns, regardless of whether it was expected or unexpected. We are not formally testing the Fisher hypothesis in the manner of Boudoukh and Richards (1993).

A. Data

We use well known benchmark total return indices for the asset classes, starting as far back as the data is available. Table 1 presents summary statistics for the data and in the Appendix, we describe the data in more detail (Table A1). In some cases we have stitched together different comparable indices to maximize the number of observations, where this does not introduce significant inconsistencies. Whenever possible, we use indices which are broad-based and replicable. For example, we use the Ibbotson total return index for long-term U.S. Treasury bonds from January 1926 through December 1977. From this date forward, we switch to the Merrill Lynch U.S. Treasury bond index for maturities greater than 10 years. For inflation, we use the headline consumer price indices for each of the currencies that we include in the analysis.

[14] This ignores the inflation risk premium which, if constant, would be included in the coefficient α.

Table 1. Short-Run Model Variables: Summary Statistics, Jan-1927 to Nov-2008 1/

	Mean	Max.	Min.	Std. Dev.	Skew	Sample Start	. End
Consumer price index							
U.S.	3.2	20.1	-10.8	4.2	0.1	Jan-27	Nov-08
SDR 2/	4.4	13.6	0.9	3.1	1.2	Dec-70	Nov-08
Cash							
U.S. 3-month T-bills	3.8	15.7	0.0	3.2	1.0	Jan-27	Nov-08
SDR 3-month interest rate	5.2	13.8	1.5	2.9	0.8	Dec-70	Nov-08
Bonds							
U.S. Treasuries (all maturities)	8.5	30.6	-4.5	6.4	0.9	Dec-72	Nov-08
U.S. Treasuries (10+ year maturities	5.8	54.4	-17.1	8.8	1.5	Jan-27	Nov-08
U.S. Corporate bonds	7.7	24.3	-7.4	6.4	0.1	Dec-69	Nov-08
SDR government (all maturities)	8.6	39.3	-14.7	9.0	0.6	May-86	Nov-08
SDR government (10+ year maturiti	6.3	16.7	-2.4	4.4	0.3	May-86	Nov-08
Equities							
U.S. large cap. equities	12.4	162.9	-67.6	21.7	0.4	Jan-27	Nov-08
SDR-weighted equities	11.6	49.7	-40.1	16.8	-0.4	Dec-70	Nov-08
Alternatives							
FTSE NAREIT index	11.6	63.9	-48.3	18.7	-0.5	Jan-72	Nov-08
CRB index	3.6	91.0	-28.7	13.5	1.6	Dec-59	Nov-08
GSCI index	19.3	79.1	-35.2	26.7	-0.3	Jan-95	Nov-08
Gold spot	11.3	177.9	-36.9	29.5	1.8	Jan-68	Nov-08
Portfolios							
U.S. dollar 60-40 equity-bond portfol	9.6	94.5	-47.2	13.8	0.2	Jan-27	Nov-08
SDR 60-40 equity-bond portfolio	8.6	32.3	-24.0	10.8	-0.5	May-86	Nov-08

Sources: Ibbotson SBBI Classic Yearbook (2008), Thomson Datastream, Commodity Research Bureau, IMF International Financial Statistics, and authors' estimates.
1/ All data end in November 2008. Using the 12-month percent change in each case.
2/ For a definition of the SDR see footnote 15 and the SDR Factsheet available at www.imf.org .

Our analysis considers two base currencies for the estimation: U.S. dollars and Special Drawing Rights (SDRs).[15] The SDR is defined as a basket of currencies, consisting nowadays of the euro, Japanese yen, pound sterling, and U.S. dollar. The basket composition is designed to reflect the relative importance of currencies in the world's trading and financial systems and this serves to weight both the various asset classes—where they are available in each currency—and inflation.[16]

[15] The SDR was originally created by the IMF in 1969 as a reserve asset. Strictly speaking, the SDR is neither a currency, nor a claim on the IMF. Rather, it is a potential claim on the freely usable currencies of IMF members. We refer to it as a base currency only for the purposes of estimating a weighted basket of asset classes denominated in the different component currencies.

[16] The SDR-based analysis assesses the inflation-hedging properties of broadly diversified international asset class benchmarks. We calculate the percent change for each SDR series—the asset classes and consumer price index—by taking the SDR basket-weighted average of the respective series in each SDR currency. See www.imf.org for more information about the SDR.

We also form two portfolios that reflect the core holdings of long-term investors such as pension funds.[17] In these two "60-40" portfolios, equities have a 60 percent weight and government bonds have a 40 percent weight. Each portfolio is rebalanced monthly and the SDR portfolio uses the SDR-weighted equity and bond asset class indices.

B. Estimation Strategy

We estimate the regressions of 12-month asset class returns on annual inflation using overlapping observations; in other words, we use the annual percent change for every month. This is a common approach in the finance literature and is aimed at maximizing the possible number of observations. We use Newey-West (1987) standard errors to correct for the serial correlation of residuals that is a by-product of overlapping data.[18]

To assess the stability of the relationships with inflation over time, we estimate the models over two sample periods: for all available data for each asset class; and from March 1973, when the Bretton Woods system gave way to the era of flexible exchange rates for the major economies.[19] The shift to fiat money and flexible exchange rates seems like a natural breakpoint, as this engendered a much higher degree of uncertainty regarding the interaction of economic growth and inflation. For example, Cottarelli and Giannini (1997) highlight a sentiment expressed by the U.S. Council of Economic Advisors in 1974 in which they conclude that "there is no simple explanation for this price behavior, which was the most extraordinary in almost a generation and which confounded the Council and most other economists alike."

As a further test of stability, we applied the Quandt-Andrews breakpoint test for one or more unknown structural breakpoints over the post-Bretton Woods sample. Although changes in monetary regimes can sometimes be identified in a similar way to the events of 1973, their magnitudes—defined as the number of economies undergoing transition—tend to be of several degrees smaller and less difficult to identify informally.[20] If a breakpoint is found, we re-estimate the model for both sample periods and compare the coefficients on inflation to assess the extent to which inflation hedging properties have changed over time.

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[17] As reported in IMF (2005), the market-value weighted average of pension fund asset allocations, excluding alternative assets, at the end of 2003 in France, Germany, the U.K, and the U.S. was 59 percent in equities and 40 percent in bonds.

[18] Overlapping data introduce the problem of serially correlated errors, with the residuals from OLS estimation of equation (1) following a K-1 order stochastic moving average process. A range of estimators have been used in the literature to correct for the inefficient estimators that this produces (e.g., Hansen and Hodrick (1980), Andrews (1991), and Richardson and Smith (1991)). We use the well-known Newey-West (1997) estimators, with a K-1 bandwidth, as it has been regarded as the most commonly used method and therefore provides some comparability with earlier research (Campbell, Lo, and McKinley (1996), p. 535).

[19] We use this start date as the Group of Ten countries abandoned the par values of their currencies on March 16, 1973.

[20] For example, see Cottarelli and Giannini's (1997) analysis of the distribution of monetary frameworks across 100 industrial and developing countries.

C. Results

The estimations provide strong evidence that changes in the rate of inflation, and in some cases the level of inflation, affect the nominal returns across asset classes (Table 2). The results tend to be more conclusive for the post-Bretton Woods period since 1973 than for the period from the 1920s, at least in the United States where these data are available.

Cash returns influenced by the monetary policy regime

Cash has not been an effective hedge against ex post inflation over a 12-month period. The coefficient on the level of inflation is less than one while the coefficient on the change in inflation is negative and statistically significant for the U.S. dollar and SDR. This suggests that, following an increase in the rate of inflation, the 12-month return on short-term cash instruments declines. Although this may seem a puzzling result, it underscores the dangers of concluding too much from simple regressions and the importance of testing for model stability.[21]

The ability of cash to hedge against inflation is heavily influenced by the prevailing monetary policy regime. For example, the results in Table 2 using a sample since 1973 are driven largely by the 1980–82 period in which nominal interest rates continued to rise even as the first-round effects of the second oil price shock on headline inflation began to abate. As policymakers achieved some success in anchoring inflation expectations, particularly since the 1990s, we might expect to see some change in the sensitivity coefficients (see below).

Bonds and equities adversely affected by higher inflation

Both equities and bonds see their returns negatively affected by an increase in the rate of inflation, particularly since 1973. For a 1 percentage point increase in the rate of inflation over a one-year period, the nominal annual return on bonds declines by about 1⅓ percentage points on a broad U.S. Treasury benchmark to over 2½ percentage points for an SDR-weighted benchmark of long-term government bonds. Equities experience even larger negative effects, with the same 1 percentage point increase in inflation leading to a fall in returns of 2⅔ percentage points and 3½ percentage points for the large capitalization U.S. equity and SDR-weighted equity benchmarks respectively.

The results for the 60-40 portfolios were less conclusive, with inflation coefficients that were mostly statistically insignificant and lower in absolute value than for equities and bonds. This suggests that the sensitivity of the portfolio's components to changes in inflation vary over time and, in the case of the SDR portfolio, across currencies. The portfolios did not provide a hedge, which is unsurprising given their components, but they were less negatively affected by changes in inflation.

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[21] It is important to note that the sample periods over which we have tested for inflation sensitivity have not, in general, been characterized by sustained periods of deflation (or falling consumer prices). The dynamics of this process would likely be very different and it would be inappropriate to apply this model's inherent assumption of symmetry to assess the affects of deflation.

Commodities provide an effective hedge

All three commodity measures—the CRB index, the GSCI total return index[22], and the spot gold price—experience higher returns when inflation rises. The effects have been both economically and statistically significant, with a 1 percentage point increase in the annual U.S. inflation rate leading to increases of between 3.8 percent and almost 10 percent among the three relevant measures.

The other alternative asset class, the U.S. REIT index, performs similarly to equities, a common finding for equity-listed real estate assets. The hedging properties of direct holdings of real estate may differ and will be determined by the factors outlined in section II. A.

Evidence of changing inflation sensitivities

A formal analysis of breakpoints in these models reveals that inflation sensitivity tends to be unstable over time (Table 3). For every asset class, it was possible to reject the null hypothesis of no breakpoints—and hence model stability over the entire sample—at the 99 percent confidence level. The dates of the breakpoints vary widely and, in many cases, are influenced by the length of the full sample period. For cash, breakpoints around the change in the U.S. monetary policy regime at the start of the 1980s are clearly evident. For U.S. bonds, the inflation sensitivity has increased since the late 1980s, which could reflect the lagged reaction to inflation in the 1970's. For global bonds and equities in general, the breakpoints come very late in the samples and there are too few observations to draw strong conclusions.

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[22] The Reuters/Jefferies-Commodity Research Bureau (CRB) Index, which was developed in 1957, is a broad Index currently comprised of 19 commodity futures prices. The S&P Goldman Sachs Commodity Index (GSCI) is comparatively more heavily driven by its energy component, which represents about 65 percent of the index.

Table 2. Asset Class Sensitivity to Inflation Over a 12-Month Horizon

	Coefficients on CPI inflation		Sample	
	Level	12-month change	Start date	Number of obs.
Maximum sample for each asset class				
Cash				
U.S. 3-month T-bills	0.39 ***	-0.24 *	Jan-28	971
SDR 3-month interest rate	0.27 *	-0.65 **	Dec-71	444
Bonds				
U.S. Treasuries (all maturities)	-0.10	-1.33 ***	Dec-73	420
U.S. Treasuries (10+ year maturities)	-0.12	-0.38 *	Jan-28	971
U.S. Corporate bonds	-0.74 **	-1.81 ***	Dec-70	456
SDR-weighted government bonds (all maturities)	1.57 **	-2.36 ***	May-87	259
SDR-weighted government bonds (10+ year maturities)	0.92	-2.55 **	May-87	259
Equities				
U.S. large cap. equities	0.07	-0.03	Jan-28	971
SDR-weighted equities	-0.35	-3.50 ***	Dec-71	444
Alternatives				
FTSE NAREIT index	-0.16	-3.84 ***	Jan-73	431
CRB index	0.42	3.41 ***	Dec-60	576
GSCI index	7.71	9.87 **	Jan-96	155
Gold spot	2.78 *	6.36 ***	Jan-69	479
Portfolios				
U.S. dollar 60-40 equity-bond portfolio	0.00	-0.16	Jan-28	971
SDR 60-40 equity-bond portfolio	-0.31	-1.35	May-87	259
Sample Mar-1973 to Nov-2008				
Cash				
U.S. 3-month T-bills	0.75 ***	-0.57 ***	Mar-73	429
SDR 3-month interest rate	0.28 *	-0.69 **	Mar-73	429
Bonds				
U.S. Treasuries (all maturities)	-0.10	-1.33 ***	Dec-73	420
U.S. Treasuries (10+ year maturities)	-0.98 **	-1.88 ***	Mar-73	429
U.S. Corporate bonds	-0.70 **	-1.91 ***	Mar-73	429
SDR-weighted government bonds (all maturities)	1.57 **	-2.36 ***	May-87	259
SDR-weighted government bonds (10+ year maturities)	0.92	-2.55 **	May-87	259
Equities				
U.S. large cap. equities	-0.42	-2.59 ***	Mar-73	429
SDR-weighted equities	-0.36	-3.48 ***	Mar-73	429
Alternatives				
FTSE NAREIT index	-0.16	-3.84 ***	Mar-73	429
CRB index	0.30	3.77 ***	Mar-73	429
GSCI index	7.71	9.87 **	Jan-96	155
Gold spot	3.05 **	6.87 ***	Mar-73	429
Portfolios				
U.S. dollar 60-40 equity-bond portfolio	-0.66	-2.29 ***	Mar-73	429
SDR 60-40 equity-bond portfolio	-0.31	-1.35	May-87	259

Source: Authors' estimates.
1/ Significance at the 1, 5, and 10 percent levels is denoted by ***, **, and * respectively, using Newey-West standard errors and a lag truncation of 11.

Table 3. Breakpoint Tests and Sub-Sample Regressions

	Breakpoint		Coefficients on CPI inflation rate			
			First sample 2/		Second sample 3/	
	Date	Probability value 1/	Level	12-month change	Level	12-month change
Cash						
U.S. 3-month T-bills	Jun-81	0.0000	0.91 ***	-0.24	1.36 ***	-0.80 ***
SDR 3-month interest rate	Jul-79	0.0000	0.12	-0.32 ***	0.85 ***	-1.02 ***
Bonds						
U.S. Treasuries (all maturities)	Feb-87	0.0000	-1.20 ***	-0.66	1.38 **	-1.75 ***
U.S. Treasuries (10+ year maturities)	Feb-87	0.0000	-2.51 ***	-1.13	0.98	-2.22 **
Lehman Global Treasury Aggregate	Jan-01	0.0001	1.45	-2.21 *	-7.07 ***	5.58 ***
U.S. Corporate	Dec-86	0.0000	-2.36 ***	-1.12 *	1.11	-2.21 ***
SDR-weighted government (all maturities)	Nov-01	0.0000	1.13	-2.91 ***	-1.21	1.17
SDR-weighted government (10+ year maturities)	May-99	0.0004	-0.86	-2.81 *	0.19	0.53
Equities						
U.S. large cap. equities	Oct-00	0.0000	-1.31	-2.40 **	-0.15	0.19
SDR-weighted equities	Nov-00	0.0014	-1.16	-2.90 ***	9.74	-9.55
Alternatives						
FTSE NAREIT index	Aug-78	0.0000	-8.46 ***	-2.58 ***	0.74	-3.23 **
CRB index	Jun-79	0.0004	0.33	3.32 ***	3.40	4.98
GSCI index	Jan-01	0.0000	46.32 ***	-7.17	-7.48 *	17.28 ***
Gold spot	Jan-81	0.0000	4.48	9.44 ***	-3.03 ***	2.04

Source: Authors' estimates.
1/ Probability that the null hypothesis of no breakpoints is true.
2/ The first sample starts from March 1973 or the first observation available for each asset class benchmark and ends at the breakpoint date.
3/ The second sample starts the month following the breakpoint and ends at November 2008.

IV. Inflation Hedging over the Long Term

For long-term investors, a 12-month horizon is likely to be too short. [23]To assess asset class inflation-hedging properties over such horizons, we use a vector autoregression (VAR) approach that allows us to both identify whether asset class returns and inflation share common trends over the long-run and assess the dynamics over the short run.

It is important at the outset to understand what the VAR approach can and cannot do. We will use this model to assess how different asset classes react to unexpected increases in inflation. We will not test specific hypotheses regarding causality—this is not what VARs were designed for. What are we to make of these inflation "surprises"? In this section, we refer to unexpected inflation as a rise in the consumer price index that is not anticipated by the model. What might be a surprise for the VAR may be expected by market participants that access a larger information set. However, one of the strengths of the VAR approach is

[23] Many investors set their strategic asset allocation on a less frequent basis and often base their investment decisions on expected risks and returns for periods of 5 years or more.

that it encapsulates a lot of information already. The log of each variable—the consumer price index and each of the asset class return (or price) indices—is assumed to be a function of a constant and a specified number of lags of its own log values and those of all the other variables. The VAR model that we will use may be written as:

$$\mathbf{Z}_t = \boldsymbol{\gamma} + \sum_{p=1}^{P} \boldsymbol{\Phi}'_p \mathbf{Z}_{t-p} + \boldsymbol{\upsilon}_t \tag{3}$$

The endogenous variables are denoted by the (5 x 1) vector **Z**. The coefficients on each of these lags are collected in the (5 x 1) matrix **Φ**, where *P* refers to the number of lags, which is the same for all variables. The residuals are denoted by the (5 x 1) vector $\boldsymbol{\upsilon}$.

A. Data

Our focus on the long term necessitates that we attempt to use asset class total return indices with as much history as possible, while keeping relatively broad coverage. International total return series extend back only to the 1970s or 1980s, so we use data from the United States for cash, bonds, equities, and inflation—which have a longer history—for these models. We also use, wherever possible, indices that have the qualities typically required for a valid investment benchmark.[24]

For the cash asset class we use the U.S. Treasury 90-day bill total return index provided by Ibbotson and the Merrill Lynch index from January 1978. For bonds, we use the Ibbotson long-term U.S. Treasury bond total return index and the Merrill Lynch index for U.S. Treasuries with maturities in excess of 10 years from January 1978 onward. For equities, we use the Ibbotson large-cap equity total return index until December 1969, from which point we switch to the MSCI United States index. For commodities, we use the Reuters-CRB CCI index, which approximates a spot price index and serves as a proxy for commodity asset class returns, while recognizing that the risk-return profile of an investment strategy based on commodity futures may be different.[25] Although commodity total return indices are available for the later periods of the sample, stitching together price and total return indices would likely compromise the consistency of the data.

A summary of these data is provided in Table 3 and Appendix Figure A1 and shows their evolution over the entire sample period. The VAR approach that we use requires that the data

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[24] Bailey (1992) lists six qualities of a valid benchmark: unambiguous, investable, measurable, appropriate, reflective of current investment opinions, and specified in advance.

[25] See Greer (2000), Gorton and Rouwenhorst (2006), and Erb and Harvey (2006) for overviews of commodity future total returns, which include the price return, the yield from a risk-free instrument used as collateral, and the roll yield from the term structure.

be non-stationary, and in log-index form; results from unit root tests indicate that this is the case for each of the variables. The first differences of the logs are stationary (Table A2).[26]

Table 3. Long-Run Model Variables: Summary Statistics, Aug-1956 to Oct-2008 1/

	Obs.	Mean	Max.	Min.	Standard deviation	Skew
Treasury bills	621	0.5	1.8	0.0	0.3	157
Long-term Treasury bonds	621	0.6	13.6	-9.3	2.7	34
Large cap. Equities	621	0.7	16.4	-23.9	4.2	-67
Commodities	621	0.2	17.1	-20.2	3.3	-7
Consumer price index	621	0.3	1.8	-1.7	0.3	32

Source: Ibbotson SBBI Classic Yearbook (2008), Thomson Datastream, Commodity Research Bureau, and authors' estimates.
1/ Using the first difference of the log index multiplied by 100 in each case.

B. Estimation Strategy

We begin by identifying that the system has an optimal lag length of 7 months using standard selection criteria (Table A3).[27] We can then rewrite the system in terms of its vector error-correction (VEC) form. This expresses the change in the log value of the vector **Z** as a function of a constant vector **μ**, a coefficient that measures the speed of adjustment to disequilibrium in the long-run relationship **α**, the long-run cointegrating vector **β**, and *P*-1 lags of the log changes of all variables.

$$\Delta \mathbf{Z}_t = \boldsymbol{\mu} + \boldsymbol{\alpha}\boldsymbol{\beta}'\mathbf{Z}_{t-1} + \sum_{p=1}^{P-1} \boldsymbol{\Psi}_p \Delta \mathbf{Z}_{t-p} + \boldsymbol{\varepsilon}_t \tag{4}$$

This VEC form is only valid if there is indeed a long-run relationship among the variables. We find strong evidence—using the Johansen (1991, 1995) procedure and based on the VEC representation (4)—of such a relationship for a wide range of specifications, including the most common form, which includes constants for the log changes and in the cointegrating vector (Table A4). As a result, our results are based on the maximum likelihood estimation of the VEC model described by system (4).

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[26] The hypothesis that the first differences follow a unit root process can be rejected at the 5 percent level for all variables, except for the Treasury bill total return index for which rejection is possible only at the 10 percent level.

[27] We use the Aikaike information criterion. Although both alternative criteria—the Schwarz and Hannan-Quinn—indicate a much shorter lag length, likelihood ratio tests find that this lag is a binding restriction at the 5 percent level, while the VAR's residuals exhibit significant serial correlation with only 2 lags.

C. Results

The interactions of the variables in system (4) are complex and difficult to disentangle from the estimated coefficients. Instead, we focus on impulse responses, which trace out the impact of a one-time inflation shock on the cumulative total return (or change in price in the case of commodities), assuming all coupons and dividends are reinvested. We assume that all other variables at the time of the shock and for all previous periods are held constant. However, the model as estimated is not yet identified, as the residuals of each equation represent a combination of idiosyncratic shocks to all the other variables. To isolate an inflation-specific shock, we need to impose some restrictions on the system (4).

The most common and simple approach is to order the residuals in a triangular Cholseki decomposition; this restriction assumes that certain variables do not contemporaneously affect others in the system. This assumption may be relatively uncontroversial for inflation, for which the report is released by the U.S. Bureau of Labor Statistics around 15 days after the end of the month. This means that publicly disseminated information about inflation shocks for a particular month would not affect the other variables during the same month. One potentially problematic variable is the commodity price index, as this may directly affect headline inflation in the same month.[28] All of the other variables are market-determined and are likely to move in a synchronized fashion to various shocks, which makes any ordering somewhat ad hoc. As a robustness check, we changed the ordering of the market variables—including by allowing commodity prices to contemporaneously affect inflation—and found that this made little difference in the results, particularly over the long term. The results that follow are based on the ordering: cash → bonds → equities → commodities → inflation.

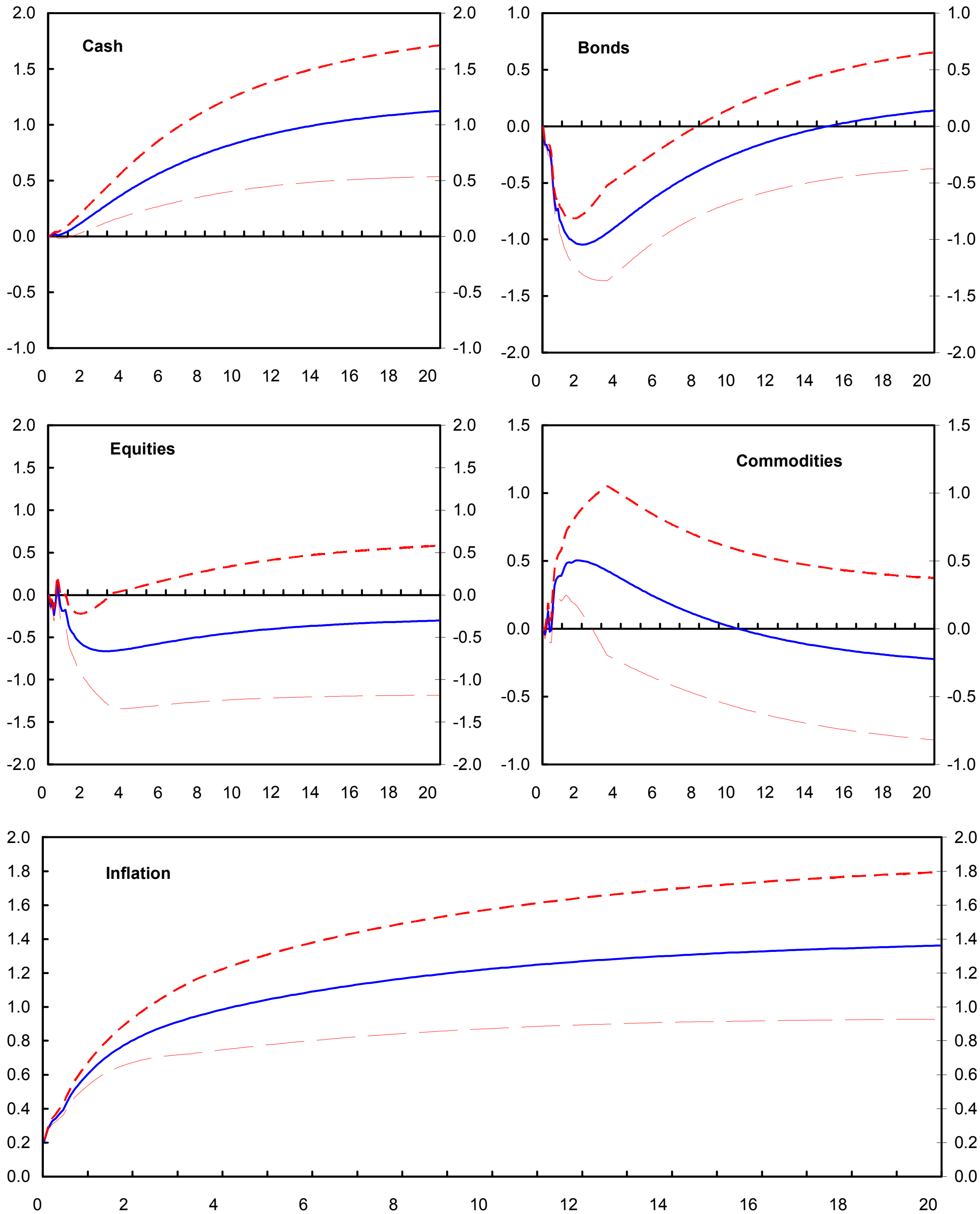
We applied a one standard deviation shock of about 0.2 percentage points (ppts) to the monthly change in inflation. The impulse responses then trace out the reaction of the other variables in the system, presented in Figure 2 as the cumulative change in the level of the total return or price index over a 20-year period. To provide an indication of the parameter uncertainty resulting from the estimation process, we also show standard error bounds around the response functions, which were calculated using a bootstrap procedure and 1,000 iterations. We then show the accumulated long-run inflation elasticities in Figure 3. This elasticity (η) is defined as the cumulative percent change in the asset class total return or price index ($\Delta \log z$) divided by the cumulative percent change in inflation ($\Delta \log \pi$) at some time t and may be written as:

$$\eta_{i\pi,t} = \Delta \log z_{it} / \Delta \log \pi_{it} \tag{5}$$

An elasticity of 1 indicates that the asset class provides a perfect hedge against inflation shocks and that real returns remain unchanged.

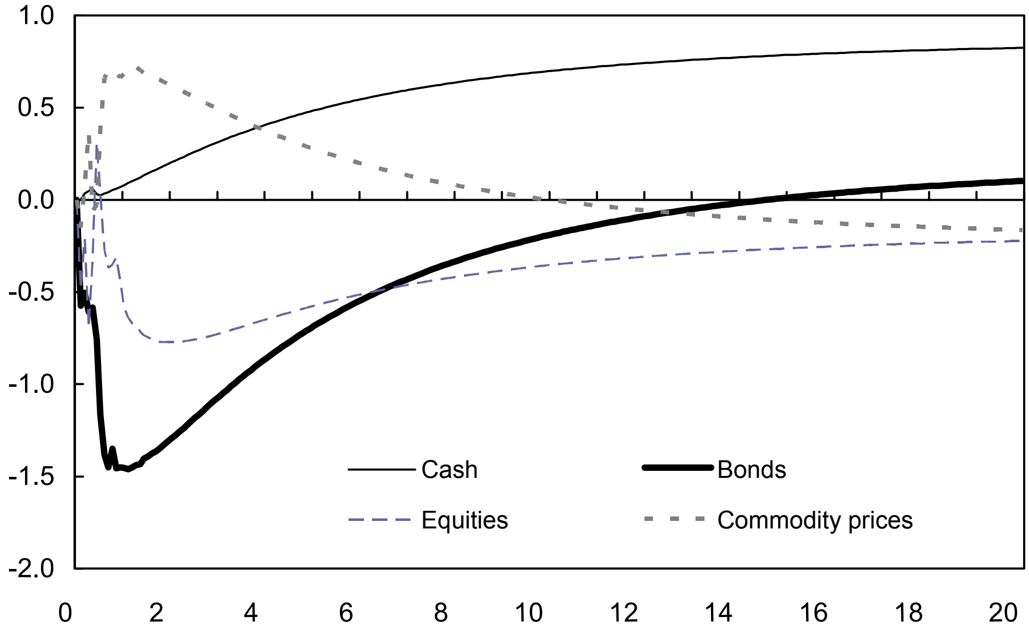
[28] To some extent, these effects are ameliorated by the construction of the Reuters-CRB CCI index, which is an unweighted geometric mean of price relatives. This implies that the effect of an influential commodity price on inflation, such as crude oil, is somewhat diluted for any particular month, assuming that correlations among the components is not especially high.

Figure 2. Inflation Shock 20-Year Cumulative Impulse Response Functions (percentage points)



Source: Authors' estimates
1/ A one standard deviation shock, equivalent to about 0.2 percentage points, was applied to inflation.

Figure 3. Inflation Shock Elasticities 1/



Source: Authors' estimates.
1/ Defined as the percent change in the asset class total return or price index (Δlog z) divided by the percent change in inflation.

Inflation—shocks persist

Inflation exhibits strong autoregressive properties, with the effects of a shock persisting for some time. After 1 year, the cumulative increase in the price level is nearly three times the size of initial shock and after 5 years, this has risen to five times. Over the very long run, defined here as a 20-year period, the effect of this initial shock is to raise the price level by about 1.4 ppts, with the one standard error range between 1.0 and 1.8 ppts.

Cash—offers a partial hedge

Cash returns do increase in response to an inflation shock, but the response is very gradual and less than full. Figure 2 shows that after 1 year, the cumulative effect on cash returns is less than 0.1 ppt, implying that the real cumulative return is about 0.5 ppt lower due to the inflation shock. Over time, cash begins to recover on an inflation-adjusted basis, but this process plays out over a very long period. After 5 years, the real decline in cash returns remains at about 0.5 ppt, then slowly recovers thereafter. The long-run multiplier of T-bill returns to an inflation shock is about 0.8.

Cash returns are to a large extent determined by monetary policy and the real interest rate targeted by policymakers.[29] This sluggish reaction and less-than-full inflation compensation

[29] At times, the yield on short-term denominated Treasury instruments may diverge from the monetary policy interest rate due to special market factors; for example, the safe-haven status of treasuries during the financial crisis that began in 2007.

partly reflects the actions of policymakers during the 1956–2008 sample period, which includes the 1970s, a period in which central banks were perceived to be "behind the curve" as policy-determined interest rates rose only belatedly in the face of higher inflation (see Levin and Taylor (2008)).[30] The more activist role of monetary policy since the early 1980s, as described by Taylor (1993), may mean that cash returns are more sensitive to surprise inflation (or disinflation).

Bonds—suffer short-term, then recover
Long-term Treasury bonds are the worst performing asset class in the immediate aftermath of an inflation shock as yields increase. After 1 year, inflation causes the total return index to decline by 0.9 ppt, which implies a reduction in real returns of about 1.4 ppts. After about 3 years, and peak real return losses of nearly 2 ppts, the return dynamics begin to work in favor of long-term Treasuries, albeit gradually. As yields and prices stabilize, returns begin to be dominated by higher running yields rather than price declines.

The inflation shock is, over time, likely to lead to higher long-term real yields, increasing the total return of bonds once the effects of the shock have been fully priced-in and implying a long-run elasticity of about 0.1. This is due, in part, to higher inflation risk premia which evidence shows covaries positively with realized inflation; see Evans (1998).

Equities—experience losses, no meaningful recovery
Equity returns decline in the months following an inflation shock and do not experience a meaningful recovery thereafter, leaving them as the worst performing asset class in our sample. After 1 year, equity returns are about 0.3 ppt lower (0.9 ppt in real terms) due to the inflation shock and the decline in returns bottoms out after about 3 years and a 1.6 ppts loss (3 ppts in real terms). Returns then begin to stabilize, with the long-run inflation elasticity of an inflation shock on equities at about -0.2. However, inference is much weaker for equities; the width of the standard error bounds is about 2 ppts at the 20-year horizon, twice the width of those for bonds.

Our findings are consistent with evidence from a range of earlier studies and add further weight to the evidence against the theoretical arguments for equities as a real asset class providing inflation protection when inflation is rising. This result does not imply that equities underperform inflation over the very long run; indeed there is ample evidence that equities outperform other traditional asset classes in real terms over long horizons—see among others the Ibbotson SBBI Yearbook (2008) and the Barclays Capital Equity-Gilt Study (2008). However, these results do suggest that investors with strong non-consensus views regarding inflation may be able to enhance returns by tilting portfolios toward or away from equities, conditional upon their expectations for inflation trends.

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[30] Levin and Taylor (2008) suggest that monetary policy from 1965–1980 is not well-represented by a linear reaction function but rather as a sequence of stop-start episodes in which belated policy tightening induced a contraction in economic activity, but that stance of policy was not sustained long enough to bring inflation back to previous levels.

Commodities—effective short-term hedge, protection erodes over time
Commodities are the best performing asset class over the short term, but the long-term effects of inflation cause prices to fall gradually over time.[31] One year following the inflation shock, commodity prices increase by 0.4 ppt, which implies a decline in real returns of just 0.2 ppt. After about 2 years however, commodity prices begin to decline and continue falling for a number of years. The elasticity for commodities peaks at about 0.7 after 12–15 months and in the long-run converges to about -0.2.

Why might commodity prices fall over the long run in response to an inflation shock? Real interest rates and commodity prices tend to be inversely correlated, so if real interest rates gradually rise in response to an inflation shock, this could lower commodity prices with a lag.[32] However, the weight of evidence suggests that short-term real interest rates and inflation tend to covary negatively and that these effects can persist for some time—for example, see Ang, Bekaeart, and Wei (2008) and Giordani (2003). An alternative channel is through output, which recent evidence suggests declines following a positive inflation shock, particularly if real long-term yields rise (Fair (2002) and Giordani (2003)).[33] If higher inflation triggers a business cycle downturn, the pro-cyclical nature of demand for some commodities and a sluggish supply response should lead to lower prices.[34]

V. Summary and Investment Implications

Summary of results
Our results provide more evidence for the conventional wisdom about the inflation-hedging properties of various asset classes, but they offer salutary warnings against relying on this wisdom too much. Table 4 provides a summary.

From the analysis of 12-month returns, we find that bonds and equities have been poor hedges against ex post inflation, and that commodities have performed well when inflation has risen. However, these relationships are far from stable and there is clear evidence of

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[31] Our results are broadly consistent with Gorton and Rouwenhorst (2006) who find positive correlations between inflation and commodities at the 5-year return horizon. Our results, however, suggest that the positive response to an inflation shocks peaks well before the end of this period.

[32] See Frankel (2008) which argues that higher real interest rates cause commodity prices to fall due to three main factors: by increasing the discount rate for future extraction and increasing current supply; by raising the carry cost of inventories; and by encouraging speculators to shift out of commodity contracts and into treasury bills.

[33] Annicchiarico and Piergallini (2006) develop a model which explains this result within a New Keynesian framework.

[34] Although it is tempting to assume that commodity prices follows a common cycle positively correlated with global output, Cashin, McDermott, and Scott (1999) find no evidence for comvement across unrelated commodities. Procyclicality of the equally-weighted CRB price index may be driven by a smaller number closely-related sectors with output-sensitive demand, such as industrial metals; see Labys, Achouch, and Terraza (1999).

structural changes in how different asset classes behave. These changes have occurred around the time of monetary policy regime shifts (e.g., for cash and gold in the early 1980s), more speculatively when that policy regime gains sufficient credibility (e.g., for U.S. bonds in the late 1980s), and when the risks of deflation begin to rival those of inflation following the Asian crisis (e.g., for equities in the late 1990s).

Taking a longer term view, we find that dynamics of a response to unexpected inflation indicate a shifting pattern of asset class returns. Over a 12–18 month period following an inflation shock, the best and worst performing asset classes—commodities and bonds, respectively—correspond closely to those found in the short-run model. Beyond this period, however, relative returns among the asset classes begin to change significantly. Bond returns, helped by higher yields and more stable prices, begin to outperform inflation, whereas commodity prices begin to fall in nominal terms.[35] Meanwhile, equities suffer short-term losses from which they subsequently fail to recover over the longer term.

Investment implications

For long-term investors with confidence in their views about the path of inflation, these results have major implications. This is particularly true for "non-consensus" views in which investors may expect inflation surprises, whether positive or negative. These results may not say too much about deflation, however. Although the Gaussian assumptions underlying these models suggests that responses to inflation or deflation shocks should be symmetrical, with the exception of Japan's contribution to the SDR-weighted variables we do not have an example of deflation in our sample. The dynamics of unexpected deflation may be very different and this remains a fertile area for future research.

The results imply that it is difficult for a long-term strategic asset allocation to protect a portfolio against unexpected inflation using traditional asset classes. However, there is scope to enhance inflation protection through tactical asset allocation, for example by tilting the portfolio towards commodities and away from bonds in the aftermath of a positive inflation shock. However, at some point the hedging properties of commodities begin to diminish and a switch back towards bonds, at the expense of commodities, should be implemented.

What about equities? The literature remains far from a consensus on the hedging properties of this "real" asset class. Our results suggest that for investors who do not take tactical portfolio positions, the rationale for holding equities should be based on a very long-term horizon to ensure that the effects of inflation cycles average out. Investors with the scope to tilt their portfolios could underweight equities relative to their strategic benchmark in anticipation of higher inflation, but it may be more efficient to use other assets given their stronger and more consistent reactions (see Figure 3).

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[35] As noted in section IV, we use commodity prices as a proxy for asset class returns, while recognizing that the total return performance of futures contracts will differ due to the yield on collateral and roll returns.

Alternative inflation-hedging options for the long-term investor
There is one result about which the literature has come to a consensus: among traditional asset classes, inflation hedges are imperfect at best and unlikely to work at worst. This suggests that markets will continue to search for low cost and efficient methods to hedge inflationary risks for the long-term investor.

Worth noting in this respect is the growing use of so-called inflation derivatives (at least until the recent freeze of credit markets in 2008) which can be combined with a diversified investment portfolio through an overlay strategy with very limited cash mobilization. While the introduction of a CPI-based futures contract on the Chicago Mercantile Exchange in 2004 has met with timid investor interest, despite repeated calls for such an instrument (Lovell and Vogel (1973), Koppenhaver and Lee (1987)), over-the-counter vehicles have emerged in recent years in an attempt to meet investors' specific requirements and better insulate portfolios from the eroding effects of inflation.

Inflation swaps, swaptions and inflation options have gathered interest in Europe and in the U.S., particularly among those who wish to transfer inflation risk (banks, pension funds, insurance companies) and those who wish to express a view on the future level of inflation (investment banks, proprietary desks, hedge funds and relative value investors). In addition, the ability to partially hedge inflation risk, through caps and floors on inflation indices, and to select the most appropriate inflation reference, such as a wage index rather than a consumer price index, have broadened the ways in which investors can better protect their portfolios against the most relevant inflation measure.

Table 4. Summary of Results for the Effect of Unexpected Inflation on Asset Class Returns 1/

Asset class	Short term (1-18 months)	Intermediate term (18 months to 5 years)	Long-term (5 years +)	Historical long-run performance 2/
Cash	Interest rates respond gradually, leading to real losses.	Interest rates begin to climb, recovering some of the early losses.	Partial inflation hedge, elasticity of 0.8.	Modestly positive real returns.
Nominal bonds	Bond yields rise, causing price declines and real return losses.	Higher current yields begin to offset price declines, leading to some recovery.	Real losses, with elasticity of 0.1.	Real returns in excess of cash, but lower than equities.
Equities	Real return losses, but less than for bonds.	Stabilizing real returns, but no meaningful recovery.	Real losses with elasticity of -0.2.	Real returns in excess of bonds.
Commodities	Spot price increases, almost matching inflation.	Spot prices begin to gradually decline.	Real spot price losses, with elasticity of -0.2.	Insufficient total return data for commodity futures. 3/

Source: Authors' estimates.

1/ For those asset classes included in both the short- and long-run estimations.
2/ Total returns over the long-run and over all phases of the inflation cycle.
3/ Spot price data were used in the long-run analysis of inflation surprises. However, this provides only a partial picture of total returns. See footnote 25.

Appendix

Table A1. Short-Run Model Variables: Description

Variable	Description and comments
Consumer price index	
U.S.	From Jan-1926 to Dec-1959, the Ibbotson inflation index. From Jan-1960 onwards, the CPI-U, U.S. City Average, published by the Bureau of Labor Statistics.
SDR	As above for the U.S. For other SDR constituents, the headline consumer (or retail) price index published in the IMF's International Financial Statistics.
Cash	
U.S. 3-month T-bills	From Jan-1926 to Dec-1985, the Ibbotson U.S. Treasury bill total return index. From Jan-1986 onwards, the J.P. Morgan U.S. three-month cash total return index.
SDR 3-month interest rate	Total return index calculated from the official SDR interest rate, as published in the IMF's International Financial Statistics.
Bonds	
U.S. Treasuries (all maturities)	From Jan-1973, the Barclays (previously Lehman) U.S. Treasury Aggregate total return index.
U.S. Treasuries (10+ year maturities)	From Jan-1926 to Dec-1977, the Ibbotson long-term U.S. Treasury total return index. From Jan-1978, the Merrill Lynch U.S. Treasury 10+ Year Maturity total return index.
U.S. Corporate bonds	The Merrill Lynch Corporate Master total return index.
SDR government (all maturities)	SDR-basket weighted average of Merrill Lynch All-Maturity government bond total return indices in the U.S., Japan, the euro area, and the U.K. Before the advent of the euro in 1999, France and Germany are represented separately..
SDR government (10+ year maturities)	SDR-basket weighted average of Merrill Lynch 10+ Year Maturity government bond total return indices in the U.S., Japan, the euro area, and the U.K. Before the advent of the euro in 1999, France and Germany are represented separately.
Equities	
U.S. large cap. equities	From Jan-1926 to Dec-1964, the Ibbotson U.S. Large Stock total return index. From Jan-1965 onwards, the S&P 500 total return index.
SDR-weighted equities	SDR-basket weighted average of Morgan Stanley Capital International (MSCI) equity total return indices in the U.S., Japan, the euro area, and the U.K. Before the advent of the euro in 1999, France and Germany are represented separately.
Alternatives	
FTSE NAREIT index	Index of commercial real estate investment trusts, the majority of which are traded on major exchanges.
CRB index	Geometrically-weighted average price index currently with 17 individual commodity constituents.
GSCI index	Unleveraged, long-only total return index with 24 components weighted by their respective world production quantities.
Gold spot	The London Bullion Market Association PM London gold fixing price.
Portfolios	
U.S. dollar 60-40 equity-bond portfolio	Weighted average of the U.S. large cap. equity total return index (60 percent) and the U.S. Treasury 10+ year maturity total return index (40 percent).
SDR 60-40 equity-bond portfolio	Weighted average of the SDR-weighted equity total return index (60 percent) and the SDR-weighted government 10+ year maturity total return index (40 percent).

Source: Ibbotson SBBI Yearbook, J.P. Morgan, Barclays Capital, Merrill Lynch, Morgan Stanley Capital International, FTSE Group, London Bullion Market Association, IMF International Financial Statistics.

Table A2. Long-Run Model Variables: Unit Root Tests 1/

	Log index		First difference	
	Test statistic	p-value	Test statistic	p-value
Treasury bills	-0.86	0.8006	-2.64	0.0852
Long-term Treasury bonds	1.59	0.9995	-22.98	0.0000
Large cap. Equities	-0.69	0.8480	-23.35	0.0000
Commodities	-0.85	0.8045	-23.66	0.0000
Consumer price index	-1.06	0.7330	-3.72	0.0040

Source: Authors' estimates.

1/ Augmented Dickey-Fuller unit root tests, with a maximum lag of 6 and specification selected on the basis of the Aikiake information criterion.

Table A3. Vector Autoregression in Levels: Lag Length Selection Criteria

Lag Length	Likelihood Ratio Test	Information Criteria		
		Aikaike	Schwartz	Hannan-Quinn
0	…	-1.86	-1.82	-1.84
1	18389.7	-31.80	-31.58	-31.72
2	516.9	-32.50	**-32.10**	**-32.35**
3	61.5	-32.51	-31.94	-32.29
4	81.3	-32.56	-31.81	-32.27
5	31.3	-32.54	-31.60	-32.17
6	80.9	-32.60	-31.48	-32.16
7	**54.2**	**-32.61**	-31.32	-32.11
8	25.8	-32.58	-31.10	-32.00

Source: Authors' estimates.

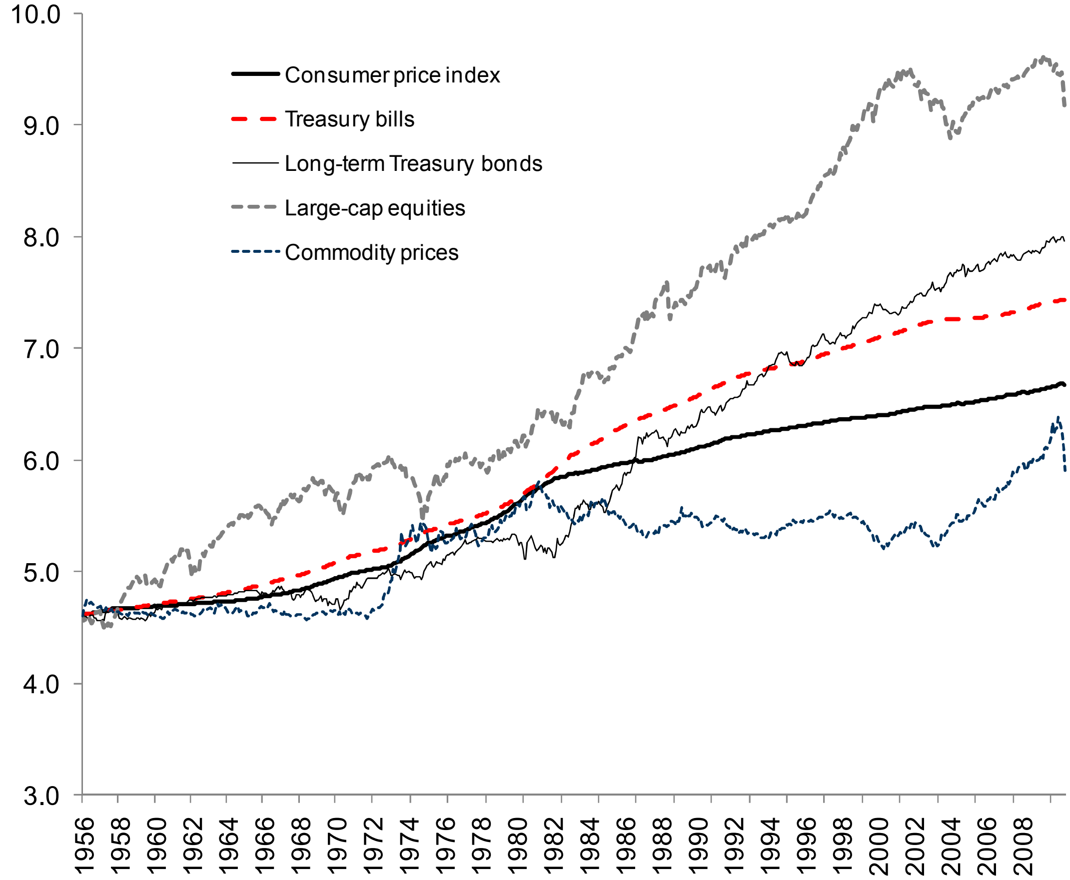
1/ Figures in bold indicate the lag order selected by the criterion. The lag order *p* selected by the likelihood ratio test is due to a rejection of the null hypothesis of a lag order *p*-1 at the 5 percent level.

Table A4. Cointegration Tests: Trace and Maximum Eigenvalue Tests 1/

Number of Cointegrating Vectors (r)	Eigenvalue	95 percent p-value 2/	
		Trace test	Max. eigen test
r < 1	0.072	0.0006	0.0010
r < 2	0.031	0.1197	0.3535
r < 3	0.023	0.2121	0.3185
r < 4	0.012	0.3530	0.4514
r < 5	0.003	0.1784	0.1784

Source: Authors' estimates.
1/ For the specification described by equation (x).
2/ MacKinnon-Haug-Michelis (1999) p-values, indicating the probability that the null hypothesis is true.

Figure A1. Long-Run Model Variables: Total Return and Price Indices, Aug-1956 to Nov-2008 (log of rebased indices)



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