The Long Horizon Benefits of Traditional and New Real Assets in the Institutional Portfolio

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WOOD CREEK
CAPITAL MANAGEMENT

Connecticut Financial Center
157 Church Street, 20th Floor
New Haven, CT 06510

P: 203.401.3220
F: 203.401.3219

Athomson@woodcreekcap.com

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If you have questions about Wood Creek and how we can help your institution implement its real asset investment mandate, or would like to set up a discussion with the paper's author, please contact us.

I look forward to hearing from you.

Brett D. Hellerman
CEO and Founder
Wood Creek Capital Management, LLC
bhellerman@woodcreekcap.com
P: 203.401.3220

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Introduction

Increasingly over the past five years, and particularly in today's environment, investors have a renewed interest in the risk and return properties of "real assets." The motivations of the investors, however, are far more clearly defined than their goals: What are the specific characteristics of the group of assets that comprise real assets? As is discussed in this paper, investors are increasingly seeking real asset investments that have more than one of the properties listed below. They pursue returns that:

- Are positively correlated with US or European price inflation;
- Preserve value during periods of financial market contagion or substantial changes in the economic environment due to changes in the business cycle;
- Benefit directly from the increasing scarcity of production inputs, particularly in core economic sectors such as energy, manufacturing, and agriculture;
- Are essential components to economic infrastructure, including the built environment of commercial and residential real estate; transportation, including roads, rail, shipping and air; and major projects, such as telecommunications and pipelines; and,
- Offer long-term risk and return properties suitable for investors seeking to fund long-term liabilities.

Assets that are typically mentioned in conjunction with these characteristics can be divided into "traditional" and "new" real assets. Institutional investors, particularly endowments, have pursued investments in traditional real assets for many decades. These real assets include:

- Equities
- Inflation-Linked Bonds or Derivatives
- Commodities and Commodity-Linked Derivatives
- Direct or Indirect Real Estate
- Gold, and
- Timber

As part of the quest for real exposure, newer real asset classes have come within the purview of investors. These "new" real asset classes include:

- Infrastructure
- Farmland, and
- Intellectual Property

While Infrastructure and Farmland are becoming well-accepted real assets, Intellectual Property and other related intangible assets, including brands, have only recently been recognized by the investment community for their central role in economic infrastructure and their ability to preserve value in the face of substantial changes in the business environment. In particular, growth in the importance of intangibles has made direct investment more feasible through the unbundling of intangible assets from their typical home on the corporate balance sheet.

Within the broader investment community, limited knowledge exists of the risk and return properties of real assets, particularly as it relates to the key properties ascribed to real assets by institutional investors and their advisors, such as: i) a hedge to inflation; or ii) a store of value in the face of fluctuations in broader financial markets. While each of these asset classes has been the subject of varying degrees of non-proprietary research on risk and return properties, there has been little research that either systematically defines the properties of these asset classes as *real assets* or provides a roadmap as to how each type of asset – or a portfolio of these assets – can affect the ability of institutional investors to achieve their investment objectives. Given the growing attention to the potential role of real asset allocations in institutional portfolios, particularly pension and endowment portfolios, we believe there is an immediate need for a coherent framework for understanding the risk and returns of real assets. In particular, we believe that the framework must explicitly recognize the *long-horizon* nature of the assets with which institutional investors seek to hedge long-horizon, inflation-sensitive liabilities.

The present economic environment provides many sources of inflation risk over short and long time horizons, specifically: i) expansionary monetary and fiscal policy; ii) increasing scarcity of energy, industrial metals, and agricultural resources; and iii) the weakening of the US dollar. Given these risks, a driver of demand for real assets investments is the expectation that real asset performance is positively correlated with inflation. A subtle understanding of the characteristics of the assets comprising real assets as potential inflation hedges requires going beyond simple consideration of historically measured contemporaneous correlation with CPI. In particular, a fuller understanding of each asset's relationship to inflation risk comes from considering the entire stream of cash flows attached to an asset and not merely a directional bet on the price at which an asset can be resold into the market at future date. This understanding requires consideration of how changes in inflation may affect the value of those intermediate cash flows directly, as with income or dividends, or how changes in inflation may be correlated with other factors, such as the state of the business cycle and/or monetary policy, that may affect the value of those cash flows over the life of the asset. More broadly, critical questions that must be considered when evaluating the inflation "protection" provided by a real asset are:

- Are changes in the value of the asset related to changes in current, realized inflation or expected future inflation, or are they related to unanticipated changes in inflation? To what extent do changes in the value of the asset depend on persistence[1] in inflation?
- Given that energy makes up a significant portion (roughly 80% by one estimate) of inflation (CPI-U) volatility, to what extent is an asset's correlation with inflation merely a direct proxy for energy exposure?
- To what extent do short-term shocks in inflation affect both short-term and long-term returns of an asset?
- To the extent that inflation is correlated with broader macroeconomic conditions, is an asset's correlation with inflation merely a proxy for broader macroeconomic exposure, or is the correlation with inflation the result of some sector-specific economics?

1. In its simplest form, current realized inflation may be decomposed into an "expected" component and an "unexpected" component. As a general rule, inflation is persistent: For example: next quarter's increase in CPI is likely to be very similar to this quarter's increase.

- To the extent that an asset has zero or positive correlation with inflation, does the primary benefit of holding that asset in an institutional portfolio come from its diversification properties or from its inflation hedging properties?
- To what extent do the asset's inflation properties match the specific inflation exposures of the underlying investor? Does the price mix of liabilities (i.e. medical price exposure) match the price exposure of the asset being used as a hedge?

Wood Creek Capital Management is actively engaged in the management of new and traditional real assets and has conducted a substantial amount of research to guide its practical investment activities in these areas.

This paper addresses many of these questions as we survey and analyze the potential role of the various real asset classes listed above in reducing inflation risk in the portfolios of long-horizon institutional investors. In this paper, we propose a simple model of the evolution of asset cash flows that can be parameterized by key variables, including: i) sensitivity of the level of returns to expected and unexpected changes in inflation; and ii) the degree of persistence in inflation. Each of these variables is a significant determinant of the long-horizon inflation properties of assets. Using that model and our research, coupled with research available in academic literature, we identify the viability of various real asset classes as potential hedges for inflation; further, we illustrate the sensitivity to changes in parameter values that best reflect the current macroeconomic environment rather than the outdated historical market environment.

We show that traditional and new forms of real assets classes have differential value as inflation hedges. We summarize those results in Figure 1. Each column asks if, as a stylized fact, each asset class can be considered a hedge for inflation at either a short-horizon or a long-horizon. "Yes" indicates that, as a general rule, the asset class has positive correlation with inflation. "No" indicates that the asset class has a negative correlation with inflation. "Uncertain" indicates that no generalization can be made, while "Diversifier" indicates that the asset has neither positive nor negative correlation with inflation. *In all circumstances, the inflation hedging characteristics of an individual asset within an asset class may be better or worse than the asset class as a whole.*[2]

2. CPI-U, the base measure of inflation used in this paper, represents a specific, diversified basket of price exposures. Any one real asset class may be more or less correlated with specific sectors of the CPI basket; however, in addition to risk diversification, an additional motivation for holding a portfolio of real assets with positive correlation of inflation may be to better calibrate the exposure of the portfolio of real assets, and hence, reduce tracking error, with respect to the CPI basket. Additionally, it is worth noting that, while the analysis in this paper focuses on CPI-U, the analysis could be done using other measures of inflation without any significant change in approach.

Figure 1

Asset Class	Traditional Argument for Being Inflation Hedge	Short Horizon Inflation Hedge?	Long Horizon Inflation Hedge?
Equities	Diversified nominal cash flows should adjust with changes in inflation	No	No
TIPS	Size of principal adjusted by CPI-U	Yes	Yes
Commodities	Increasingly scarce production inputs, particularly in core economic sectors like energy, manufacturing, and agriculture	Yes	Yes
Real Estate	Essential component of economic infrastructure	No	Uncertain
Timber	Scarce production input, particularly in core economic sectors like manufacturing, real estate	Yes	Yes
Infrastructure	Essential component of economic infrastructure	Uncertain	Uncertain
Gold	Traditional store of value	Diversifier	Diversifier
Farmland	Essential component of economic infrastructure	Yes	Yes
Intellectual Property	Essential component of economic infrastructure, particularly as intangibles become an increasingly large part of the economy	Uncertain	Uncertain

Traditional Real Assets as an Inflation Hedge: The Case of Equities

As an introduction to our discussion on traditional and new real asset classes, we explore some of the inflation hedging properties of equities, among the oldest forms of real assets. We take advantage of the greater availability of data as well as the large body of research established to investigate the possibility that equities could function as a hedge to inflation exposure embedded in the institutional investor's portfolio. In this section, and that which follows, we present some elements of our model and show that equities in general are *not* a good hedge to inflation. We also show the analytical power of our model, as it allows us to demonstrate the potential benefits of listed energy-related equities, when separated from embedded market beta, in offering a viable hedge to inflation risk.

Until the mid-1970's, it was commonplace for academics and practitioners to claim that (US) equities were real assets. The argument was simple and derived primarily from conventional academic economic theory: equities are a claim on cash flows, so changes in the overall price level should both increase the nominal discount rate as well as the corresponding dollar value of cash-flows, leaving the net effect of zero on equity valuations. However, with the experience of inflation in the early and mid-70's, increasing empirical evidence (such as Bodie [1976]) seemed to suggest that changes in the price level were *negatively* correlated with broad equity indices. This negative correlation between inflation and equities was considered a conundrum, particularly to advocates of "efficient markets."

Fama [1981] tried to advance the analysis of the apparently negative relationship between inflation and stock returns by offering what has come to be known as the "proxy theory" of the stock-inflation relationship. In short, the core hypothesis of this theory is that: "the negative relations between stock returns and inflation are proxying for positive relations between stock returns and real variables which are more fundamental determinants of equity values. The negative stock-return relations are induced by negative relations between inflation and real activity which in turn are explained by a combination of money demand theory and the quantity theory of money" (545). Fama finds that when one combines both inflation and measures of real activity and growth of money as joint explanatory variables for real stock returns, the explanatory power of measures of real activity and growth of money dominate those of inflation. However, inclusion of real activity alone is insufficient to eliminate the negative explanatory relationship between stock returns and inflation. As such, one cannot conclude that the negative relationship between stock returns and inflation is fully explained by the negative relationship between real activity and inflation; consequently, while partially successful, the "proxy theory" was not fully validated by the data.

Other contemporaneous authors, such as Geske and Roll [1983], advanced hypotheses that involved feedback between changes in inflation and inflation expectations, changes in monetary policy, and stock returns; the empirical evidence for these hypotheses has been weaker. Kaul [1987] suggests that the negative relationship between stock returns and inflation was not present in the pre-WWII period; nor has it generally been the case that inflation and stock returns have been negatively correlated in non-US markets.

Research on the relationship between equity returns and inflation has continued to develop, further exploring: i) the time dynamics between changes in inflation and stock returns, and ii) the cross- sectional, international or microeconomic interaction between inflation and stock returns.

Initial rounds of research focused on the *short-term* relationship between inflation and stock returns. However, short-term, contemporaneous changes may be of less relevance to long-term investors seeking to hedge or diversify away the risks of inflation-linked liabilities. Boudoukh and Richardson [1993] study the long-horizon interaction between inflation and stock returns for both the US and the UK for the respective periods of 1802-1990 and 1820-1998. They find that stock returns and inflation are *positively* correlated at five year holding periods for both the US and the UK.

Ely and Robinson [1997] present international evidence on sixteen industrialized countries indicating that, in general, the long-term effects of inflation shocks do not include loss of value in equities. In addition, they also find that the nature of the inflation shock – monetary or real – does not typically matter, except, most notably, for the case of the US, where real inflation shocks result in a long run decline in US share prices.

There has also been significant interest in understanding the relationship between stock returns and industry groupings. Wei and Wong [1992] investigate the relationship between stock returns and inflation for nineteen industry portfolios. They find that, for the post-war period through 1985, the relationship between all industry portfolio returns and inflation is negative, with the exception of natural resources, which is uncorrelated. Revisiting the "proxy theory" hypothesis at the industry level, they find that introducing a real explanatory variable (a proxy for anticipated growth in industrial production) eliminates the negative relationship between stock returns and expected inflation. For the pre-WW II period, Wei and Wong found, consistent with Kaul [1987], that there is a generally *positive* relationship between expected inflation and industry returns. They note that adding a proxy for anticipated growth in industrial production for the industry regressions does not negate the significance of the change in expected inflation.

While the above results on industry returns are helpful, they are somewhat antiquated and do not account for market beta embedded in each industry's returns. This beta is a significant component of industry returns and makes it more difficult to disentangle industry effects from broader market factors; hence, we also look at returns *net* of market beta. Using industry data provided by Ken French (and derived from CRSP) for the period of 1926-2008, we examine correlations between industry and inflation for both actual and "hedged" quarterly returns. Hedged returns are industry returns less industry beta (estimated on the 20 previous quarters, through t-1). We look at these correlations in Figure 2.

Figure 2: Industry Correlations with CPI

Correlations with Inflation

Quarterly Returns

Correlations

	SP500	NoDur	Durbl	Manuf	Enrgy	HiTec	Telcm	Shops	Hlth	Utils	Other
1930-2008	-0.02	-0.06	-0.03	-0.03	0.10	-0.04	-0.04	-0.05	-0.06	-0.01	-0.03
1990-2008	-0.01	-0.06	0.08	0.05	0.37	-0.01	-0.13	-0.03	-0.09	0.07	-0.04
1945-1989	-0.23	-0.20	-0.24	-0.22	-0.06	-0.25	-0.18	-0.19	-0.21	-0.22	-0.21
1930-1944	0.14	0.08	0.12	0.11	0.21	0.15	0.14	0.09	0.09	0.09	0.11

Hedged Returns

Correlations

		NoDur	Durbl	Manuf	Enrgy	HiTec	Telcm	Shops	Hlth	Utils	Other
1930-2008		-0.05	-0.06	-0.07	0.20	-0.07	-0.04	-0.04	-0.05	-0.01	-0.01
1990-2008		-0.07	0.04	0.06	0.33	0.03	-0.24	0.10	-0.06	0.02	-0.09
1945-1989		-0.02	-0.12	-0.04	0.21	-0.11	-0.01	-0.03	-0.09	0.05	0.03
1930-1944		-0.14	0.02	-0.08	0.17	-0.05	-0.01	-0.11	-0.05	-0.16	0.00

positive correlation at 5% level

negative correlation at 5% level

Source: Ken French, derived from CSRP

Clearly, the broad notion that stock returns are negatively correlated with inflation in the short run is still largely true for the more recent period of 1990-2008 (with the general exception of Energy) as with the period 1945-1989;[3] further, the pre-WWII correlations, as mentioned in the above research, are positive. Stripping out broad market beta, we find that the correlations between Energy and inflation are more positive over the entire history of the analysis and that the hedged returns to other industries are generally negative for both the pre-WWII period and the post-war period through 1989. Interestingly, the strength of the relationship between both hedged and un-hedged industry returns and inflation is less negative for the period 1990-2008. We hypothesize that this change is more a function of the relatively benign nature of inflation during this time period rather than some structural change in the way that realized inflation and forward inflation risk might be priced by equity markets or some structural change in the relationship between real activity and changes in inflation. In particular, the nature of the shocks to the real and monetary economy has changed substantially. Du [2006] presents empirical evidence to suggest that the positive correlation between inflation and equity returns in the pre-WWII period was largely due to pro-cyclical monetary policy; and that post-WWII through 2001, the negative correlation between stocks and inflation has been due to counter-cyclical monetary policy.[4]

3. We choose the breakpoint of 1989 to correspond to the breakpoint used in a number of academic articles. Alternately, we could have chosen a breakpoint of 1985, in order to correspond with the typical dating of the "Great Moderation," a period of tame inflation. Minor changes in the breakpoint do not have material implications for the specific results mentioned here.
4. As suggested, the response of equity returns to changes in the macroeconomic environment is highly firm specific. For example, Ehrmann and Fratzscher [2004] find (for the period 1994-2003) that the equity of firms with high cash flow to income are less sensitive to monetary policy shocks than low cash flow firms; they also find that firms with a high market to book (Tobin's Q) are more sensitive to monetary policy shocks. Using Fama-French portfolios sorted on book to market and size, we find that, for the period 1946-2008, high market to book firms are more adversely sensitive to unexpected inflation, but that difference in sensitivity is not large. No pattern emerges for expected inflation. Also, using data available from Ken French, we estimate the relationship between the returns to portfolios of firms sorted on cash flow (to market value) and inflation based on available data since 1951 (through 2008). We find that no clear (e.g., monotone) pattern in unexpected inflation betas emerges across portfolio deciles; returns to high cash flow firms are generally less sensitive to changes in *expected* inflation than are returns to low cash flow firms.

Sharpe [2002] takes a somewhat different approach to disentangling the interrelation between current stock prices and changes in inflation, focusing on how the market values changes in intermediate cash flows (as proxied either by analyst earnings forecasts) that may be subject to inflation-related changes in discounting or inflation-associated changes in business cycle-related earnings growth. Sharpe finds a negative relationship between analyst-based expectations of earnings growth and expected inflation; additionally, he finds that stock prices impound inflation-related changes in real long term bond yields that are used to discount cash-flows. He thus concludes that the equity risk premium (expected returns of stocks over bonds) is uncorrelated with expected inflation. Pilotte [2003] decomposes stock prices into dividends and capital gains, and finds that Cyclical industry returns are more sensitive to changes in expected inflation than are Non-Cyclical industries. He also finds that dividend yields for both types of stocks are significantly positively correlated with changes in expected inflation, and that the returns from capital gains for Cyclical industries are negatively affected by changes in expected inflation (whereas the returns due to capital gains for Non-Cyclicals is not significantly related to changes in expected inflation).[5] Pilotte finds that the negative relationship between capital gains returns and changes in expected inflation, as well as the positive relationship between dividend yield and expected inflation, hold for a number of European countries (FR, DE, SE, UK).[6]

From the above discussion and analysis of equities, we see that understanding the value of a particular asset class in hedging inflation risk[7] requires that one understand:

- That the primary source of short-run correlation between real asset values and inflation comes from the fact that inflation proxies for changes in real activity.
- That the relationship between the value of an asset and inflation may vary over different macroeconomic periods.
- That the relationship between inflation and asset values varies across industries and countries.
- That long-horizon inflation hedging properties of assets may be significantly different from short-horizon hedges, and – as we demonstrate in the model below and with subsequent discussion in this document – the crucial variable generating a horizon-based difference in hedging properties is the persistence of inflation. Forward-looking estimates of inflation persistence are therefore essential for determination of the appropriate assets to deploy to hedge inflation risk in a portfolio.

5. We caution the reader seeking to interpret these results, since dividends tend to relatively sticky, especially downward, where as prices adjust faster. A decline in prices due to expectations about output that are concomitant with increases in inflation will tend to induce a positive inflation beta for dividend yield.

6. Unfortunately, we have little immediately available evidence to determine if the market prices the expected cash flows associated with listed equities in the same or a different manner than it does for the cash flows of private companies or assets. There is however, substantial evidence that shows that, when all other factors are controlled, private companies are valued at lower multiples to earnings or other cash flow when compared to public companies (Koeplin *et al.* [2000], DiGabriele [2008]).

7. In this paper, we do not address in any meaningful way possible behavioral or cognitive biases or predispositions. For example, Shiller [1997] reports the predisposition that 90% of survey respondents believe that inflation is harmful to growth.

Estimating Inflation Hedge Ratios for Assets

We can better understand the relationship between the return properties of assets and their role as inflation hedges by laying out a simple model of the relationship between asset cash flows and an inflation-linked liability. The analysis below was originally developed in the context of equities, but is applicable to other asset classes. Following Schotman and Schweitzer [2000], let inflation, π, evolve as an autoregressive process,[8] where η is unexpected inflation:

$$\pi_{t+1} = \mu + \alpha(\pi_t - \mu) + \eta_{t+1}$$

Asset cash flows are assumed to evolve as a function of expected and unexpected inflation, as well as an unpredictable idiosyncratic component, ε_{t+1}:

$$r_{t+1} = \upsilon + \beta E_t[\pi_{t+1}] + \phi\eta_{t+1} + \varepsilon_{t+1}$$

We are interested in five parameters:

- α, the degree of persistence of inflation;
- β, the inflation beta, which equals 1 if nominal returns fully account for inflation;
- ϕ, the "beta" of returns to unexpected inflation;
- σ_ε, return volatility; and
- σ_η, inflation volatility.

We form a portfolio, with real return, R, of the risky asset *r* and a nominal discount bond, *b*, with real returns equal to:

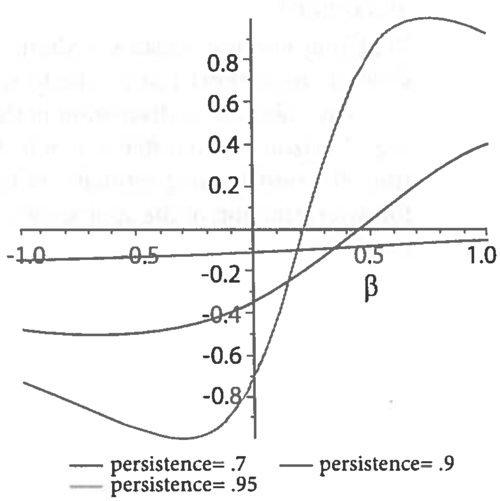
$$R^k_{t+k} = w(r^k_{t+k} - \pi^k_{t+k}) + (1-w)(b^k_{t+k} - \pi^k_{t+k}) \text{ or}$$
$$R^k_{t+k} = wr^k_{t+k} + (1-w)b^k_{t+k} - \pi^k_{t+k}$$

All variables are cumulative sums, where the superscript, k, denotes the number of periods over which the sum is taken – i.e. the horizon of the investor. Since all volatility risk comes from the risky asset and inflation, for the minimum variance hedge ratio we are looking for the regression beta of cumulative inflation on the cumulative value of the risky asset. We call this hedge ratio, Δ.

As shown by Schotman and Schweitzer [2000], the long run,[9] minimum variance hedge ratio is:

$$\Delta = \frac{((1-\alpha)\phi + \alpha\beta)\sigma^2_\eta}{(1-\alpha)^2\sigma^2_\varepsilon + ((1-\alpha)\phi + \alpha\beta)^2\sigma^2_\eta}$$

Figure 3: Inflation Hedge Ratio



For the hedge ratio to be positive (that is, for the asset to be a bona fide hedge of inflation risk) we need to have:

$$((1-\alpha)\phi + \alpha\beta) > 0$$

8. Intuitively, an autoregressive process is a process in which today's value of an economic variable depends on yesterday's value of that economic variable.
9. Where the "long run" is defined as the limit (k →∞).

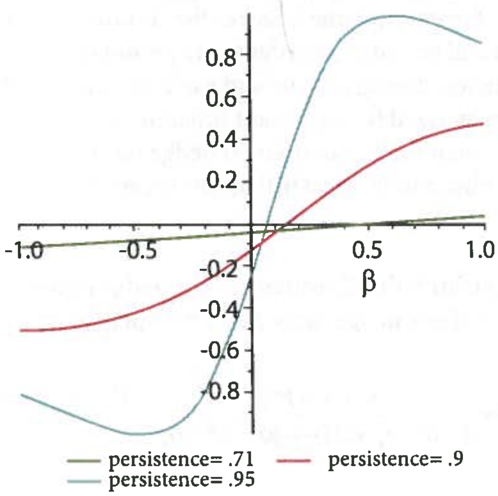
We can look to the general literature to determine what appropriate parameters for the hedge ratio might be. Empirical evidence for the US and other developed countries (Wang and Wen [2007]) indicates that $.7 < \alpha < 1$. For equities or many other assets, unexpected inflation shocks tend to induce negative short term returns; exact values of ϕ are very much a function of specific assets under consideration, as is beta, β, of the asset toward changes in inflation. For equities, we might have $\beta > 0$, $\sigma_\varepsilon = 20\%$, and $\sigma_\eta = 2\%$, and $\phi = -4$. Graphically, we can see that the value of an asset as a long-horizon inflation hedge is very sensitive to assumptions about inflation persistence and beta versus expected inflation.

This long horizon hedge ratio differs from the one-period hedge ratio:

$$\Delta_1 = \frac{\phi\sigma_\eta^2}{\sigma_\varepsilon^2 + \phi^2\sigma_\eta^2}$$

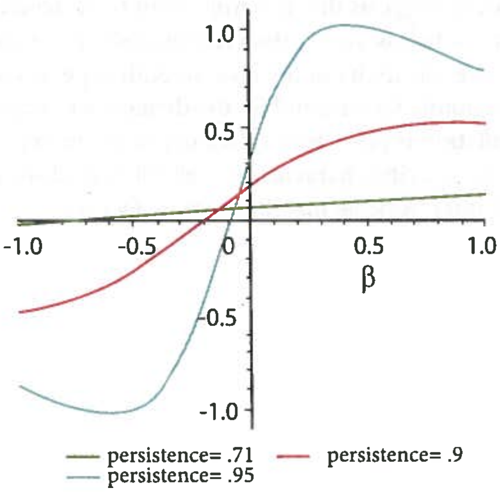
For the above parameter values, the hedge ratio is -.034, which is negative (rather than positive for a hedge), and therefore the asset is not a hedge. Keep in mind that asset volatility is ten times the volatility of inflation, so that hedge ratios will be scaled accordingly. For asset volatility equal to inflation volatility, the maximum hedge ratio occurs at $\phi = 1$.[10]

Figure 4: Inflation Hedge Ratio for SP500



We can also estimate the model relative to specific data to get a better feel for the properties of the hedge ratio, as well as for the general sensitivity of parameters to market environments associated with different sample periods. We estimate the properties of inflation from quarterly CPI data for the period 1946:1 – 2008:4. We find that our estimate of inflation persistence, α, is .71. (We base our estimate on an AR [4] process which has an adjusted R^2 of .31). We use this estimate as a plug-in to determine our expected inflation process, $E_t(\pi_{t+1})$ and our unexpected inflation process, η_t. We then estimate our asset return/inflation model. For the SP500, for this period, our estimate of β is -.95 ($p = .21$) and $\phi = -1.20$ ($p = .02$), $\sigma_\varepsilon = 14.4\%$, and $\sigma_\eta = 1.4\%$. From the chart, we can see that, except for higher levels of persistence, or higher levels of inflation beta ($\beta > .5$) and higher levels of inflation persistence ($.7 < \alpha < 1$), the SP500 is not a good hedge for inflation.

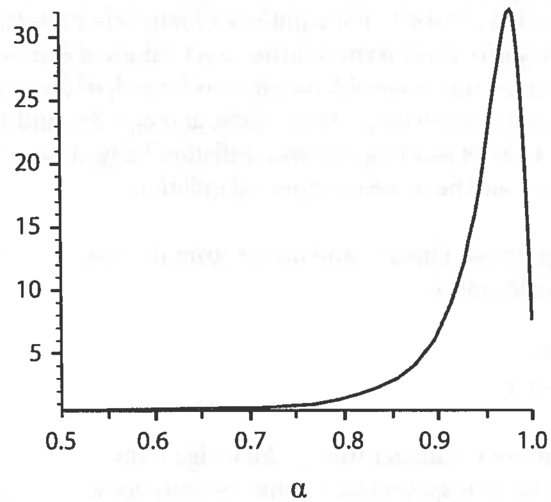
Figure 5: Inflation Hedge Ratio for Hedged Energy Stocks



10. Note that the short horizon (one period) hedge ratio differs from the long horizon hedge ratio by ignoring the effects of inflation persistence (α) and beta (β) against expected inflation. Throughout this document we present graphical figures that show the effects of varying these parameters, in part to show the difference between long horizon and short horizon hedge ratios (equivalent to $\alpha = 0$ and $\beta = 0$).

We argued above that energy-related stocks, particularly if overall market beta is removed, may offer a hedge for inflation. Estimating our model for such hedged energy equity returns, we find that: β is .43 ($p = .50$) and $\phi = 1.8$ ($p = .0001$), $\sigma_\varepsilon = 13.5\%$, and $\sigma_\eta = 1.4\%$. While there is substantial estimation uncertainty in β,[11] using the point estimate of .43, the estimated hedge ratio for hedged energy stocks is .096. (We also see that the hedge ratio is positive for all $\beta > 0$.) However, if one believes that future inflation will be more persistent (the period of high inflation during the 70s and early 80s was also characterized by significant inflation persistence), then the actual optimal hedge ratio may be substantially greater than the estimate of .096.

Figure 6: Sensitivity of Hedge Ratio to Changes in Inflation Persistence



We can quantify this sensitivity of the hedge ratio to changes in persistence by calculating the derivative of our hedge ratio, Δ, with respect to α:

$$\frac{\partial\Delta}{\partial\alpha} = \Delta_\alpha = \frac{(-\phi+\beta)\sigma_\eta^2}{(1-\alpha)^2\sigma_\varepsilon^2 + ((1-\alpha)\phi+\alpha\beta)^2\sigma_\eta^2} - \frac{((1-\alpha)\phi+\alpha\beta)\sigma_\eta^2(2\,((1-\alpha)\phi+\alpha\beta)\sigma_\eta^2(-\phi+\beta) - 2(1-\alpha)\sigma_\varepsilon^2)}{((1-\alpha)^2\sigma_\varepsilon^2 + ((1-\alpha)\phi+\alpha\beta)^2\sigma_\eta^2)^2}$$

So, for the above parameter values: $\beta = .43$, $\phi = 1.8$, $\sigma_\varepsilon = 13.5\%$, and $\sigma_\eta = 1.4\%$, we have Figure 6. We can see that the hedge ratio is of increasing sensitivity to the amount of persistence in inflation and for these parameters up until the point that $\alpha = .978$.

This analysis suggests that it is important to understand: i. the return drivers of a specific subsector in an asset class, rather than rely exclusively on asset class level estimates of inflation sensitivity; ii. the sensitivity of the asset to both expected and unexpected inflation, as well as other macroeconomic factors; and iii. the dynamics of impending inflation, in particular, the degree to which inflation is persistent, transitory or mean-reverting. We now move on to a consideration of some of the specific characteristics of different classes of real assets and their sensitivity to inflation and other possible macroeconomic factors.

11. An asset's β versus expected inflation is generally difficult to estimate, since expected inflation tends to change far more slowly than asset returns. In general, throughout this paper, we present figures analyzing inflation hedge ratios of assets relative to a range of values of β, rather than particular point estimates, since those are subject to substantial uncertainty. In general, we chose the range of β to graph as either a symmetric range around zero (when there is substantial uncertainty about whether β is positive or negative) or in the range, $\beta > 0$, when there is economic or empirical evidence to believe that β is reliably greater than zero. The choice of ranges is based on our current, forward looking estimates of this parameter for the asset being discussed.

Inflation and Inflation-Linked Bonds

Inflation-linked bonds have drawn the attention of investors seeking assets with values explicitly linked to inflation. While there is a long history of inflation-linked assets, primary issuance of inflation-linked assets are by the UK, with the government first issuing index-linked gilts in 1981, and by the United States, where TIPS were first issued in 1996. Institutional investors have been particularly interested in TIPS because of their relative liquidity. The key components of value for inflation-linked bonds are the real interest rate, r, the expected inflation rate, π, and the inflation risk premium, ρ, reflecting uncertainty about future inflation rates. Using the classic Fisher relationship, the nominal yield, y, is given as: $(1 + y) = (1 + r)(1 + \pi)(1 + \rho)$. In general, the "break-even" inflation rate is approximated as $\pi = y - r$ under the assumption that the inflation risk premium is zero.[12] Each one of these factor is subject to independent variation, which makes actual TIPS returns only mildly correlated with realized inflation in the short- to medium-term.

However, there are substantial issues with inflation-linked bonds that make them imperfect hedges for inflation risk.

1) On a stand-alone basis, inflation-linked bonds are bundled with nominal exposure. Inflation volatility is generally lower than interest rate volatility, but it can spike during times of macroeconomic uncertainty. This makes efficiently extracting inflation risk from bonds difficult.
2) Long-lived dollar denominated inflation-linked assets with durations appropriate for pension funds (15+ years) and endowments are still rare and illiquid. Such long duration assets may also have meaningful credit risk.
3) Break-even inflation rates may not be a good forecast of expected future inflation. In particular, break-even rates for US TIPS tend to understate forward inflation; UK index-linked gilts tend to overstate.
4) Break-even rates may be subject to substantial distortions or other dynamics not directly related to expected inflation in the market place. For example, changes in domestic break-even rates may be more highly correlated with changes in *foreign* real rates. See Figure 7 below.

Figure 7: Correlation matrix between changes in break-even rates (BEIR) and changes in real interest rates (RBY)

		RBY					
		Australia	**Canada**	**Euro Area**	**Great Britain**	**Sweden**	**United States**
BEIR	**Australia**	**0.27*****	0.19***	0.37***	0.33***	0.41***	0.34***
	Canada	0.30***	**-0.06**	0.37***	0.33***	0.29***	0.45***
	Euro area	0.20***	0.04	**-0.18*****	0.09	0.11**	0.13**
	Great Britain	0.20***	0.14**	0.31***	**-0.07**	0.28***	0.29***
	Sweden	0.30***	0.19***	0.43***	0.39***	**0.13****	0.37***
	United States	0.19***	0.10*	0.10*	0.15***	0.13**	**-0.03**

*** Significant at the 1% level (critical value at 0.15)
** Significant at the 5% level (critical value at 0.11)
* Significant at the 10% level (critical value at 0.09) using an asymptotic T-test with T=312

Source: Cette and Jong [2008]

12. Recent estimates of the inflation risk premium are in the 30-60 bps range.

Relatedly, we find that changes in monthly break-even rates (at the 1, 2, 5, 10, 20 and 30Y horizons, of the period 12/31/05 to 09/15/09) are more correlated with changes in prompt commodity prices than contemporaneous changes in CPI (or Industrial Production). We would expect break-even rates to be most correlated with changes in CPI, given the generally persistent nature of inflation. This anamolous result - the low correlation between break-even rates and realized inflation - does not hold for European inflation. Cicarelli and Garcia [2009] find that HCPI is the most important explanatory variable for Euro-area break-even rates, particularly at short-horizons, and that financial variables, which may be more linked to inflation risk premia, are more important for longer horizon break even rates.[13]

Figure 8: Correlation Between Break-Even Rates, Commodities, Inflation, and Industrial Production

Correlation 12/31/2005 - 09/15/2009

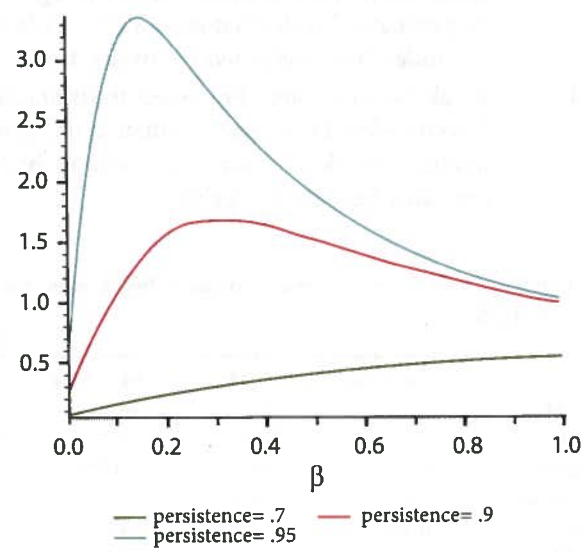
	1 Year Break-Even	2 Year Break-Even	5 Year Break-Even	10 Year Break-Even	20 Year Break-Even	30 Year Break-Even	S&P GSCI	Industrial Production	CPI
S&P GSCI	0.49	0.49	0.63	0.53	0.47	0.43	1.00	0.14	0.48
Industrial Production	-0.13	-0.16	-0.09	-0.06	0.01	-0.03	0.14	1.00	0.28
CPI	0.39	0.45	0.37	0.42	0.48	0.44	0.48	0.28	1.00

positive correlation at 5% level

Source: Author's calculations, Bloomberg

5) The expected returns to holding inflation-linked government bonds are typically insufficient to meet the required funding rates of pension and endowments. In principal, this could be addressed somewhat by holding inflation-linked derivatives as an overlay; however, current inflation-linked derivatives, such as swaps, now trade richer for countries like the US. Reflecting the relatively mild inflation environment, the returns to the BarCap US Government Inflation Linked TR Bond Index and the BarCap (Nominal) Bond Index have been virtually identical since the TIPS market: 54 bps/month for TIPS and 51 bps/month for nominal government bonds. The correlation between monthly returns on both has been .67. However,

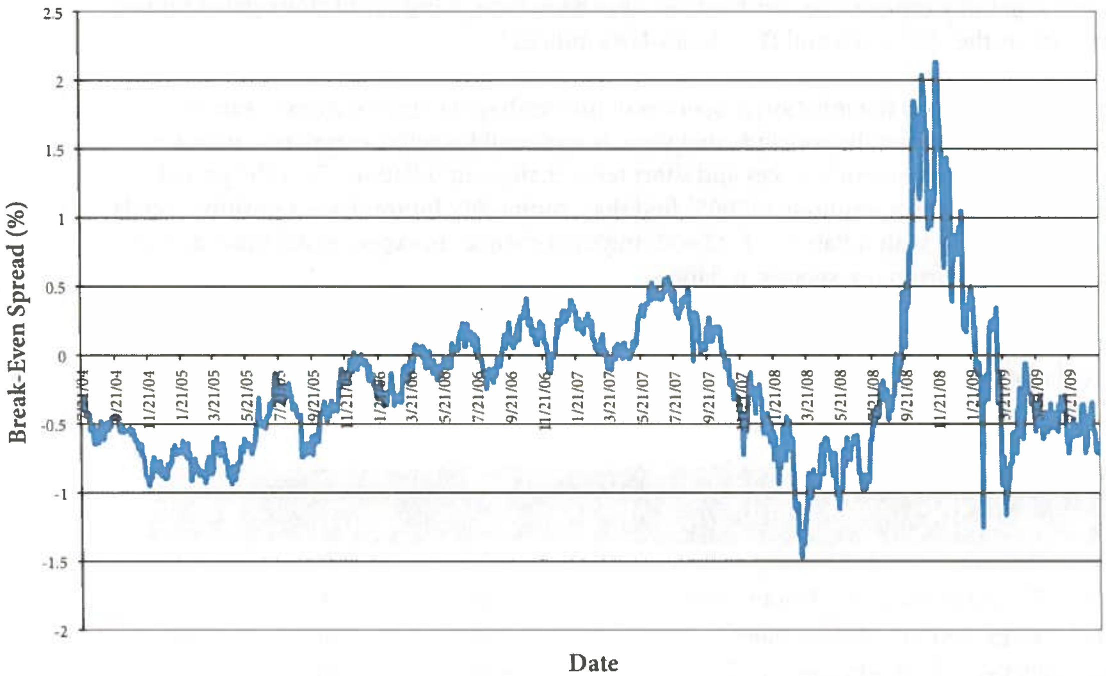
Figure 9: Inflation Hedge Ratio for TIPS



13. Commodity prices are not statistically significant in the Ciccarelli and Garcia [2009] statistical model, which is based on data prior to the boom in commodity prices, 1995-2006.

the annual volatility of the TIPS index has been substantially greater at 6.0% vs. 4.5% for nominal government bonds. Thus, unfortunately, at least for recent times, the higher volatility and comparable returns of TIPS relative to nominal government bonds, leave investors with insufficient justification for fully allocating inflation risk to TIPS.

Figure 10: 10 Year Swap Break-Even Less 10 Year Bond Break-Even



6) Using our hedging framework, and the assumptions that we might have $\beta > 0$, $\sigma_\varepsilon = 6\%$, and $\sigma_\eta = 2\%$, and $\phi = .2$, we see that TIPS can be used to hedge inflation risk, though they may not, because of their low overall returns, generate the least-cost hedge. Furthermore, based on regression of realized monthly inflation, the empirical value of β is closer to zero than 1 relative to the BarCap Inflation-Linked index; moving to quarterly data holding periods substantially increases the estimated value of β toward 1.

Thus, from the above, we can see that TIPS, or related inflation-linked derivatives, may provide institutional investors with a somewhat effective hedge to inflation-linked liabilities. However there are a number of reasons that inflation-linked bonds and derivatives do not offer a perfect hedge; nor do they offer an ideal return profile for a typical pension fund or endowment seeking to meet funding requirements.

Inflation and Commodities

Since the late 1970's, and in particular, as the result of the pioneering work of Greer [1979], institutional investors have considered commodities as a stand alone investment class. Investors have focused on the ability of commodities to offer low-Sharpe ratio but diversifying returns relative to stock and bond portfolios. See, for example, Froot [1995]. Additionally, they have considered the potential for commodities to offer returns that are positively correlated with inflation. The typical vehicles for gaining exposure to commodities have been though indices of short-dated futures contracts, such as the S&P GSCI and Dow Jones-UBS indices.[14]

The empirical evidence on the inflation properties of futures-based commodity exposure is relatively modest but does generally conclude that there is some mild positive correlation between short term changes in commodity prices and short term changes in inflation. Over the period 1959-2004, Gorton and Rouwenhourst [2005] find that commodity futures have a positive correlation with US CPI of .14 with inflation, of .22 with imputed changes in expected inflation, and .25 with imputed changes from unexpected inflation.

We can disaggregate these results by commodity and time period to determine if commodities as whole offer inflation protection.

Figure 11: Commodities and Inflation

Quarterly Correlations	03/31/91-12/31/08	03/31/91-12/31/04	12/31/04-12/31/08
Dow Jones - UBS Commodity Index Excess Return	0.58	0.24	0.76
Dow Jones - UBS Excess Aluminum Return Index	0.28	-0.10	0.52
Dow Jones - UBS Excess Cocoa Return Index	0.11	-0.01	0.29
Dow Jones - UBS Excess Coffee Return Index	0.00	-0.04	0.10
Dow Jones - UBS Excess Copper Return Index	0.41	-0.02	0.68
Dow Jones - UBS Excess Corn Return Index	0.17	0.13	0.22
Dow Jones - UBS Excess Cotton Return Index	0.11	-0.06	0.41
Dow Jones - UBS Excess Crude Return Index	0.55	0.30	0.82
Dow Jones - UBS Excess Gold Return Index	0.02	-0.03	0.07
Dow Jones - UBS Excess Heating Oil Return Index	0.61	0.27	0.88
Dow Jones - UBS Excess Lean Hog Return Index	0.19	0.16	0.32
Dow Jones - UBS Excess Live Cattle Return Index	0.27	0.19	0.39
Dow Jones - UBS Excess Natural Gas Return Index	0.32	0.11	0.55
Dow Jones - UBS Excess Nickel Return Index	0.09	-0.10	0.25
Dow Jones - UBS Excess Silver Return Index	0.08	0.00	0.17
Dow Jones - UBS Excess Soybean Oil Return Index	0.36	0.04	0.61
Dow Jones - UBS Excess Soybean Return Index	0.18	0.14	0.23
Dow Jones - UBS Excess Sugar Return Index	0.07	0.07	0.09
Dow Jones - UBS Excess Unleaded Gas Return Index	0.66	0.37	0.86
Dow Jones - UBS Excess Wheat Return Index	0.06	0.02	0.09
Dow Jones - UBS Excess Zinc Return Index	0.08	-0.07	0.16

Source: Author's calculations, Bloomberg

14. See Geman [2005] for a comprehensive overview of commodity markets and related financial instruments.

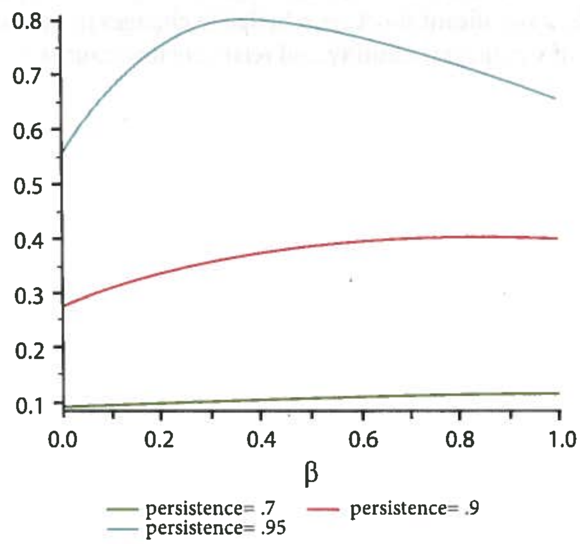
We can see from the results that the primary source of inflation protection associated with commodities comes from the energy complex, as one would expect given that CPI is overweight energy on the basis of volatility. We can also see that for the period 1991-2004, commodities were only mildly correlated with inflation but that during the period 2005-2008, commodities became highly correlated with inflation as global concerns intensified about the scarcity of commodity-based inputs due to the continuing industrialization and growth of emerging markets.

Kogan and Konstantinovsky [2008] examine the relationship between individual commodities and TIPS-implied break-even inflation rates and find roughly the same pattern. Changes in energy complex prices are correlated with changes in expected inflation; in general, the linkage between individual commodity prices and inflation has grown substantially more positive during the period 2005-2008.

However, what of the investor with long term liabilities? Do commodities retain their long run inflation hedging properties, especially given the fact that excess returns (over collateral, namely T-Bills) to most commodity indexes have averaged near zero for the period 1990–8/2009? Amenc *et al.* [2009], using quarterly data since 1973-2007, find that commodities (as proxied by the SP GSCI) retain their positive hedging properties at the short-horizon and at the long-horizon. Using monthly data for the period 1956–2008, Attie and Roache [2009] find that commodities (as proxied by the CRB) are good short-term hedges against inflation but that they lose their effectiveness at longer horizons. We draw attention to the fact that, because of the index construction methodology applied, the CRB tends to *underweight* the energy complex relative to other commodity indexes such as the SP GSCI.

It is worth noting explicitly that there is a substantial mismatch between the duration of commodity indexes, which focus on front month commodity prices and the longer term focus of institutional investors. Futures-based commodity exposure has the advantage of liquidity, but the disadvantage of limited intermediate cash-flows that may used to extend the total duration of a commodity-related asset's total package of cash-flows. Most commodities do have positive roll yields, which may be thought of as intermediate cash flows, reflecting the risk premium available for holding longer dated exposure; however, these roll yields are unstable and can be negative for extended periods of time (such as for Crude).

Figure 12: Inflation Hedge Ratio for Commodities



One approach to remedy this are so-called "commodity bonds" that pay coupons and principal in commodity units (e.g., barrels of oil or ounces of gold).[15] Historically, there have been such bonds for gold; in recent times, there has been an effort to revive this approach to include other commodities. The primary difficulty has been the absence of a sufficiently long-dated forward curve for the underlying commodities that could serve as a basis for hedging the issuance of these bonds. Producers of these commodities, however, may be in a better position to issue such bonds in a corporate framework.

Returning to our focus on hedging, we can estimate the range of inflation betas that are consistent with a positive allocation to commodities. In particular, we assume that the primary value of commodities, as is indicated by the empirical evidence, is their positive sensitivity to changes in unexpected inflation – perhaps because unexpected shocks to commodity prices are often responsible for changes in inflation. However, changes the overall price level are less robustly embedded in changes in commodity prices. Hence for the following parameters: $\beta > 0$, $\sigma_\varepsilon = 25\%$, and $\sigma_\eta = 2\%$, and $\phi = 5$ (from Attie and Roache [2009]), we see that long term hedge ratio associated with commodities is positive for any $\beta > 0$. Based on the above formula for the short term hedge ratio, the one-period minimum variance hedge ratio for commodities is .03.

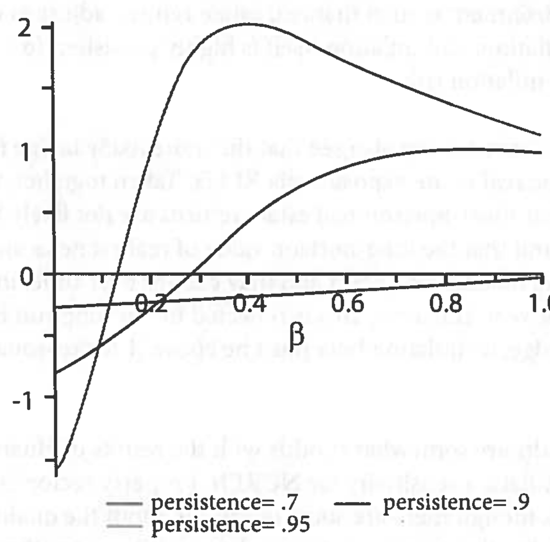
In addition to the contemporaneous relationship between commodities and inflation, there is also significant empirical evidence (see for example Bhar and Hamori [2008]) that commodity prices may actually be a leading indicator of realized inflation and hence, the stance of the central bank toward monetary policy. Investors may wish to design asset allocation strategies that take additional advantage of this predictability in conjunction with the relatively positive hedging properties of commodities.

Thus we see that futures-based exposure to commodities, particularly energy related commodities, may offer a significant short term hedge to changes in inflation. However, this hedge is available at the cost of significant volatility and relatively low returns.[16]

15. Richard Spurgin, of Commodity Investment Analytics, LLC has greatly contributed to our understanding of commodity bonds.
16. This suggests the benefits of "enhanced" index products, which can raise the overall level of return relative to risk for commodities, while maintaining the broad, inflation-risk reducing properties of a futures-based index.

Real Estate and Inflation

Figure 13: Inflation Hedge Ratio for Real Estate



Institutional investors have long looked to include real estate in their portfolio, either through direct investment in commercial holdings, or indirectly, through vehicles like REITS. While REITs have the advantage of liquidity, most empirical evidence (Hoesli *et al.* [2008] and the literature survey therein, Attie and Roache [2009]) suggests that their inflation related properties are very similar to that of common stocks: mildly negatively correlated with inflation.

The most thorough analysis of the inflation hedging properties of public and private real estate was conducted by Hoesli *et al.* [2008], based on quarterly data 1977-2003. They look at US and UK markets, using NCREIF and MIT transaction based indices for US private real estate, and Lasalle indices for UK private real estate. They present results for both Error-Correction Models,[17] which allow for long-term price levels to explain changes in short-term variables, as well as standard regressions of short-term changes in variables on short-term changes in variables. They find that unexpected inflation has negative effects on US REITS for short-run and long-run models. For NCREIF index returns, they find that the effect of unexpected inflation is negative for both short-run and long-run models but is only statistically significant for the long-run model. Expected inflation is not significant in the short run NCREIF model, but is positive in the long-run model. UK results show an insignificant relationship between unexpected inflation and UK REITS in the short-run but a positive relationship in the long-run; they also show statistically positive relationship between unexpected inflation and UK private real estate in both the short and long run.

One possible reason for the finding of insignificant exposure to inflation in US private markets is the fact that NCREIF indexes are appraisal based and subject to substantial smoothing that reduces correlations with macroeconomic variables that might affect actual valuation. Hoesli *et al.* [2008] look at MIT's *transaction-based* real estate index and re-estimate their model for the period 1985-2003. For this time period they find a statistically significant negative relationship between expected and unexpected inflation and MIT private real estate returns for both short-run and long-run models. Results for the same time period for NCREIF also show negative relationships between returns and unexpected and expected inflation. However, the MIT numbers also show a weak negative relationship with changes in real GDP, to which the (smoothed) NCREIF numbers show a mild positive relationship.

Reconciling the two sets of results for 1985-2003 and 1977-2003, we can hypothesize that during periods of sustained inflation, such as the late 1970's, real estate prices tended to be positively correlated with expected inflation, but that during normal times, real estate prices are likely to experience short-term negative effects from changes in the macro environment that are associated with increases in inflation.

17. See Engle and Granger [1987] for the theoretical foundations of ECM's; see Juselius [2007] for a textbook treatment.

We parameterize our hedging equation $\beta > 0$, $\sigma_\varepsilon = 10\%$, and $\sigma_\eta = 2\%$, and $\phi = -2.5$. We see that only if the environment is such that real estate returns adjust to incorporate significant changes in expected inflation, and inflation itself is highly persistent ($\alpha > .7$) will private real estate be a positive hedge for inflation risk.

From the above we can also see that the more likely hedge for inflation is private real estate rather than public real estate exposure via REITs. Taken together, the above results on private real estate suggest that short-horizon real estate returns are not likely to be a good hedge for short-horizon inflation and that the long-horizon value of real estate as an inflation hedge is a function of many parameters that are uncertain and may change over time, including, specifically, the beta of real estate relative to inflation. This is reflected in our long run hedge analysis – for real estate to be a good hedge, its inflation beta must be above .1 for reasonable assumptions on inflation persistence.

These results are somewhat at odds with the results of Huang and Hudson-Wilson [2007], who estimate inflation sensitivity for NCREIF Property sector indices of Apartments, Office, Retail and Industrial, though there are some questions about the quality of the index construction process.[18] They find that these property sectors have positive sensitivity to expected and unexpected inflation. Of particular interest is their analysis of inflation sensitivity in terms of income return and capital appreciation. They find that income return is largely uncorrelated with inflation and that capital return is positively associated with both expected and unexpected inflation. Le Moigne and Viveiros [2008] also investigate the sensitivity of private real estate returns to expected and unexpected inflation for the Canadian market. They find somewhat different results: income returns are negatively affected by changes in expected inflation; capital appreciation is positively affected.[19] At a minimum, this suggests that for markets that have significant institutional rigidities and peculiarities (e.g., monetary policy), there may be differential response to changes in expected or unexpected inflation.[20]

Timber and Inflation

Timber related assets have long held attraction for long-horizon investors seeking assets that might hold value against changes in inflation. Some of the key reasons that timber has been so attractive is that its inputs have relatively low cost and, therefore, sensitivity to inflation; its products are homogeneous and used through out the economy, and therefore unlikely to be exposed to substantial idiosyncratic price volatility; and the harvesting option is a "real option" that allows the owner to generate cash flows at the time of elevated demand; and lastly, it is a long duration asset, suitable for matching long duration liabilities. While there are many reasons why timber is thought to be a real, inflation-robust asset, there is surprisingly little published empirical work to investigate this reasoning.

Washburn and Binkley [1993] offer one of the few in-depth analyses of the relationship between forest assets and inflation. They analyze data based on historical "stumpage" prices rather than the

18. Our own econometric work, using a somewhat different methodology, generates results that are largely consistent with Huang and Hudson-Wilson [2007]. That said, our analysis suggests the presence of a unit root in the global as well as sector indices. This suggests that standard regression based inference (and inferential test statistics) using this data should be considered with caution.

19. They use quarterly data from 1973-2007. However they do not present all results, which makes it somewhat difficult to interpret all of the evidence presented.

20. We are also mindful of the fact that CPI measures residential real estate rental costs, rather than real estate costs directly; this, in addition to the weighting of residential over commercial real estate, may introduce some mismatch between returns on real estate, which include capital appreciation, and CPI.

entire package of timber revenues and other land valuation and revenues. Specifically, they focus on unexpected inflation for the period 1953-1987, the regression coefficient of which is denote γ^2; γ^1 denotes the coefficient for the S&P 500. From the results, we can see that Western and Southern timber assets are positively correlated with unexpected inflation. Maine forestry asset values are positively related to unexpected inflation, but not in a statistically significant manner. Washburn and Binkley [1993] also find that the beta of forestry assets relative to expected inflation is generally positive but rarely statistically significant.

Figure 14: Estimates of the Two-Factor Model for Real Rate of Return

Asset	γ^0	γ^1	γ^2	DW	R^2
Western National Forest Softwood Stumpage					
PNW, Westwide (1955-87)	-0.0107	0.4855*	4.8008*	1.9558	0.1667
	(0.0310)	(0.2424)	(2.2748)		
PNW, Eastside (1955-87)	-0.0467	1.0407*	6.0593*	1.8065	0.2658
	(0.0418)	(0.3270)	(3.0681)		
California (1955-87)	-0.0586	1.2881*	6.1248*	2.1431	0.2924
	(0.0477)	(0.3728)	(3.4983)		
Rocky Mountains (1960-87)	-0.0653	1.3724*	4.9232	2.0311	0.2708
	(0.0584)	(0.4617)	(4.2093)		
Louisiana Stumpage (1955-87)					
Southern Pine	-0.0197	0.3913*	5.8794*	1.9203	0.2516
	(0.0261)	(0.2044)	(1.9183)		
Ash	0.0104	0.3311*	3.9404*	1.8550	0.1549
	(0.0249)	(0.1948)	(1.8276)		
Gum	0.0018	0.1658	2.3010	1.6073	0.0860
	(0.0196)	(0.1531)	(1.4370)		
Oak	0.0044	0.2311	2.7673*	1.8118	0.1395
	(0.0186)	(0.1452)	(1.3623)		
Maine Stumpage (1959-87)					
Spruce	0.0040	-0.1385	0.5675	2.4156	0.0784
	(0.1840)	(0.1375)	(1.0242)		
Hemlock	-0.0123	-0.1462	0.4580	2.4804	0.0589
	(0.0211)	(0.1576)	(1.1742)		
Sugar Maple	0.0190	-0.3366	0.3704	2.2209	0.1275
	(0.0275)	(0.2059)	(1.5336)		
Yellow Birch	0.0182	-0.3716*	0.8421	3.1247	0.2529
	(0.2163)	(0.1618)	(1.2052)		
Financial Assets (1955-87)					
One-Month U.S. Treasury Bills	0.0087*	0.0375	-0.8382*	1.2084	0.4097
	(0.0036)	(0.0278)	(0.2609)		
Five-Year U.S. Bonds	0.0101	0.1379*	-2.1071*	1.7099	0.4255
	(0.0096)	(0.0754)	(0.7076)		
Twenty-Year U.S. Bonds	-0.0092	0.2392*	-2.8044*	1.6457	0.3720
	(0.0159)	(0.1241)	(1.1648)		
Corporate Bonds	-0.0059	0.2771*	-2.8207*	1.5448	0.4108
	(0.0157)	(0.1226)	(1.1502)		
Small Stocks	0.0434	0.9569*	-0.6041	0.8671	0.4881
	(0.0269)	(0.2104)	(1.9740)		

Note: Standard errors of the coefficient estimates are given in parentheses.
An asterisk (*) indicates that the coefficient estimate is different from zero at the 0.10 level of statistical confidence.
A tilde (~) indicates that the Durbin-Watson statistic is beyond the lower limit for significance at the 0.05 level.
Source: Washburn and Binkley [1993]

Using the parameters from estimates made by Washburn and Binkley for non-Maine assets: $\beta > 0$, $\sigma_\varepsilon = 10\%$, and $\sigma_\eta = 2\%$, and $\phi = 5$, we find that for all positive estimates of timber's beta versus inflation, that the hedge ratios, and hence portfolio demand, for timber for the long-horizon investor are positive.

Washburn, Anieri and Aranow [2005] conduct a similar analysis as Washburn and Binkley [1993]. However, they focus instead on the entire stream of returns to timber*land* assets. To that end, they use the NCREIF Timberland Property Index for returns for the period 1987-2004. They extend their data by using a rolling average of timber prices (John Hancock Timber Index) for the period 1960-1986; as such, the data is a mixture of timber-only returns and timber and land returns. The results are largely consistent with the results of Washburn and Binkley [1993].

Figure 15: Estimates of Sensitivity of Timber Asset to Inflation (Washburn *et al.* [2005])

	US	South	Pacific NW	Northeast
Sensitivity to Unexpected Inflation	1.96	1.18	3.01	1.45

Given the result (discussed above) that real estate has a negative beta to unexpected inflation, we are led to ask: do timberland assets or stumpage respond differently to unexpected changes in inflation? As an initial, indicative test of this, we estimate two separate models: one for NCREIF Timberland, and the other for Timber Mart South's Average Pine Sawtimber index for the same time period, 1987-2008. We find that that timberland is negatively affected by unexpected inflation; however, timber itself is *positively* correlated with unexpected inflation. Since the TMS index is available back until 1977, which includes a period of significant inflation, we also estimate the model for all available data. We find that including this period of significant inflation *increases* the estimated sensitivity (ϕ) of timber returns to inflation.

Figure 16: Inflation Hedge Ratio for Timber

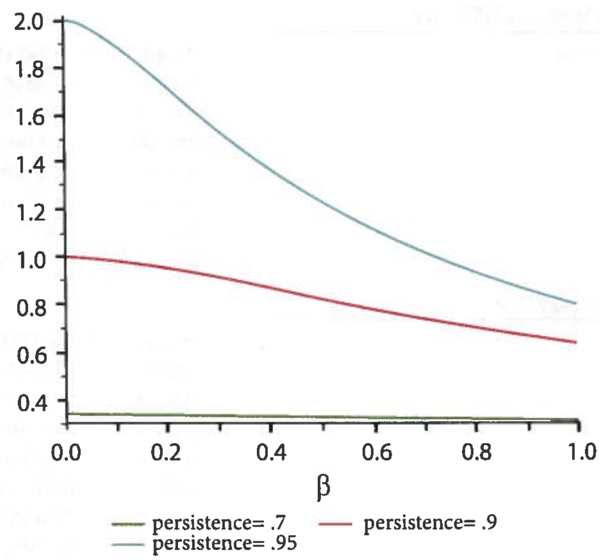


Figure 17

	NCREIF-TIMBER 1987 - 2008	TMS Average Pine Sawtimber 1987 - 2008	TMS Average Pine Sawtimber 1977 - 2009
Sensitivity to Unexpected Inflation	-0.45	0.97	1.34

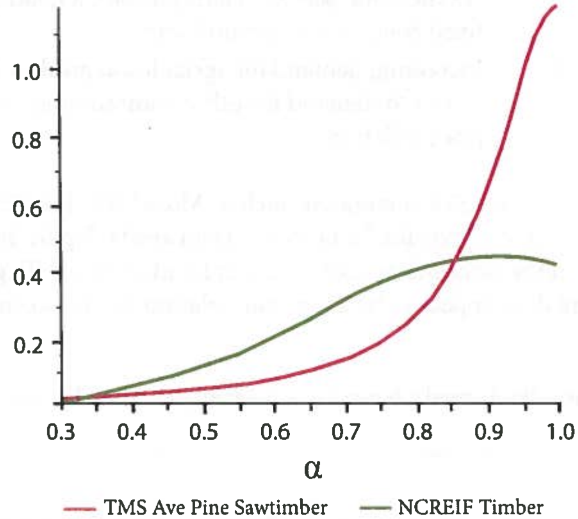
We can also ask, how sensitive are timber related assets to *expected* inflation? To which the results indicate that the timberland package is more sensitive (β) than the timber itself to changes in expected inflation.

Figure 18

	NCREIF-TIMBER 1987 - 2008	TMS Average Pine Sawtimber 1987 - 2008	TMS Average Pine Sawtimber 1977 - 2009
Sensitivity to Expected Inflation	2.37	0.85	0.32

Together, these results suggest that timberland assets may be a helpful hedge to predictable changes in inflation, but that timber itself is a better hedge against unexpected changes in inflation. In practice, the value of each sensitivity to an overall portfolio hedge will depend on the degree of persistence, α, in inflation. We can see this in the adjacent figure which compares hedge ratios of NCREIF Timberland Index and TMS Average Pine Sawtimber (based on parameters estimated 1987-2008). The figure suggests that for low levels of persistence in inflation ($.31 < \alpha < .86$), investors should allocate more to NCREIF Timberland; but for high levels of inflation persistence, one should allocate more to timber itself. [21]

Figure 19: Inflation Hedge Ratio for TMS Average Pine Sawtimber vs. NCREIF Timber



Farmland and Inflation

At approximately $2 trillion in market value, US farmland represents about 6% of the aggregate value of real estate (Francis and Ibbotson [2009]), and 51% of total land in the US (Forster [2006]). Institutional investors have had a long history of investing in farmland and related assets. NCREIF offers a Farmland index based on institutional investment in farmland, based on invested assets of $1.2 billion at the end of 2006 that are divided roughly equally into allocations into row crop (corn, wheat, etc.) assets (44%) and permanent crop (fruit, nuts, etc.) assets (56%).[22]

Academics and practitioners have long considered the positive correlation of farmland and associated assets with the overall price level to be an important benefit of investing in farm related assets—see for example Kaplan [1985], Rubens *et al.* [1988], Irwin *et al.* [1988]. While most research that brings up the relationship between the returns of farm related assets and inflation merely

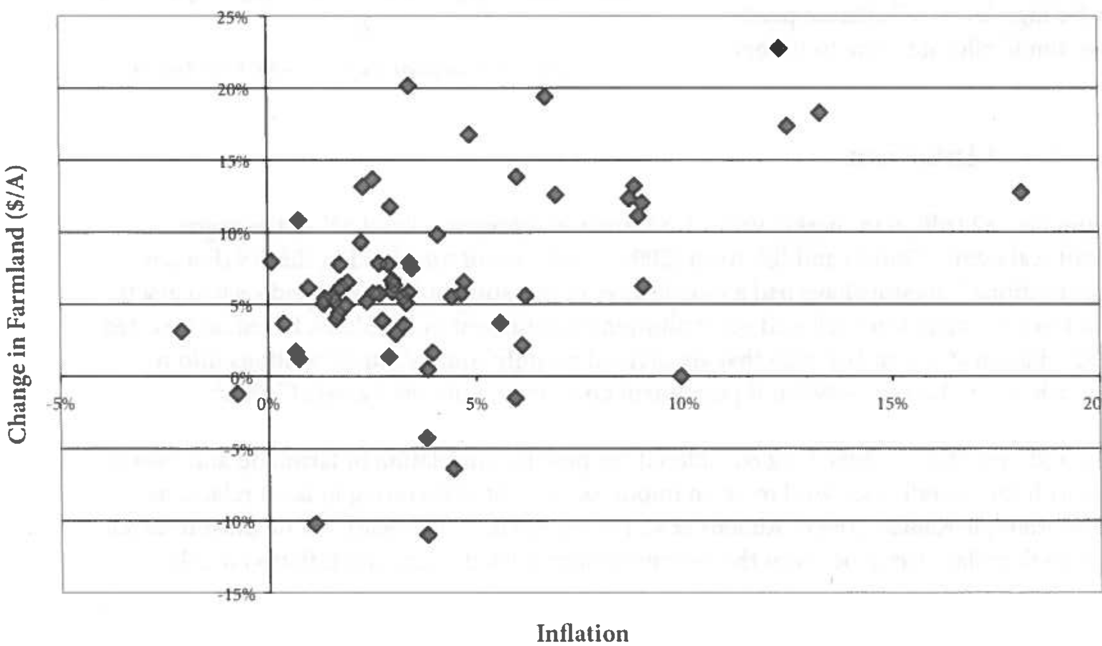
21. These results stand in contrast to less refined analyses of the inflation hedging properties of timberland assets. For example, Browning [2007] estimates the correlation between the NACREIF Timberland Index and CPI using rolling return periods. The use of such overlapping returns, especially for series that may contain artificial smoothing or a persistent return component (inflation expectations tend to change slowly), generates return series which are close to a random walk (or, in technical terms, possess a "unit root").* Computing correlations or regressions between series that are random walks tends to induce spurious and unstable correlations (Phillips [1986]).
22. Newell and Eves [2007]

notes that there has been a historically positive relationship between farm asset and inflation, the primary economic arguments[23] for this to be so include:

1) Farm land is a tangible and scarce asset, with a use value to produce tangible goods;
2) Land used for row crop production can be seeded according to highest yielding crops, and therefore can capture price appreciation in particular agricultural sectors (such as food crops or biodiesel crops);
3) The price of farm land, particularly in specific regions, reflects the option to convert farm land to other uses (such as residential or commercial real estate);
4) Farm land generates a significant amount of cash flow, which is typically not the subject of significant multi-year price contracts, which lowers the inflation risk (in the same way as, *ceteris paribus*, a floating rate note has lower duration than a fixed coupon instrument); and
5) Increasing demand for agricultural product from developing economies is broadly linked to demand for other commodities that collectively may contribute to US price inflation.

There is some empirical research, such as Moss [1997], which sets itself to the task of showing that inflation actually "explains" changes in farm assets. Figure 20 presents a scattergram of annual changes in the price per acre of US Farm Land against CPI, gives some initial indication that, in fact, there does appear to be a long run relationship between the two quantities.

Figure 20: Annual Changes in US Farmland Value Versus Inflation 1941 - 2008



Source: USDA, CRSP

23. We do not address academic arguments, such as that of Feldstein [1980], for the positive correlation between inflation and land prices. These arguments rely on highly stylized theoretical constructions—for example that land prices can be explained by the optimal actions of a single representative economic agent - which we do not believe to be robust.

More detailed research on the return properties of farmland assets requires consideration of available data. Readily available data on farmland returns can be divided into two types: data that covers land value only (USDA Farm Land Value series [1913-present]), or data that covers all major sources of income associated with farmland, including agricultural proceeds (NCREIF Farmland Index [1992-present]). The Farm Land Value series has the advantage that it includes data from all 48 continental US states, and covers a wide range of macroeconomic cycles; the NCREIF data has the virtues of economic completeness and represents estimates of returns to actual investments, but is based on a relatively small number of properties and is only available since 1992. Therefore, we provide estimates based on both.

We begin by estimating the inflation sensitivity of the value of Farm Land itself to inflation, for the long period 1941-2008. We estimate using two methods: 1) using the USDA Farm Land Value series for the US as a whole; and, in order to test the representativeness of that series,[24] and increase the statistical confidence of our estimates, we estimate the sensitivities 2) using pooled state by state information on Farm Land Value. The results are highly consistent, showing that farmland prices rise with both expected and unexpected changes in inflation.

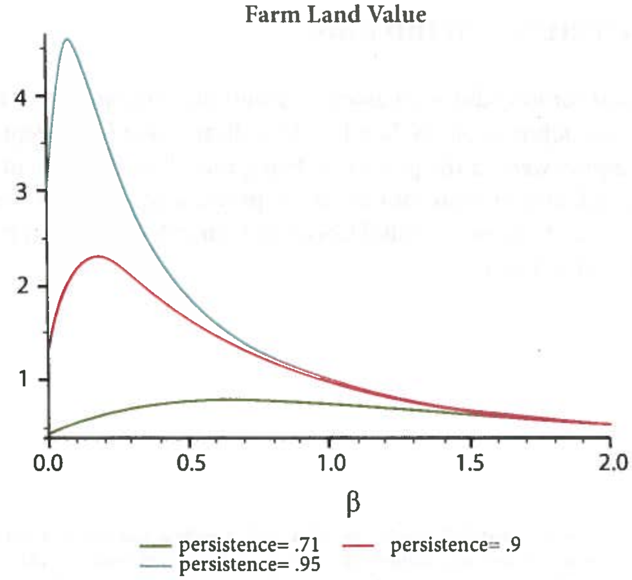
Figure 21: Sensitivity of Farm Land Value to Inflation (1941-2008)[25]

	Expected Inflation	Unexpected Inflation
US	1.42	0.66
Pval	0.00	0.01
Pooled State-Level Estimate	1.39	0.65
Pval	0.00	0.00

Estimates based on these annual series parameterize our hedge ratio equation as $\beta > 0$, $\sigma_\varepsilon = 6.3\%$, and $\sigma_\eta = 2.9\%$, and $\phi = .66$. For all values of $\beta > 0$ we have a positive hedge ratio for Farm Land values.

We can also take advantage of the availability of state-by-state data on farm land values to ask: 1) is there any systematic relationship between sensitivity of farmland values to expected inflation and sensitivity to unexpected inflation? 2) are there some states which have farm land with more preferable inflation properties? The answer to 1) is "no", as the

Figure 22: Inflation Hedge Ratio for Farm Land Value

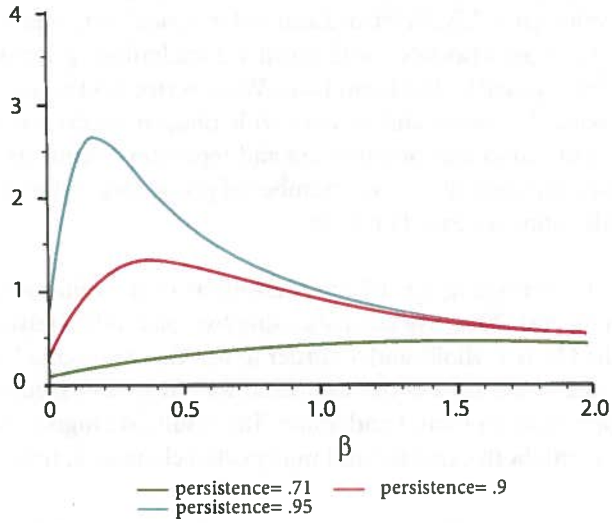


24. There is a meaningful amount of heterogeneity in state-by-state returns to farmland—a principal components analysis indicates that the largest common factor explains 55% of return variation across states.

25. Pooled estimates are based on 1941-2003, since USDA state level data for 2003-2004 appears to include erroneous observations. Other estimation results given below that use state level data also use this date range.

correlation between state level sensitivity to expected inflation is near zero with its sensitivity to unexpected inflation. As to 2), we identify those states with above median sensitivities to both unexpected and expected inflation, and find: AL, CA, IA, IL, IN, MN, MS, NE, NM, OK, UT, WA, WI, WV, and WY. Interestingly, we find no East Coast states in this list (except WV).

Figure 23: Inflation Hedge Ratio for Total Farm Returns



We next estimate the sensitivity of total farm returns from quarterly NCREIF data, available from 1992-2008. Because of the high level of persistence[26] in the NCREIF Farmland Index, which is likely in part due to the use of appraisal values, we estimate our sensitivities to expected and unexpected inflation allowing for ARMA errors. From this data, we have: $\beta > 0$, $\sigma_\varepsilon = 6.8\%$, and $\sigma_\eta = 1.8\%$, and $\phi = .32$, with our point estimate of $\beta = .62$ ($p = .20$). These results are weaker, but largely consistent[27] with results for our long-horizon, farmland-only series, especially given the relatively benign macroeconomic environment for the period 1985-2007, which is known as the "Great Moderation".[28]

Thus, based on general evidence, we find that farm land, and, to a lesser extent (due to limitations on data), farm land assets, offer institutional investors an investment asset with positive expected returns that may also function as a hedge against inflation risk.

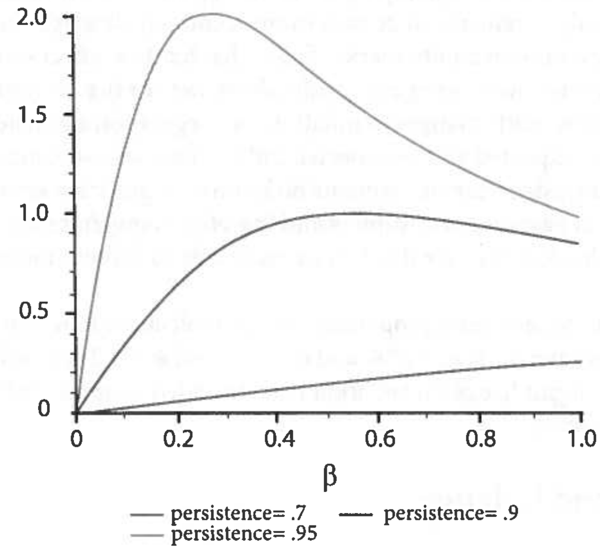
Infrastructure and Inflation

In the quest for long duration assets, institutional investors have investigated investments in large scale infrastructure projects. Jain [2008] indicates that funds representing more than $50B in investor equity were in the process of being raised for investment in projects like roads, pipelines, airports, and telecommunications. These projects typically involve some sort of regulated pricing due to natural monopoly, capital intensity, relatively stable cash flows due to relative inelasticity of demand, and so forth.

26. An Augmented Dickey Fuller test of the null hypothesis that there is a unit root in the data can not be rejected ($p = .53$).
27. In order to test the consistency between estimates derived from the USDA Farm Land Value index and the NCREIF Farmland index, we would reestimate the inflation sensitivities of the USDA index for the period, 1992-2008, for which the NCREIF index is available. However, since the USDA index is annual, this would leave only 16 observations upon which to base an estimate – far too few to have any reasonable level of confidence in the resulting estimates.
28. As we discuss in related research, since 1985, inflation has been relatively modest under the monetary policy regime that has become known as the "Great Moderation". While inflation in the pre-1985 period was relatively volatile, it contained significant predictable components that could be captured and exploited using forecasting models with more complex economic and econometric structure. However, during the period of the Great Moderation, inflation volatility has decreased substantially, with the predictable components of inflation becoming far less significant.

Very little empirical work has been done on the return properties of private infrastructure. What little work has been done is surveyed by Inderst [2009], Beeferman [2008] and Finkenzeller and Dechant [2009], and Newell and Peng [2008]. Claims about the relationship between inflation and infrastructure are primarily *ex ante* claims based on the assumed return properties of the underlying assets: i. ability to explicitly link cash flows to inflation; ii. pricing power associated with natural monopolies; and iii. low operating costs after initial construction leads to low input costs.

Figure 24: Inflation Hedge Ratio for Infrastructure



One approach is to understand the relationship between infrastructure investments and related investments, such as real estate or utilities. Newell and Peng [2008] suggest that the bulk of exposure available globally is associated with utilities. For the US, using listed companies for the period 2000-2006, data indicate that infrastructure is largely uncorrelated with real estate (.23 for REITs, .28 for NCREIF Property) and more correlated with Utilities (.44 for UBS listed Utilities (US)). By comparison, Australia has perhaps the most well developed market for listed infrastructure that can serve as a basis for understanding the return properties if infrastructure. Finkenzeller and Dechant [2009] estimate the coefficient of correlation between listed infrastructure (UBS Australia Infrastructure Index) and listed utilities (UBS Australia Utilities Index) at .39 for the period 1998-2008. Armann and Weisdorf [2008] go a step further, examining the correlation between growth rates in earnings for infrastructure-related companies (rather than returns on equity) and CPI.[29] They find that changes in infrastructure cashflows are positively correlated, at .35, with changes in CPI.[30]

Figure 25: Correlation Coefficients with Annual US Infrastructure Cashflows, 1986 - 2005

CPI	**0.35**
Real Estate Net Operating Income	**0.32**
Equity Corporate Profits	**-0.08**
TIPS	**0.18**

Source: Arman and Weisdorf [2008]/JPMorgan Asset Management

29. According to Armann and Weisdorf [2008], proxies for infrastructure assets used in the cashflow analysis include regulated utilities; concessions associated with toll roads, bridges, airports and seaports; power generating assets under long-term, private contracts.

30. Weisdorf [2009] also reports correlations between cashflow growth between infrastructure sub-sectors (electric utilities, gas utilities, airports, seaports and water/sewer) for US and for European assets. The resulting correlations are largely statistically insignificant (especially if one accounts for the "multiple testing problem" where repeated observation of random variables makes it more likely to observe some or more apparently significant results just by pure chance), and generally inconsistent across geographies. For example, correlation between US Airports and Toll Roads is .42; for the same type of assets based in Europe, the correlation is -.08.

Lacking a long history of actual returns to infrastructure (listed or private), we can compare this with the inflation hedging properties of *hedged* US utility industry returns. It is important to focus on the hedged returns, since they more accurately describe the specific returns to utilities away from the common equity market factor that tends to effect stand alone equity returns even at the industry level. Reviewing our results above, we see that *hedged* US utility returns are essentially uncorrelated with changes in inflation; our regression estimate of the sensitivity of hedged utility returns to expected and unexpected inflation are also statistically insignificant. To the extent that private infrastructure investments do not have significant energy related input costs (which are difficult to pass on to consumers and therefore dampen returns to utilities especially due to energy related shocks), they are likely to be more able to capture increased revenues than utilities.

Based on these general properties, we can look at the long run inflation on hedging properties of infrastructure: $\beta > 0$, $\sigma_\varepsilon = 10\%$, and $\sigma_\eta = 2\%$, and $\phi = 0$. The results suggest that infrastructure can be a significant hedge for inflation risk, provided ongoing cash flows are at least partially linked to the price level.

Gold and Inflation

Conventional wisdom holds that gold, as a store of value, is a hedge to dollar price inflation. However, the empirical evidence that gold is in fact a good inflation hedge is at best mixed, and usually mildly negative. Blose [2010] surveys eleven recent articles on the relationship between gold prices and expected inflation, finding that three of those articles unambiguously conclude that the answer is yes; four conclude that the evidence is mixed, and four conclude that the answer is no. In his own study, Blose [2010] finds that there is no statistical relationship between gold prices and unexpected changes in the CPI. Kogan and Konstantinovsky [2008] find little correlation between gold prices and changes in break-even inflation rates.[31] This suggests that, in the long run, gold can best be viewed as diversifier.

Intellectual Property and Inflation

Investor focus on real assets has focused on "tangible" assets, or claims on such tangible assets, that are likely to preserve value in the face of changes in the overall level of prices. However, a significant portion of GDP is now made up by so called "intangible" assets, such as intellectual property. Like tangible assets, these assets are important ingredients in the products of goods. See for example, Nakamura [2009], Corrado, Hulten, and Sichel [2006], Blair and Waldmann [2003], Lev [2001], Hand and Lev [2003].

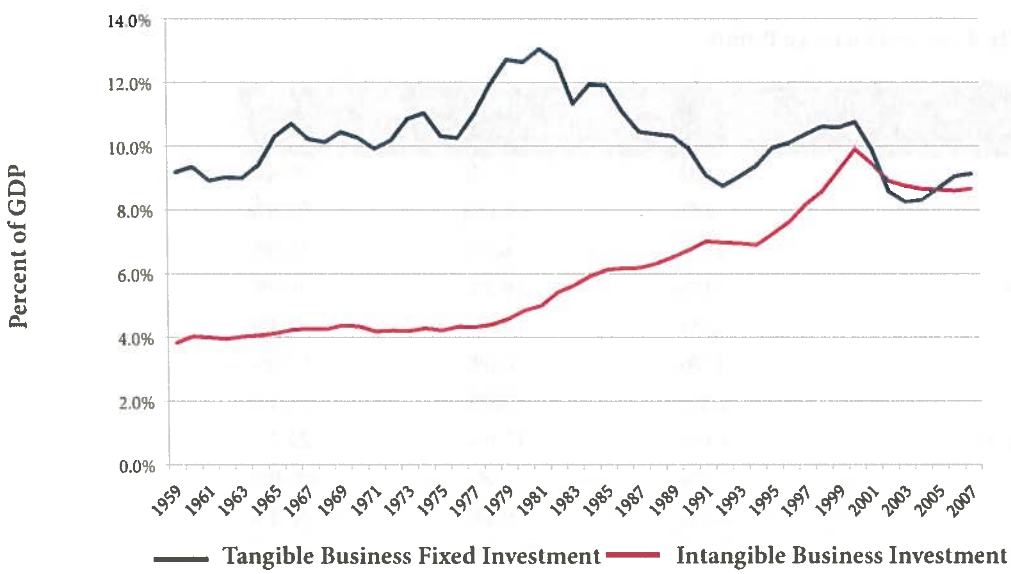
Intangible assets have historically been bundled with other corporate assets and available for investment through traditional means. However, in recent years, there has been an increased interest in unbundling and isolating intangible assets, – intellectual property, in particular – for standalone investment purposes. Examples of such assets include patent portfolios, film copyrights,

31. Many investors may be dismayed to learn that there is little empirical evidence to support investment in gold as a hedge for inflation. In general, the case for gold as a hedge for inflation has been based on recounting of anecdotal evidence, perhaps revolving around periods of hyperinflation. However, the actual empirical evidence associated with advanced, stable economies like that of the United States does not provide support for gold as a specific inflationary hedge.

music or other media, and brands. For an extensive discussion of the opportunities and strategies associated with unbundled intellectual property, see Wood Creek's white paper: "Intellectual Property Asset Management: Capitalizing on Innovation" [2008].

Much of this unbundled intellectual property is unbundled in a form that allows the owner to collect regular cash flows from licensing or other means of revenue generation. It is estimated that annual IP licensing revenues are on the order of 500 billion dollars.[32] Empirical evidence suggests that many of these forms of intellectual property are attached to economic sectors that have experienced high rates of innovation, which may (in the case of the medical sector) or may not (in the cases of the technology and chemical sectors) be attached with significant rates of price inflation, prior to quality adjustment. A further symptom of the lack of understanding of the economic role of intangibles is the fact that economists are still struggling to provide proper growth accounting for intangibles in the economy. We can say that the evidence (Nakamura [2009]) does suggest that there is substantial capital accumulation due to intangibles; this in itself suggests that there is a key investment opportunity.[33] While there are substantial issues in its measurement, estimates, for example, of the private, pre-tax returns to R&D are in the 20-30% range; inclusion of the spillover effects elevate estimated the rate of return significantly.[34] The National Science Foundation estimates that total corporate R&D in 2007 was 242 billion, with 70% of R&D being conducted by the manufacturing sector. Pharmaceuticals and Computers and Electronic products each represent about 21% of total R&D expenditure.[35]

Figure 26: Tangible/Intangible Business Investment as a Percentage of US GDP



Source: Nakamura [2009]

32. See Wood Creek [2008].
33. There are whole schools of economic thought (for example, "New Growth Theory") which emphasize the central role of intangibles in economic growth. See Cameron [1998] for a survey.
34. See CBO [2005]. It is worth noting that a divergence in the private returns and social returns to R&D suggests an investment opportunity in capturing some of the social returns to R&D. This can be done, for example, through increasing the enforcement and concomitant licensing of intellectual property rights for assets with broad applicability.
35. Correspondingly, the ratio of R&D to sales for all surveyed firms was 3.5%, with Pharmaceuticals and Computers and Electronic products at 12.7% and 8.4%, respectively. Broad survey information on corporate R&D is published by the National Science Foundation's Survey of Industrial Research and Development.

There does not appear to be significant empirical work on the actual direct investment properties of unbundled intellectual property, though there is a well developed economic research literature on patents and R&D.[36] Parr [2007] does offer substantial evidence on economic terms associated with intellectual property transactions in a wide range of industries, and provides further support for the general claim that such intellectual property transactions typically are structured in a manner that explicitly links them to user cash flows, such as sales. Goldscheider *et al.* [2007] offer suggestive evidence of the relationship between IP royalty rates and long run industry profitability (Figure 27).[37] Gu and Lev [2004] find that there are strong linkages between reported royalty income and shareholder value, and that the amount of royalty income is a signal of "quality" of firm R&D expenditures.

Figure 27: Royalty Rates and Licensee Profits

Industry	Median Royalty Rate	Average Operating Profits	Royalty Rate as a % of Profit Rate
Automotive	5.0%	6.3%	79.4%
Chemicals	3.0%	11.6%	25.9%
Computers	2.8%	8.0%	35.0%
Consumer Goods	5.0%	16.2%	30.9%
Electronics	4.5%	8.8%	51.1%
Energy	3.5%	6.6%	53.0%
Food	2.3%	7.9%	29.1%
Healthcare Products	4.0%	17.8%	22.5%
Internet	5.0%	1.0%	500.0%
Machines/Tools	3.4%	9.4%	36.2%
Media and Entertainment	9.0%	-304.0%	-3.0%
Pharma and Biotech	4.5%	24.5%	18.4%
Semiconductors	2.5%	29.3%	8.5%
Software	7.5%	33.2%	22.6%
Telecom	5.0%	14.1%	35.5%
Total	**4.3%**	**15.9%**	**27.0%**

Note: Licensee Profit Rates based on 1990-2000; License rates established 1980-2000
Source: Goldscheider *et al.* [2007]

36. For example, CBO [2005] survey results on the significant private and social returns to corporate R&D spending; Lev *et al.* [2006] find that the returns to "R&D leaders" (defined as greater than average R&D to sales for firms in a given industry) are superior—greater in magnitude and lower in volatility—than "R&D Followers". Hall *et al.* [2005] study the valuation of corporate patents; Bessen [2008, 2009] estimates the value of patents by owner and patent characteristics; Arora *et al.* (2008) and Chen and Chang [2010] examine the interaction between patent value and R&D; Goodwin and Ahmed [2006] document the increasing importance of intangible assets relative to earnings in the market valuation of firms; Fazzari *et al.* [2009] find that corporate R&D spending is sensitive to available sources of corporate finance (retained earnings, debt and equity) and the attendant frictions, which are more acute for smaller firms, younger firms—which, along with the evidence presented in Hall and Lerner [2009], suggests that intellectually property in production by smaller firms may offer a richer source of returns to the strategic investor; Barlevy [2007] and Raferty and Funk [2008] find that R&D spending is pro-cyclical. For a perspective on European intangible assets, see Sandner [2009].
37. Royalty rates themselves, however, are typically contractually linked to sales, not profits.

An alternate approach to access returns to IP is through litigation-based strategies that pursue infringement cases. Parr [2007] presents evidence that royalty rates that are *court-awarded* are typically much more favorable to the licensor, with median royalty rates of 10% in such circumstances (versus a median of 4.3% in non-court agreements).[38]

In order to investigate the possible role of intangible assets as inflation risk reducers, we can make the very imperfect start of looking at the *hedged returns* to technology stocks, which contain substantial intellectual property. From the above analysis, we can see that hedged technology stock returns have correlations near zero (-.10 – 0.03) with quarterly changes in the price level.[39] A regression of quarterly hedged returns to high technology stocks on expected and unexpected inflation results in an R-squared of .01, further indicating that there is no material statistical relationship between the hedged technology stock returns and inflation. This suggests that unbundled intellectual property is likely to be a diversifier to inflation risk and may possibly have some direct, positive inflation hedging properties, especially to the extent that royalty income is linked directly to corporate cash flow. However, the empirical data that we have do not allow us to draw any significant conclusions about long run inflation related properties of intellectual property at this time.[40]

38. See Lanjouw and Lerner [1998] for a survey of the empirical research literature on the enforcement of intellectual property rights.

39. The correlation between *hedged* equity returns of another IP-intensive industry—pharmaceuticals—and inflation for the period 1946-2008 is also near zero and therefore not statistically significant. We also estimated the inflation sensitivity of returns to portfolios of firms sorted annually on book value to market value, using Fama – French data for 1946-2008, inspired by the idea that, as a stylized fact, R&D intensive firms tend to have lower book to market. The results indicate that the equity returns of firms with lower book to market have greater adverse sensitivity to unexpected inflation than those with higher book to market.

40. While there is some research on the long term trends in the market valuation of R&D—for example, in the 1980's R&D was substantially undervalued relative to the 1990's - there does not appear to be any existing research which directly links market valuation of R&D of individual firms directly to changes in the macro economic environment, including the state of the business cycle or inflation. The author is currently conducting research in this area, the results of which should give investors insight into broad market forces that function as a backdrop to the valuation of unbundled intellectual property.

Conclusions

Wood Creek is a premier solution provider for investors seeking exposure to traditional and new real assets.[41] These assets are consistent with investment mandates that seek to diversify institutional portfolios away from assets that are highly correlated with traditional financial instruments, and, in many instances, offer return streams that may be positively correlated with inflation. As part of its investment evaluation and portfolio construction processes, Wood Creek considers how candidate assets may or may not deliver inflation-related returns. Research presented here demonstrates both the analytical complexity in evaluating inflation-related properties of assets, as well as an analytical framework that can be used as part of an assessment of those properties.

In the present paper, we have touched upon the properties of a wide variety of traditional and new asset types that have been advanced as real assets. Our key focus has been on both the short-term and long-term relationship between asset returns and expected and unexpected inflation. To understand the relationship between assets and inflation-related quantities we have also investigated some of the dynamics of the real economy that are associated with inflation that may have direct impact on the value of assets. We have proposed a modeling framework that allows us to understand the viability of an asset class or a specific sector therein as an inflation hedge. We reviewed these ideas as well as summarized the results of research on other traditional and new real asset classes (Figure 1). Of those other real asset classes, we found for many that the long-horizon inflation hedging properties were asset specific (e.g., equities versus hedged energy sector equities) or somewhat uncertain given the newness of the asset class, such as intellectual property, yet we found that many of these asset classes or subsectors within those asset classes could offer reduction in – or diversification of – inflation risk.

We emphasize that many of these real assets have substantial intermediate streams of cash flow, which may or may not be correlated with the level of prices, and that understanding the relationship between those cash flows and inflation substantially affects the effectiveness of the asset as a hedge for inflation-linked liabilities or other inflation risk.

Investors investigating the inclusion of real assets in their portfolio would do well to consider the great heterogeneity in the inflation hedging properties of each asset class under consideration, the wide range in inflation-related properties of assets within an asset class, the risk and return properties of each asset class, and the extent to which these returns are diversifiable relative to other portfolio holdings. In making these considerations, Wood Creek Capital Management can assist investors through their investment process from research and idea development to implementation and portfolio management.

George A. Martin
Senior Advisor*
Wood Creek Capital Management, LLC
gmartin@woodcreekcap.com

*George Martin is also Associate Director, CISDM at University of Massachusetts at Amherst. The opinions expressed herein are attributable to the author and Wood Creek Capital Management, LLC as of February, 2010 and not to the University of Massachusetts at Amherst.

41. As a firm, we do not directly focus on investment strategies involving listed equities or bonds.

Bibliography

Amenc, N., L. Martellini, and V. Ziemann. "Inflation-Hedging Properties of Real Assets and Implications for Asset-Liability Management Decisions," 2009.

Armann, V., and M. Weisdorf. "Hedging Inflation with Infrastructure Assets." In *Inflation Risks and Products: The Complete Guide*, ed. B. Benaben, and S. Goldenberg, pp. 111-126. London: Risk Books, 2008.

Arora, A., M. Ceccagnoli, and W. Cohen. "R&D and the Patent Premium." *International Journal of Industrial Organization*, Vol. 26, Issue 5 (2008), pp. 1153-1179.

Attie, A., and S. Roache. "Inflation Hedging for Long-Term Investors," 2009.

Barlevy, G. "On the Cyclicality of Research and Development." *American Economic Review*, Vol. 97, Issue 4 (2007), pp. 1131-1164.

Beeferman, L. "Pension Fund Investment in Infrastructure: A Resource Paper." *Occasional Paper Series*, No. 3 (2008), pp. 1-78.

Bessen, J. "Estimates of Patent Rents from Firm Market Value." *Research Policy*, Vol. 38, Issue 10 (2009), pp. 1604-1616.

Bessen, J. "The Value of U.S. Patents by Owner and Patent Characteristics." *Research Policy*, Vol. 37, Issue 5 (2008), pp. 932-45.

Bhar, R., and S. Hamori. "Information Content of Commodity Futures Prices for Monetary Policy." *Economic Modelling*, Vol. 25, Issue 2 (2008), pp. 274-283.

Blair, M., and S. Wallman. *Unseen Wealth: Report of the Brookings Task Force on Intangibles*. Washington, D.C.: Brookings Institution Press, 2001.

Blose, L. "Gold Prices, Cost of Carry, and Expected Inflation." *Journal of Economics and Business*, Vol. 62, Issue 1 (2010), pp. 35-47.

Bodie, Z. "Common Stocks as a Hedge Against Inflation." *Journal of Finance*, Vol. 31, Issue 2 (1976), pp. 459-470.

Boudoukh, J., and M. Richardson. "Stock Returns and Inflation: A Long-Horizon Perspective." *American Economic Review*, Vol. 83, Issue 5 (1993), pp. 1346-1355.

Browning, A. "Timberland Investments: Does the Return Fall Far from the Tree?" 2007.

Cameron, G. "Innovation and Growth: A Survey of the Empirical Evidence," 1998.

Cette, G., and M. de Jong. "The Rocky Ride of Break-even-inflation Rates." *Economics Bulletin*, Vol. 5, No. 30 (2008), pp. 1-8.

Ciccarelli, M., and J. Garcia. "What Drives Euro Area Break-Even Inflation Rates?" 2009.

Congressional Budget Office. "Background Paper: R&D and Productivity Growth," 2005.

Corrado, C., C. Hulten, and D. Sichel. "Intangible Capital and Economic Growth," 2006.

DiGabriele, J.A. "The Sarbanes-Oxley Act and the private company discount: An empirical investigation." *Critical Perspectives on Accounting*, Vol. 19, Issue 8 (2008), pp. 1105-1121.

Du, D. "Monetary Policy, Stock Returns and Inflation." *Journal of Economics and Business*, Vol. 58, Issue 1 (2006), pp. 36-54.

Ehrmann, M., and M. Fratzscher. "Taking Stock: Monetary Policy Transmission to Equity Markets." *Journal of Money, Credit & Banking*, Vol. 36, Part 4 (2004), pp. 719-737.

Ely, D., and K. Robinson. "Are Stocks a Hedge Against Inflation? International Evidence Using a Long-Run Approach." *Journal of International Money and Finance*, Vol. 16, Issue 1 (1997), pp. 141-167.

Engle, R., and C. Granger. "Co-integration and Error Correction: Representation, Estimation, and Testing." *Econometrica*, Vol. 55, Issue 2 (1987), pp. 251-276.

Fama, E. "Stock Returns, Real Activity, Inflation, and Money." *American Economic Review*, Vol. 71, No. 4 (1981), pp. 545-565.

Fazzari, S., J. Brown, and B. Petersen. "Financing Innovation and Growth: Cash Flows, External Equity, and the 1990s R&D Boom." *Journal of Finance*, Vol. 64, Issue 1 (2009), pp. 151-185.

Feldstein, M. "Inflation, Portfolio Choice, and the Prices of Land and Corporate Stock." *American Journal of Agricultural Economics*, Vol. 62, No. 5 (1980), pp. 910-916.

Finkenzeller, K., and T. Dechant. "Global Infrastructure - A New Dimension of Real Estate: An Asset Allocation Analysis," 2009.

Forster, D. "An Overview of U.S. Farm Real Estate Markets," 2006.

Francis, J., and R. Ibbotson. "Contrasting Real Estate with Comparable Investments." Journal of Portfolio Management, Vol. 36, No. 1 (2009), pp. 141-155.

Froot, K. "Hedging Portfolios with Real Assets." *Journal of Portfolio Management*, Vol. 21, No. 4 (1995), pp. 60-77.

Geman, H. *Commodities and Commodity Derivatives: Modeling and Pricing for Agriculturals, Metals and Energy*. Chichester, England: John Wiley & Sons, 2005.

Geske, R., and R. Roll. "The Fiscal and Monetary Linkage Between Stock Returns and Inflation." *The Journal of Finance*, Vol. 38, No. 1 (1983), pp. 1-33.

Goodwin, J., and K. Ahmed. "Longitudinal Value Relevance of Earnings and Intangible Assets: Evidence from Australian Firms." *Journal of International Accounting, Auditing and Taxation*, Vol. 15, Issue 1 (2006), pp. 72-91.

Gorton, G., and K. Rouwenhorst. "Facts and Fantasies About Commodity Futures. *Financial Analysts Journal*, Vol. 62, No. 2 (2006), pp. 47-68.

Greer, R. "Conservative Commodities: A Key Inflation Hedge." *Journal of Portfolio Management*, Vol. 4, No. 4 (1978), pp. 26-29.

Gu, F., and B. Lev. "The Information Content of Royalty Income." *Accounting Horizons*, Vol.18, No. 1 (2004), pp. 1-12.

Hall, B., and J. Lerner. "The Financing of R&D and Innovation," 2009.

Hall, B., A. Jaffe, and M. Trajtenberg. "Market Value and Patent Citations." *RAND Journal of Economics*, Vol. 36, No. 1 (2005), pp. 16-38.

Hall, B., J. Mairesse, and P. Mohnen. "Measuring the Returns to R&D," December 2009.

Hand, J., and B. Lev, eds. *Intangible Assets: Values, Measures, and Risks*. Oxford: Oxford University Press, 2003.

Hoesli, M., C. Lizieri, and B. MacGregor. "The Inflation Hedging Characteristics of US and UK Investments: A Multi-Factor Error Correction Approach." *Journal of Real Estate Finance and Economics*, Vol. 36, No. 2 (2008), pp. 183-206.

Huang, H., and S. Hudson-Wilson. "Private Commercial Real Estate Equity Returns and Inflation." *Journal of Portfolio Management*, Vol. 33, No. 5 (2007), pp. 63-73.

Inderst, G. "Pension Fund Investment in Infrastructure," 2009.

Irwin, S., D. Forster, and B. Sherrick. "Returns to Farm Real Estate Revisited." *American Journal of Agricultural Economics*, Vol. 70, No. 3 (1988), pp. 580-587.

Jain, S. "Investing in Developed Country Private Infrastructure Funds." Citi Alternative Investments, 2008.

Juselius, K. *The Cointegrated VAR Model: Econometric Methodology and Macroeconomic Applications*. Oxford: Oxford University Press, 2006.

Kaplan, H. "Farmland as a Portfolio Investment." *Journal of Portfolio Management*, Vol. 11, No. 2 (1985), pp. 73-78.

Kaul, G. "Stock Returns and Inflation: The Role of the Monetary Sector." *Journal of Financial Economics*, Vol. 18, Issue 2 (1987), pp. 253-276.

Koeplin, J., A. Sarin, and A. Shapiro. "The Private Company Discount." *Journal of Applied Corporate Finance*, Vol. 12, Issue 4 (2000), pp. 94-101.

Kogan, L., and V. Konstantinovsky. "Commodity Futures and Inflation." Lehman Brothers, 2008.

Lanjouw, J., and J. Lerner. "The Enforcement of Intellectual Property Rights: A Survey of the Empirical Literature." *Annales d'Economie et de Statistique*, Issue 49/50 (1998), pp. 223-246.

Le Moigne, C., and E. Viveiros. "Private Real Estate as an Inflation Hedge: An Updated Look with a Global Perspective." *Journal of Real Estate Portfolio Management*, Vol. 14, Issue 4 (2008), pp. 263-285.

Lev, B. *Intangibles: Management, Measurement, and Reporting.* Washington, D.C.: Brookings Institution Press, 2001.

Moss, C. "Returns, Interest Rates, and Inflation: How They Explain Changes in Farmland Values." *American Journal of Agricultural Economics*, Vol. 79, No. 4 (1997), pp. 1311- 1318.

Nakamura, L. "Intangible Assets and National Income Accounting: Measuring a Scientific Revolution," 2009.

Newell G., and H. Peng. "The Role of U.S. Infrastructure in Investment Portfolios." *Journal of Real Estate Management*, Vol. 14, No. 1 (2008), pp. 21-33.

Newell, G., and C. Eves. "The Role of U.S. Farmland in Real Estate Portfolios." *Journal of Real Estate Portfolio Management*, Vol. 13, No. 4 (2007), pp. 317-328.

Parr, R. *Royalty Rates for Licensing Intellectual Property.* Hoboken, NJ: John Wiley & Sons, 2007.

Phillips, P. "Understanding Spurious Regressions in Econometrics." *Journal of Econometrics*, Vol. 33 (1986), pp. 311-340.

Pilotte, E. "Capital Gains, Dividend Yields, and Expected Inflation." *Journal of Finance*, Vol. 58, No. 1 (2003), pp. 447-466.

Rafferty, M., and M. Funk. "Asymmetric Effects of The Business Cycle On Firm-Financed R&D." *Economics of Innovation and New Technology*, Vol. 17, Issue 5 (2008), pp. 497-510.

Sandner, P. *The Valuation of Intangible Assets: An Exploration of Patent and Trademark Portfolios.* Wiesbaden, Germany: Gabler, 2009.

Schotman, P., and M. Schweitzer. “Horizon Sensitivity of the Inflation Hedge of Stocks.” *Journal of Empirical Finance*, Vol. 7, Issues 3-4 (2000), pp. 301-315.

Sharpe, S. “Reexamining Stock Valuation and Inflation: The Implications Of Analysts’ Earnings Forecasts.” *The Review of Economics and Statistics*, Vol. 84, Issue 4 (2002), pp. 632-648.

Shiller, R. “Why Do People Dislike Inflation?” In *Reducing Inflation: Motivation and Strategy*, ed. C. Romer, and D. Romer, pp. 13-70. Chicago: University of Chicago Press, 1997.

Wang, P., and Y. Wen. “Inflation Dynamics: A Cross-Country Investigation.” *Journal of Monetary Economics*, Vol. 54, Issue 7 (2007), pp. 2004-2031.

Washburn, C., and C. Binkley. “Do Forest Assets Hedge Inflation?” *Land Economics*, Vol. 69, No. 3 (1993), pp. 215-224.

Washburn, C., P. D’Anieri, and M. E. Aronow. “What Do Public Markets Tell Us About Timberland Property Values?” *Hancock Timberland Investor*, Third Quarter 2004.

Webb, J., and J. Rubens. “The Effect of Alternative Return Measures on Restricted Mixed-Asset Portfolios.” *Real Estate Economics*, Vol. 16, Issue 2 (1988), pp. 123-137.

Weisdorf, M. “Infrastructure Investing in Today’s Market.” Presented to the Montreal CFA Society, April 1, 2009.

Wood Creek Capital Management. “Intellectual Property Asset Management: Capitalizing on Innovation,” 2008.

+ve

3×1 $\quad 2 \times 12$

1×12

−ve

1×12

2×12

$\underline{\underline{1}}$

+ve

$\frac{2 \times 12}{36}$ $\quad 0.666$

$\frac{0.333}{1 \times 12}$

$\frac{1 \times 12}{36}$

−ve

$\frac{1 \times 12}{36}$ $\quad 0.333$

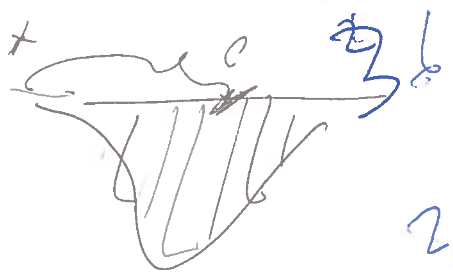
$\frac{2 \times 12}{36}$ $\quad 2 \quad 12$

$1 \quad 12$

12 $\quad$ 12

$\frac{3 \times 5 + 1 \times 12}{36}$

$\frac{36 \times 1}{36}$



$\frac{2}{3}$

$\frac{1}{3}$