Simple, Dynamic Multi-Asset Inflation Protection

The "Four-Real" Model

By Enduring Investments LLC

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ENDURING INVESTMENTS

Contents

Purpose of Analysis:

Enduring Investments has developed a strategy involving four assets with plausible connections to inflation and a set of simple, intuitive allocation rules to guide portfolio construction.

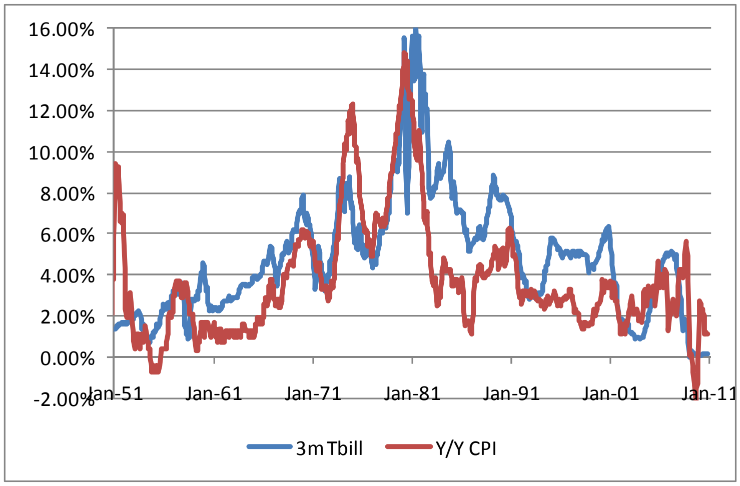
Initial results appear promising. The purpose of this white paper is to:

1. Summarize the *a priori* reasoning behind the strategy construction.
2. Perform analysis on the basic strategy using a longer and richer historical data set.
3. Examine questions of parameterization of the strategy (that is, can the strategy be optimized beyond the simple decision rules initially proposed?).
4. Propose an implementation strategy.

1. Rationale for the Four-Real Dynamic Switching Strategy

The purpose of considering other assets than those explicitly inflation-indexed is to try and achieve a higher after-inflation rate of return while continuing to realize some of the defensive benefits of improved inflation sensitivity. We identified four assets that are related either directly or indirectly to inflation:

a. **3-month Treasury Bills**. Where central bankers employ a Taylor-Rule-like approach, it is plausible to argue that short rates ought to track inflation fairly explicitly (although rising faster than inflation when policymakers seek to restrain inflation and falling faster than inflation when policymakers seek to goose growth). Historical evidence supports this notion. Over the last 60 years, the correlation between the level of T-bill yields and the year/year inflation is 0.70 (see Chart at right).



b. **Inflation-Linked Bonds**. Clearly, bonds that are *explicitly* linked to inflation have the strongest connection to inflation. As a hedge against price inflation between purchase and the bond's maturity, the performance is nearly perfect. As the time between the target horizon and the maturity of the bond lengthens the tracking error grows larger, because inflation-indexed bond short-term mark-to-market volatility is almost entirely due to changes in real interest rates. Many countries issue Inflation-Linked Bonds (ILBs); the strategy as initially proposed utilizes a quantitatively-driven active allocation process between various global ILB markets (a process Enduring Investments developed and which is believed to add alpha to an ILB portfolio), but for the longer historical test a pure TIPS allocation was used instead.

c. **Commodity Indices.** Inflation is properly defined as the progressive diminishing of the purchasing power of a currency. We observe this declining purchasing power when it manifests in higher prices; that is, a dollar buys less than it did before. Because commodities represent standard and fixed quantities and qualities of a particular good, they are good measuring sticks against which the value of fiat money can be measured. However, almost axiomatically the owner of hard commodities is locking in a zero real return. This can be seen by observing that if one starts with a pile of copper tubing, in three years it will still be a pile of copper tubing. It will neither have grown nor shrunk;

in terms of copper tubing this investor's return will be precisely zero. Depending on what the value of copper tubing has done relative to other commodities, the real return in the sense of taking the nominal value of the copper tubing and subtracting inflation may be more or less than zero, but in general the owner of a physical commodity can expect over time only an approximately zero real return. However, this is not true with commodity indices; commodity indices generally are correlated with both expected and unexpected inflation and also offer a positive real return as the result of the collateral return, the risk premium incorporated into commodity futures, the rebalancing return, the convenience yield, and expectational variance.[1] The strategy as initially designed incorporated the SummerHaven Dynamic Commodity Total Return Index, but for the longer study the CRB Index and the Goldman Sachs Commodity Index were used.

d. **Equity Indices –** Equities represent ownership in a firm that participates in the growth of the economy. In principle, as long as the private sector stays generally the same proportion of the economy, ownership of a broadly diversified portfolio of stocks ought to produce a total return related to the real growth of the economy (and hence, naturally inflation-linked). In practice, price/earnings multiples vary with inflation. At low and steady levels of inflation, P/E multiples tend to be at a maximum; when the economy is experiencing deflation or higher levels of inflation, P/E multiples tend to be lower. Consequently, except for the very long-term holder of equities the inflation-hedging properties are difficult to realize with a buy-and-hold strategy.[2] However, in the long run real equity performance is indeed related to real economic growth, so if the pricing-error problem can be mitigated tactically this asset class deserves to be included.

Very coarsely, we can think about the properties of these four asset classes along two dimensions. The first dimension is the natural volatility of the asset class. T-Bills and Inflation-Linked Bonds are relatively low-risk (**very** low risk if the investment horizon matches the maturity of the ILBs) while Commodities and Stocks are comparatively higher risk. The second dimension is how attractive these assets tend to be in high yield environments and in low yield environments. In general, buying bonds and stocks when yields are high tends to be more promising than buying them when yields are low, so ILBs and Stocks are "high yield environment" assets while T-Bills and Commodities are more attractive in low yield environments. Commodities fit well in the low-yields bucket

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[1] For more information on sources of commodity index risks and returns in the context of inflation-linked investing, see "History of Commodities as the Original Real Return Asset Class" by Michael Ashton and Bob Greer, in Inflation Risks and Products, Ch. 4 (2008).

[2] John Y. Campbell and Tuomo Vuolteenaho of Harvard, in a paper called "Inflation Illusion and Stock Prices" demonstrate a very high correlation between stock market mispricing and the level of inflation. According to the authors, "…the level of inflation explains almost 80% of the time-series variation in stock-market mispricing."

because commodities in and of themselves do not pay a yield. Therefore, when yields are low, commodities become relatively more-attractive (and some research suggests they perform better in these environments).

So, crudely, we have divided these four assets into four buckets according to their relative riskiness and the yield environment in which their prospective returns are most attractive:

T-Bills:	Low risk; low-yield environment preferred
ILBs:	Low risk; high-yield environment preferred
Commodities:	Higher risk; low-yield environment preferred
Equities:	Higher risk; high-yield environment preferred

In developing the rules for allocating between these four assets in each of these four buckets, we would like to avoid large swings in the overall riskiness of the portfolio. If we occasionally allocate entirely to T-Bills and then at other times entirely to Equities, the risk characteristics of the strategy will be very unstable. This would make the strategy problematic to implement in a risk-budgeting framework.

Accordingly, for the main strategic tilt we focus on the high-yield versus low-yield environments. If this were the only tilt, then there would always be roughly the same amount of risky and non-risky assets in the portfolio. For example, suppose the initial allocations were 25% for each asset class. If the "**yield tilt**" caused us to increase the weight of the high-yield assets by 40%, then the ILB allocation and the Equity allocation would each rise from 25% to 35% while the T-Bill and Commodities allocations would each fall to 15%. But there would still be 50% in "higher risk assets": 35% in Equities and 15% in Commodities. Because of the way we have chosen these assets, the "yield tilt" will tend to have a small impact on the portfolio's overall riskiness.

Yield Tilt

The tilt between "high yield" and "low yield" buckets is established on the basis of market real rates. This is accomplished by means of a simple table:

Real Yields	Tilt to "high yields" bucket
<-1%	0%
-1%-0%	0%
0%-1%	15%
1%-2%	30%
2%-3%	50%
3%-4%	70%
4-8%	85%
>8%[3]	100%

[3] This has never happened in the data, nor have negative real yields at the 10y point.

Example: as of February 28, 2011, 10y LIBOR was 3.54% and the 10y CPI Swap was 2.72%. The difference of 0.82% represents 10-year "constant maturity" real yields that are very low; according to the table, the tilt to the "high yields" bucket (ILBs and Equities) would be 15% and therefore 85% would be allocated to the "low yields" (T-Bills and Commodities) bucket.

Note that we use U.S. real yields even though the ILB market is global in scope, and in the original analysis represented in fact a global ILB allocation rather than being specific to TIPS. The reason is that our clients are predominantly U.S. based; more importantly, real yields among developed countries globally are in fact reasonably well-correlated.

Once the tilt between high yield and low yield buckets has been determined, we tilt again on the basis of the relative value between the two assets within each bucket.

Relative Value Tilt

For the relative value tilt, we focus on the two assets in the high yield bucket: ILBs and Stocks. We choose one simple screen for each of these assets. Obviously, much more-elaborate relative value work can be performed but this has two drawbacks. First, it may not be easy historically to examine the performance of a complex relative value scoring system. A related problem is that the more complex the system, the more likely it is that the relationships are not stationary and so the strategy may not be robust across many different types of markets. (We will examine the question of this strategy's robustness later.)

For example, to score the relative attractiveness of Equities we look at only one number: the latest year-on-year change in the Consumer Price Index (CPI). As alluded to previously and as discussed in the literature, equities tend to be priced at high multiples when inflation is low and stable, and lower multiples if either higher inflation or deflation occurs. The following data is derived from Shiller's long-term equity market data.

CPI Range		**Since 1881**	
Low	**High**	**Avg CPI**	**Avg P/E[4]**
less than	-2.00%	-5.73%	14.10
-2.00%	0.00%	-0.68%	16.47
0.00%	1.00%	0.74%	18.02
1.00%	2.00%	1.47%	19.97
2.00%	4.00%	3.03%	17.95
4.00%	6.00%	4.91%	17.29
6.00%	8.00%	6.62%	14.41
8.00%	10.00%	9.07%	10.12
10.00%	higher	14.94%	10.12

[4] The P/E is the 10y Cyclically-Adjusted P/E, or CAPE, also known as the "Shiller P/E."

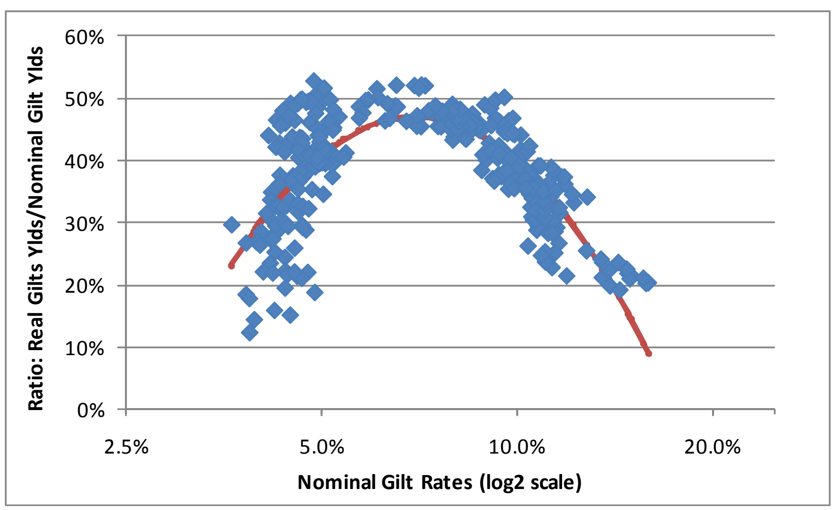
If CPI is low and stable, stocks are likely to be richly valued and thus we want to de-emphasize them. If CPI is high or very low, then valuations are likely to be lower and we're more likely to want to own them. We encode this observation into a simple, even naïve table, which appears below.

CPI	S&P RV[5]
<-2%	1
-2%-0%	0.8
0%-1%	0.6
1%-2%	0.2
2%-4%	0.4
4%-6%	0.5
6%-8%	0.75
>8%	1

As of February 28th, year/year CPI is 1.6%, so the S&P RV score would be 0.2. In isolation, this doesn't mean that we will totally de-emphasize Equities, however; we need to determine how the other asset in the high yield bucket, ILBs, performs on its relative value test.

To determine the relative value of inflation-linked bonds, we must first recognize that real yields do not behave just like nominal yields. Very high nominal yields tend to be caused by rising inflation expectations, which do not affect TIPS (since the inflation compensation is added to the bonds, the real return is not affected by changes in inflation). Real yields track the cost of money, which is related to the growth rate of the economy.

In the United States we do not have a lengthy history of yields in the inflation-linked bond market, but the UK has a history back to the early 1980s. When we look at the relationship between real yields and nominal yields, we find quite an interesting relationship. The chart at right illustrates that relationship, which was first demonstrated by Enduring Investments.



[5] Higher is better.

The cyclical model simply observes that when nominal rates are very low, it tends to be because growth is very low and so real yields are low…but inflation expectations tend to be sticky at some level and so real yields become an ever-smaller proportion of nominal yields. At "normal" growth around 2-3% and "normal" inflation around 2-3%, nominal yields tend to be around 4-6% and in this range real yields are about half of the nominal yield. Higher nominal yields are caused by unhinged inflation expectations while real growth expectations have a natural ceiling around 4%; therefore the ratio declines at high nominal yields.

This observation allows us to compare current real yields with modeled real yields and to determine objectively if inflation-linked bonds (ILBs) are *probably* rich (too low a ratio) or cheap (too high a ratio). The table below represents the "TIPS Relative Value" scoring system. The "Cyclical Residual" is the difference between the relationship modeled according to the prior chart and the current *actual* ratio of real yields to nominal yields.

Cyclical Residual (higher is cheaper)	**TIPS RV (higher is cheaper)**
<-15%	0
-15%- -7.5%	0.111111
-7.5%- -4%	0.222222
-4%- -2%	0.333333
-2%- 0%	0.444444
0%-3%	0.555556
3%-6%	0.666667
6%-9%	0.777778
9%-12%	0.888889
>12%	1

Historically, TIPS have often been cheap as an asset class because they have been underowned. As of February 28th, the residual was only 2.1%, implying an "RV score" for TIPS of 0.556.

Remember that we are trying to decide how to weight our S&P position relative to our TIPS position within the "high yields" bucket. So we now compare the relative value scores; the tilt towards TIPS is simply:

$$TIPStilt = \frac{TIPSrv}{(TIPSrv + S\&Prv)}$$

So within the "high yields" bucket right now, the allocation would work out to be:

$$TIPStilt = \frac{0.556}{(0.556 + 0.2)} = 73.5\%,$$

Implying in turn that within the bucket the S&P allocation will be 100%-73.5%=26.5%:

Because we want to preserve as much as possible the aggregate risk of the whole portfolio, and to keep the rules as spare as possible, the "low yields" bucket is tilted the other way so that *within the "low yields" bucket* the allocations are reversed between the risky and less-risky assets. That is, to balance the 26.5% allocation to S&P (the "higher risk" asset in the "high yields" bucket), 26.5% in the "low yields" bucket will be allocated to T-Bills. Similarly, to balance the 73.5% allocation to the lower-risk TIPS in the "high yields" bucket, the higher-risk Commodities will be weighted 73.5% in the "low yields" bucket.

Summarizing the model as of the end-of-February:

Yield Tilt: High yields bucket: 15%; Low yields bucket 85%.

RelVal Tilt: TIPS: 73.5%, S&P 26.5% within the high-yields bucket

Commodities: 73.5%, T-Bills 26.5% within the low-yields bucket.

Therefore:

Asset	Yield Tilt	x	RelVal Tilt	=	Allocation
TIPS	15%	x	73.5%	=	11.03%
S&P	15%	x	26.5%	=	3.97%
Commodities	85%	x	73.5%	=	62.5%
T-Bills	85%	x	26.5%	=	22.5%

We put one further constraint on the portfolio, and that is that the T-Bill allocation cannot exceed 33%.

2. Performance of the Strategy:

Initial Results on Available Data

With this simple approach, it's remarkable how this strategy fares through several different market types over the last decade. Note that there is no leverage inherent in this strategy. The following data represent performance starting December 31, 2000 and ending December 31, 2010. Returns are presented gross of fees in all cases:

	Max Weight	Min Weight	Avg Weight	Index Return	Index Std Dev	Sharpe
TIPS[1]	58%	10%	29.1%	6.97%	6.51%	0.76
Commod[2]	71%	21%	42.6%	5.78%	24.24%	0.14
TBills[3]	33%	5%	17.0%	2.44%	0.56%	n/a
S&P[4]	20%	3%	11.3%	1.41%	16.30%	-0.07
Four-Real			**100.0%**	**8.08%**	**11.86%**	**0.50**

[1]TIPS returns calculated from the Barclays TIPS 5-10y Total Return Index.

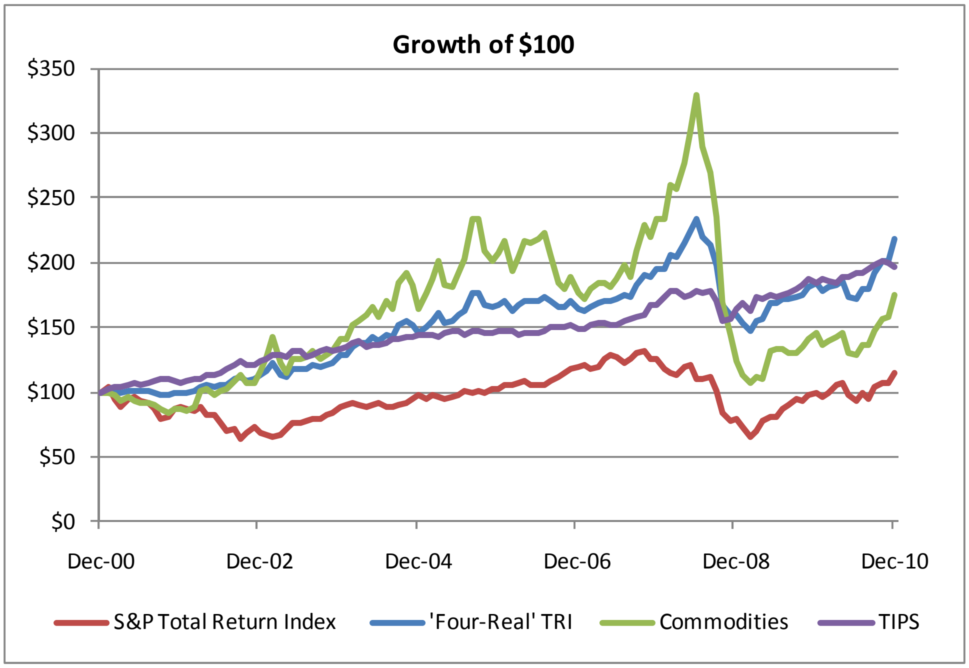
[2]Commodities series is spliced from the CRB Total Return Index from Dec-00 to Jan-02; the SP-GSCI Total Return Index from Feb-02 to Dec-09; and the Summerhaven Dynamic Commodity Total Return Index from Jan-10 to Dec-10.

[3]TBills: Ryan Labs 3m Tbill Total Return Index

[4]S&P Total Return Index with dividends reinvested

The annual returns have been relatively steady as well:

	Return	Std Dev		Return	Std Dev
2001	-0.9%	5.1%	**2006**	-2.3%	8.9%
2002	14.1%	6.7%	**2007**	18.8%	6.4%
2003	13.5%	12.6%	**2008**	-17.9%	21.2%
2004	13.3%	11.2%	**2009**	15.1%	12.0%
2005	15.4%	12.4%	**2010**	18.3%	13.9%



The chart shows total return indices ex-TBills, standardized to 12/31/2000=100. Four-Real has performed well although when everything went down in 2008, it did as well. Note that this incarnation of Four-Real utilizes a passive TIPS index and a broad, naïve commodity index. On both counts, there are superior investments available with similar risk characteristics but better return possibilities. These will be discussed later, in the section on optimization, but for the period Dec-00 to Dec-10, it would have produced Four-Real compounded annual gross returns of 12.90% (higher than in the simple case) with 9.98% volatility (lower than in the simple case). However, since these alternatives were not available for the full period from 1956-2010 that we wanted to study, for ease of comparison we chose the indices that had more history.

Sourcing Data for an Extended Backtest

Upon viewing the preliminary results, we were interested in examining how the strategy performed under much more grueling conditions. By extending the back-test to include the 1960s, 1970s, 1980s, and 1990s, the model's performance can be dissected against a much richer set of economic environments.

However, this is not a trivial task. TIPS only began to be issued in 1997, and there were no real bonds of any kind prior to the early 1980s issuance of UK linkers. Some commodity index histories have been backfilled by their calculation agents, but the suite of available commodity markets in 1970 was very different from the collection available today. Even equity index series are different; the S&P Total Return Index with dividends reinvested has been calculated since 1970, but prior to that we had to construct a synthetic total return index.

Treasury Bills

The Treasury Bill Total Return Index was the easiest to construct and required few assumptions. From January 1989 to December 2010 we used the Ryan Labs 3m Tbill Total Return Index, but had to create the series from 1959-1989. We began with a series of secondary 3-month Treasury bill rates extracted from the Federal Reserves H.15 report.[6] Because we needed monthly granularity, however, and using a 3-month TBill rate would upwardly bias the series, we subtracted 5bps from the entire series since on average, the 1m-3m TBill curve is worth about 5bps.[7] The total return series then simply represents the monthly rolling of our putative 1m TBill rates.

S&P Total Returns

As mentioned above, from Dec-69 to Dec-10 the S&P Total Return Index with dividends reinvested is available from Standard & Poors. A pure price index is available prior to

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[6] This series, as well as several of the other series, was sourced from Economagic at http://www.economagic.com.

[7] There is no basis market for 1m bills vs 3m bills, but the 1m LIBOR vs 3m LIBOR basis market quoted at Tullett Prebon (PREB<GO> on Bloomberg) is 2.75-4.75bps for 10 years and 1.25-3.75bps for 30 years so 5bps is probably slightly conservative.

that. Conveniently, Professor Robert J. Shiller has constructed a monthly series of rolling 12-month dividends for the S&P back to 1871.[8] From that, we constructed an approximate monthly total return by taking 1/12th of the index's then-current dividend yield for each month and adding it to the monthly percentage price change. We then compounded these in series and spliced the end of the series to the official S&P series beginning in 1970.

Commodities

Commodity price series have been kept for a very long time, and kept in average "index" form for a long time as well. However, the concept of an *investible* commodity futures index was only first defined by Robert Greer in 1978.[9] In a commodity futures index, Treasury Bills serve as collateral for a collection of commodities futures contracts selected according to some set of rules. Consequently, in addition to the price return of the contracts in the index, a return from the collateral is earned.

Of the investible commodity futures indices currently in use, the one with the longest backfilled history is the S&P Goldman Sachs Commodity Index (SP-GSCI), which begins in Dec-1969. The Reuters/Jefferies-CRB Total Return Index begins in 1982, but more importantly the price series begins in 1956. Fortunately, because we already had a series of 1-month T-Bill rates, it was possible to extend the CRB Total Return Index further by simulating the investment of collateral at the T-Bill rate and then adding in the index return.

All commodity indices, however, are unique and have very different properties as a result of the markets they choose to invest in, the weighting scheme for those commodities, and the rules for rolling the contracts as they come into the delivery month. Consequently, the CRB index has a very different behavior from the SP-GSCI. Our preferred commodity index, the Summerhaven Dynamic Commodity Index, is even more quirky because the commodities it invests in can change each month based on the degree of backwardation or contango in each market as well as momentum characteristics of different markets. As an example, the CRB TRI from 1982 to 2002 had a compounded annual return of 2.46%, while the SP-GSCI TRI had a compounded annual return of 7.58%. These are very different indices.

Accordingly, when we spliced the various indices together for our long test, we did it in several alternative ways so that we could be sure it wasn't the choice of index that was

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[8] This data is available at http://www.irrationalexuberance.com.

[9] Greer, R. J., 1978 "Conservative Commodities: A Key Inflation Hedge", *Journal of Portfolio Management*, Summer, pp. 60–77.

driving returns. In what we call the "slow" commodities total return index, we used the CRB from Dec-1959 to Jan-2002, the SP-GSCI from Feb-2002 to Dec-2009, and the Summerhaven for only 2010. For our "fast" commodities index, we used the CRB only from Dec 1959 to Dec-1969, then the GSCI from Jan-1970 to Dec-1990, then the Summerhaven index from Jan-1991 to Dec-2010. The difference was stark, as the table below illustrates.

1960-2010	"Slow" Index	"Fast" Index
Compounded Return	7.72%	13.65%
Standard Deviation	14.44%	15.03%

Six percent, compounded over fifty years, is a truly enormous difference. While we believe the "Fast" index returns could actually have been earned over that period by following the index rules, we used the "Slow" index for our long testing.[10]

Inflation-Linked Bonds

Most challenging was creating a series not just of real yields, but of the total return of a hypothetical index of bonds that paid a real yield. With commodities, we were able to create a modern-type index from a primitive price index, but for inflation-linked bonds there is simply no equivalent market prior to the early 1980s. Accordingly, any series must be *simulated*.

Of course, there is a very long history of *nominal* interest rates. Historically, researchers have used models of inflation expectations to back into *a priori* real rates. For example, a naïve extrapolation model, in which $\pi_{expected}=\pi_{t-1}$ (that is, inflation next year is expected to be the same as last year's inflation), can be combined with nominal interest rates to

[10] Actually, the fast index may be *more* investible than the slow index, which was mostly the CRB. The construction of the CRB involves geometric averaging of the component commodities, of which there were anywhere from 17 to 28 depending on the revision. This approach means that the index was continually rebalanced (rather than rebalanced monthly like other indices), which is obviously quite difficult to effect in practice. Also, the averaging implied equal weights to each commodity, so that Frozen Concentrated Orange Juice carried an equal weight to Crude Oil. Since Crude is a much larger market than FCOJ, it implies that the indexed investor in the CRB would have a much higher than market weight in the OJ and a much lower-than-market weight in oil. If the size of the account dedicated to the strategy was very large, the process of investing in the smaller commodities would have been very limiting.

produce a hypothetical real return series (if we assume the risk premium is constant) using the Fisher equation $(1+n)=(1+r)*(1+\pi)*(1+\rho)$. This approach, or some slightly more-sophisticated version of it, was typically used in the late 1970s and 1980s, especially by scholars such as Eugene Fama and other proponents of the rational expectations hypothesis. Unfortunately, once real bonds began to actually trade it became apparent that this description of how inflation expectations are formed bears little resemblance to actual time series of inflation expectations derived from the market, so series of hypothesized real yields based on this assumption bear little resemblance to reality.

We considered deriving our own hypothetical series using the "yield arch" model illustrated on p. 8 of this paper; this approach, however, fails for us because we would be beginning with an assumption that our model was successful, and then testing our model on the basis of that assumption. This wouldn't be particularly enlightening.

However, an article written in 2000 (which means it had the advantage of being able to compare its method with actual market realities) by professors at MIT and the University of Rochester derived an inflation-indexed bond return series based on fairly sophisticated models of one, two, and three-year inflation expectations.[11] Their modeled series behaved very similarly to actual time series of real bonds. We contacted the authors and were able to purchase their modeled monthly time series of annual year-on-year real and nominal returns for 5-year inflation-indexed bonds dating to mid-1953.

What we actually needed, however, was a time series of *real yields* (for the yield tilt filter) and a total return series for the inflation-indexed bond nominal returns. Because the series was of overlapping annual returns, we were forced to back into these series by making some assumptions.

First, we observed that the annual total return would consist of (a) the real coupon plus (b) a return due to the change in real yields (multiplied by the duration of the hypothetical bond) plus (c) the year-on-year change in prices. The latter series is easy to obtain, so by subtracting out trailing annual inflation we had a series of returns due to (a) plus (b).

The problem starts to look circular but is in fact merely recursive. The coupon of the bond is related to the real yield that we want to derive (specifically, the return due to the coupon over the last year is approximately equal to the real yield one year ago, if this was a par bond then).

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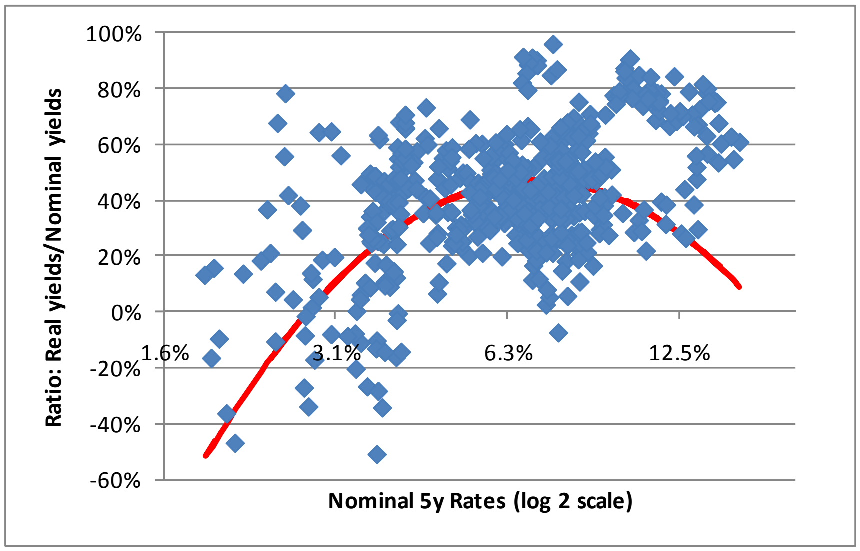
[11] Kothari, S.P. and Shanken, Jay, *Asset Allocation with Conventional and Indexed Bonds,* presented at the 2000 Barclays Inflation-Linked Bond Conference; available at http://web.mit.edu/kothari/www/attach/KS%20Inflation%20paper%20March%202000.pdf.

We don't know the real yield from one year ago, but if we know *today's* real yield we can figure out the real yield from one year ago. We know that (a) plus (b) equals the year-ago real yield, plus the bond price change associated with the change of real yields over that horizon. That is,

$$\text{(Coupon + bond price change)} = r_{t\text{-}12} + (r_t - r_{t\text{-}12}) * \text{duration}$$

With an estimate of duration, we can now solve the real yield series backwards, since at the end of the series we will have the yield of the Barclays 5-10 Index to serve as r_t. We can then step backwards through time and fill in the real yield series. Then, stepping forward, we can separate the coupon and price change effects. And this is what we did.

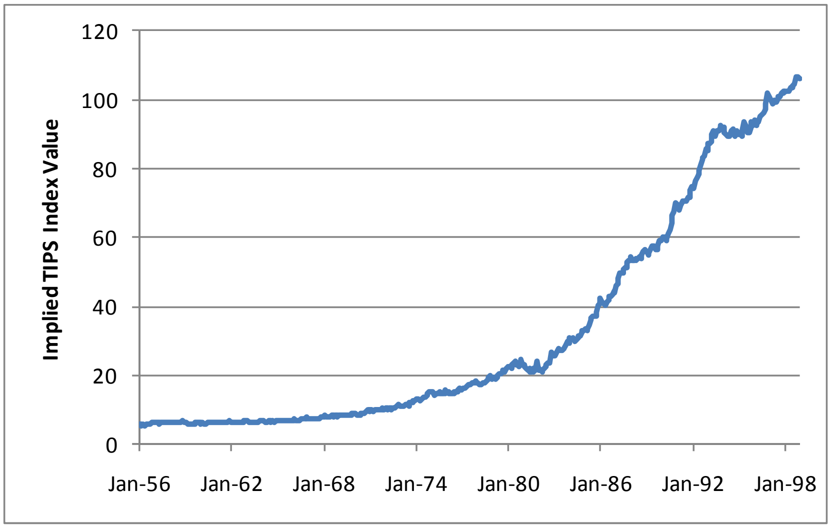


The resulting yield series unfortunately does not share the tight 'arch-shaped' phenomenon that actual real yield series do (see Chart at right), but it is probably not reasonable to expect it to do so since it has not been reported in the literature and, as far as we know, Enduring Investments in the only firm to have identified it. However, as the chart shows it does share the *broad* shape that is expected. All real yields are less than the corresponding nominal yield (the ratios are uniformly less than 100%) and the ratio rises at a slower pace as nominal yields rise.

Creating the total return series is actually relatively easier since the authors had estimated the year-on-year nominal return to the 5y TIPS bond. Because there is an overlap with the actual Barclays series, we can work backwards with this information. For example, in February 1997 the Barclays index value is 100. The authors of the inflation-indexed bond study report their estimate that the total return in nominal terms from February 1996 to February 1997 would have been 8.032%. Therefore, we can conclude that the February 1996 index value was:

$$Feb\ 1996\ index\ value = \frac{100}{(1 + .08032)} = 92.565$$

From Feb 1996 we can bootstrap Feb 1995, from Feb 1995 we can calculate Feb 1994, and so on. Because the series overlap by a sufficient amount, we can also calculate the January series, the March series, etc. The resulting series does not look unreasonable (see Chart at left). The summary statistics also seem reasonable. Between February 1997 and December 2010, for which we have actual TIPS data, the compounded return was 6.54% and the annualized risk was 5.69%. For the simulated period of December 1959 through February 1997, the compounded return was 7.78% and risk of 8.11%. Since that period included the 1970s and 1980s, a higher return and higher risk seems reasonable, and a risk:return ratio of around 1.0 is consistent.



Results of the Full Backtest on Simulated Data

With the data in hand, we can now run the model over the entire period from 12/31/1959 to 12/31/2010.

Note that none of the original decision rules have changed. There is still a yield tilt and a relative value tilt, and relative value for TIPS is determined by the same model as it was in the initial test even though, as we have seen, the behavior of the simulated data do not necessarily conform to the reality we had previously modeled.

The only significant change is that the composition of the various strategy constituents have changed. The TIPS allocation is now purely TIPS and the simulated TIPS returns, includes no international inflation-linked bonds and no alpha from our quantitative inflation-linked bond ("GRIP") strategy. We have used the "slow" commodity returns that consist mainly of the CRB and simulated CRB Total Returns with the GSCI and Summerhaven indices from 2002 to present. The T-Bill and S&P indices have been backfilled as described above.

The results of the test, rebalancing monthly, are shown below.

	Max Weight	Min Weight	Avg Weight	Index Return	Index Std Dev	Sharpe
TIPS[1]	71%	0%	31.8%	7.44%	7.53%	0.20
Commod[2]	71%	0%	26.7%	7.72%	14.44%	0.24
TBills[3]	33%	0%	17.1%	5.47%	0.84%	n/a
S&P[4]	63%	0%	24.5%	9.70%	14.74%	0.39
Four-Real			**100.0%**	**9.18%**	**7.73%**	**0.54**

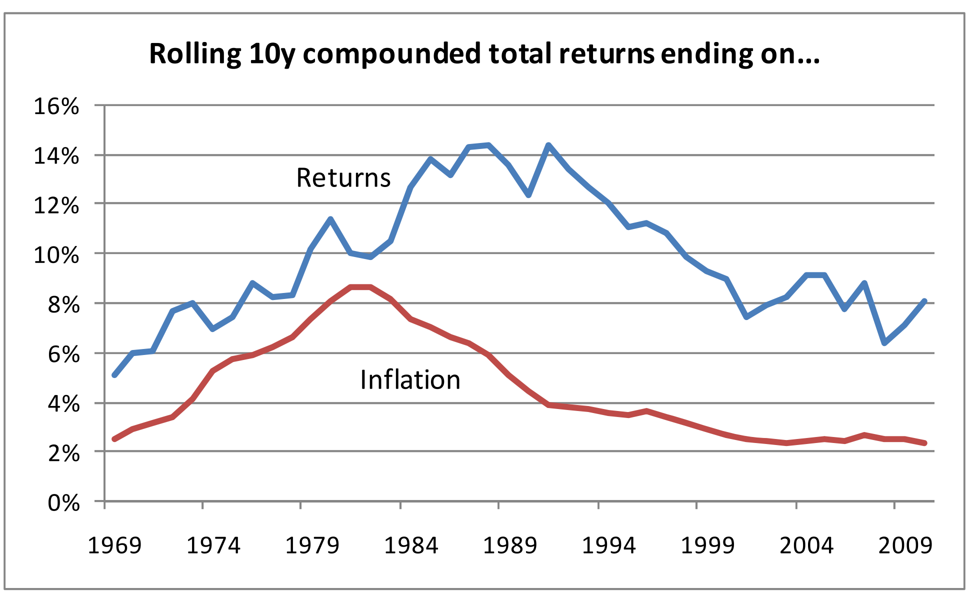
[1]TIPS simulated as described above from Dec 1959-Feb 1997; Barclays TIPS 5-10y Total Return Index from Feb 1997-Dec 2010.

[2]Commodities series is spliced from the simulated CRB Total Return Index (described above) from Dec 1959-Dec 1981; the actual CRB Total Return Index from Jan 1982-Jan 2002; the SP-GSCI Total Return Index from Feb 2002-Dec 2009; and the Summerhaven Dynamic Commodity Total Return Index from Jan 2010-Dec 2010.

[3]TBills: Reconstructed index as described above for Dec 1959-Dec 1988; Ryan Labs 3m Tbill Total Return Index from Jan 1989-Dec 2010.

[4]S&P Total Return Index with dividends reinvested. Official series used from Jan 1970-Dec 2010; from Dec 1959-Dec 1969 the series was recreated as described above.

Remarkably, the Four-Real strategy only showed 5 losing calendar years in the 51 years of the simulation. In only 9 years did it underperform inflation, and the average real return over the entire period was an impressive 5.43% over inflation. The chart below shows rolling 10-year compounded returns.



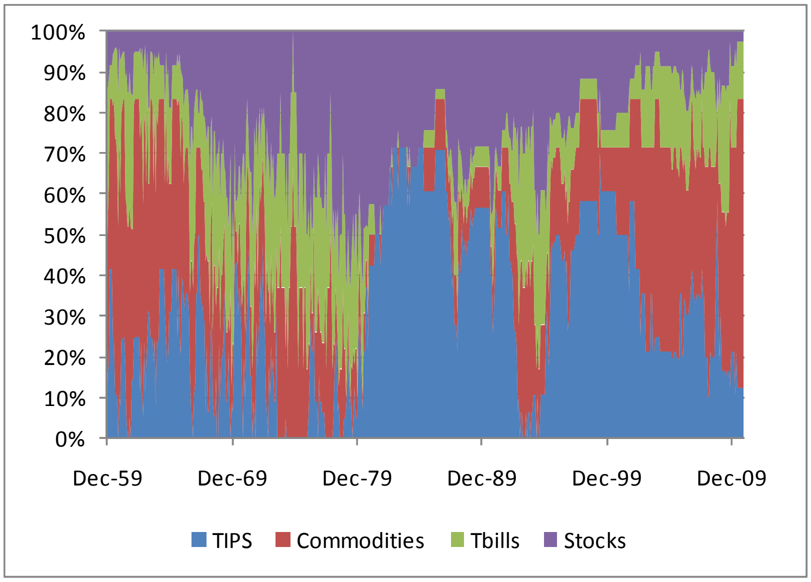
The table below gives the gross calendar year return and the annualized standard deviation of monthly returns for each year.

	Return	Std Dev		Return	Std Dev		Return	Std Dev
1960	1.6%	2.8%	**1977**	1.0%	4.9%	**1994**	4.6%	4.5%
1961	8.1%	3.9%	**1978**	11.8%	7.4%	**1995**	15.0%	1.9%
1962	2.4%	2.9%	**1979**	21.3%	7.7%	**1996**	11.0%	5.2%
1963	8.3%	4.9%	**1980**	23.8%	12.1%	**1997**	8.2%	4.6%
1964	0.6%	4.1%	**1981**	-3.9%	12.2%	**1998**	2.7%	4.8%
1965	7.4%	3.3%	**1982**	17.9%	14.8%	**1999**	7.8%	3.6%
1966	3.2%	4.7%	**1983**	17.7%	7.4%	**2000**	7.8%	5.2%
1967	6.0%	2.4%	**1984**	11.1%	7.4%	**2001**	-0.9%	5.1%
1968	11.4%	3.7%	**1985**	24.7%	7.0%	**2002**	14.1%	6.7%
1969	2.6%	3.5%	**1986**	9.6%	5.3%	**2003**	13.5%	12.6%
1970	10.6%	6.4%	**1987**	12.2%	10.5%	**2004**	13.3%	11.2%
1971	8.7%	5.2%	**1988**	12.2%	4.7%	**2005**	15.4%	12.4%
1972	19.7%	4.5%	**1989**	13.4%	4.8%	**2006**	-2.3%	8.9%
1973	10.9%	6.6%	**1990**	11.1%	5.5%	**2007**	18.8%	6.4%
1974	-8.6%	8.9%	**1991**	14.3%	4.4%	**2008**	-17.9%	21.2%
1975	12.9%	7.5%	**1992**	8.5%	2.4%	**2009**	15.1%	12.0%
1976	16.7%	7.1%	**1993**	10.5%	3.5%	**2010**	18.3%	13.9%

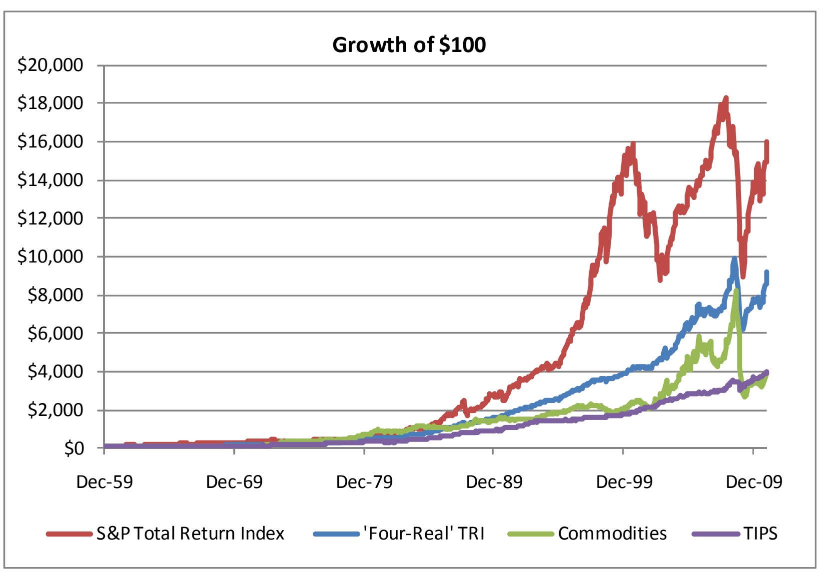
By decade:

	Annualized Total Return	Annualized Inflation
1960s	5.1%	2.5%
1970s	10.2%	7.4%
1980s	13.6%	5.1%
1990s	9.3%	2.9%
2000s	7.1%	2.5%

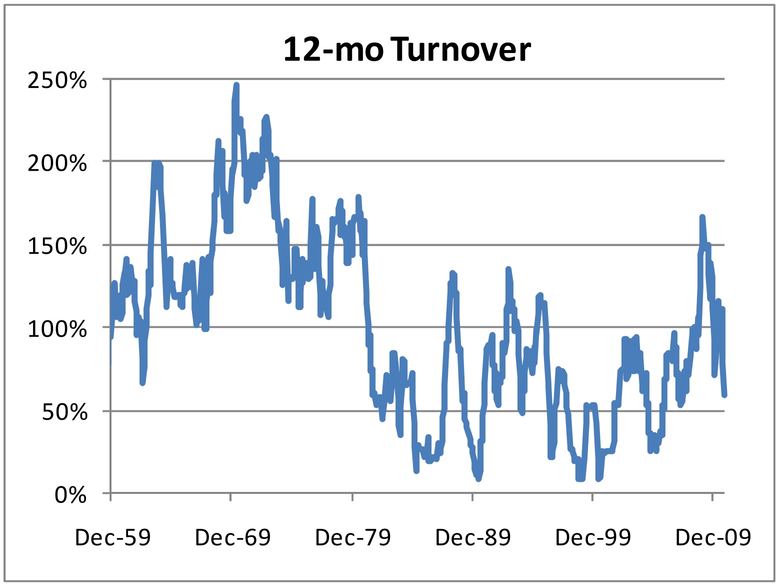
The evolution of weights over time is interesting. The chart below shows the proportions allocated to each of the four asset classes. The model was mostly in commodities in the early 1960s, increased equity allocation in the Go-Go years and in the early 1980s divided the portfolio essentially between TIPS and stocks. As the stock market rallied the allocation progressively moved to commodities, and now the allocations are fairly similar to what they were in 1960 (actually, in September 1960 the allocation was 11% TIPS, 62.5% commodities, 22.5% T-Bills, and 4% equities – statistically identical to the current allocations).



The chart below shows the growth of $100 at the beginning of the simulation period until December 2010.



Turnover at the asset class level was manageable. There were a few periods in which the model made no allocation changes at all for an entire 12-month stretch and the only turnover was from rebalancing to policy weights necessitated by price changes. Turnover for the entire period of study averaged 99%.



Finally, the strategy showed a positive correlation with all of the included asset classes, which isn't that surprising. More interesting is that each of the asset classes shows a very low correlation with all of the others. This is encouraging and suggests that at least over the studied period, each asset class is tapping a different risk.

	GRIP	USCI	Bills	SPY	Four-Real
GRIP	1.00	0.11	0.07	0.05	0.39
USCI	0.11	1.00	-0.02	0.12	0.68
Bills	0.07	-0.02	1.00	0.00	0.02
SPY	0.05	0.12	0.00	1.00	0.58
Four-Real	0.39	0.68	0.02	0.58	1.00

3. The Question of Further Optimization

We have specifically avoided optimizing at this point for the practical reason that if the strategy works after optimization there is the question whether the strategy was overfitted/data mined. The strategy works – indeed, surprisingly well – using simulated data on the original parameterization. This increases the chance that the *a priori* reasoning behind the strategy is sound and valuable. We believe that the strategy could be implemented at this point with no further optimization and have a strong chance of success.

There are three avenues for exploration with respect to further optimization.

First, the tilt tables might be improved. As designed, they are discontinuous and arbitrary. In constructing the original strategy, we were guided by intuition on the weightings and chose a tabular approach because of the ease with which such a model can be explored using Microsoft Excel. There is, however, no good reason that this approach should be superior to having formula-based allocation rules that permit continuous allocation changes rather than step changes. It may not be the case, though, that a continuous formula significantly *improves* performance and it will tend to produce more turnover since moves that would have been below the "sensitivity" defined by the table-step and therefore ignored will now result in a small allocation change. With respect to the rules themselves, it might well be worth optimizing the parameters of the rules although there is something to be said for intuition. It is hard to believe that we completely by chance stumbled on the optimal parameters; that being said, it is a different question entirely that we can establish with *confidence* that some new parameter is actually superior to the old parameter and isn't just a data-fitting exercise. This improvement is harder than it sounds, in other words.

Second, while there is virtue in simplicity we can imagine that there are other relative value rules that could be considered. The equity relative value score, for example, has nothing whatsoever to do with directly-observable variables like dividend yield or other traditional value metrics. Implementing a relative value test on the basis of the real equity risk premium (10y projected real return based on CAPE convergence, compared with 10y TIPS yields, for example) seems an obvious choice. Again, however, it isn't immediately apparent that additional complexity will lead to marked improvement, and it has very clear costs in terms of marketability and explainability of the strategy.

Third, in our final tests we did not include certain assets that are very likely to add significant alpha. One of these we will recommend as part of the implementation strategy: the Summerhaven strategy is fundamentally sound and should produce significantly positive returns compared to a conventional commodity strategy. It is also tradeable as an ETF (USCI). The TIPS return can also be improved upon by making the allocation into a quantitatively managed global inflation-linked bond strategy such as

Enduring Investments' GRIP strategy. This strategy is not presently tradable as a mutual fund or ETF, though, so it would be difficult to include in the initial implementation.

4. Implementation Strategy

The beauty of this strategy is that an elementary version of it can be implemented immediately:

The TIPS allocation can be invested in the iShares Barclays TIPS Bond Fund, (TIP), which has $19.8bln in AUM and an expense ratio of 0.20%

The Commodity allocation can be invested in the United States Commodity Index Fund (USCI), which tracks the Summerhaven Dynamic Commodity Total Return Index, has $356mm under management and an expense ratio of 1.16%.

The S&P allocation of course can be invested in the SPDR S&P 500 ETF Trust (SPY), which has $88.8bln AUM and an expense ratio of 0.095%.

The T-Bill allocation can be invested in any old high-quality money market fund, or directly into T-Bills. In calculating effective average fees, We assume zero fee (or, equivalently, that a money fund returns exactly the T-Bill rate after fees).

Using those fees for the constituent pieces, the annual fee drag on performance would have been as much as 0.85%, as little as 0.11%, and on average 0.40% over the 51 years of the simulation. To that, a research fee to Enduring Investments will be added.

Operationally, Enduring Investments would determine the approximate re-weightings a day in advance of month-end the expected allocation adjustments that would need to be made, based on the model's current readings. These will be updated during the day at month-end.[12] We will make the necessary adjustments in client portfolios as needed.

If customers have sufficient interest in the strategy, it may make sense to establish it as a separate fund that Enduring Investments could manage. Inside a fund, T-Bills could actually be purchased in sizes for which it would be efficient, and the TIPS allocation could be actively managed or GRIP employed if sufficient assets were committed to the fund. Customers would also save the research overlay expense as that would be incorporated into fund expenses.

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[12] N.b.: There is no natural reason that the portfolio adjustments must be made at calendar month-end, and in the future we may choose some other day (but the same day each month) on which to make the rebalancing transactions.

Conclusion:

This study was conducted in order to more fully evaluate the Four-Real Dynamic Switching Strategy over a lengthier (and "out of sample") historical data set. Performing this analysis required some painstaking re-creation of indices that were not in existence during the period of interest. Despite this fact, the strategy performed well.

The Four-Real strategy returned 9.18% per annum, compounded, over the 51-year simulated period. Only equities had a higher return among the studied asset classes, but Four-Real produced 95% of the return on only half the risk and with an 0.58 correlation to stocks. Moreover, the strategy only had 5 losing years out of 51 (equities had 13) and beat inflation in 42 out of 51 years (equities did 36/51).

Turnover was modest, and fees quite reasonable for such a robust and valuable strategy. Implementation poses few challenges as rebalancing can occur monthly with existing ETF products, or the entire portfolio management task can be simply outsourced to Enduring Investments as an established, segregated fund.

Disclaimer

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2012 Four-Real Methodology Change, and New Options

As 2011 winds to a close, we are making a minor change to the Four-Real methodology and offering a new option for investors.

The minor change concerns how we convert a 'signal' on one of our two 'tilts' into an actual asset allocation proportion. Until now, we have taken the signal – say, the 10-year real yield, for the purposes of evaluating the yield tilt – and compared it to a table of proportions. So a real yield of 2.5% would fall between 2% (0.5 tilt score) and 3% (0.7 tilt score) on the table; since it is above 2% but not above 3%, the tilt score would be 0.5.

The possibility exists with this method that if the real yield was 2.99% in one month, then 3% in the next month, and then back to 2.99%, the tilt score would call for a significant change in weightings and then change them *back* even though the real yield didn't actually change much. We call this "oversensitivity to boundary conditions."

We are going to resolve this issue by interpolating along the table values. In the example above where the yield went from 2.99% to 3.00% to 2.99%, very little would change. In each case, the tilt score would be **near** 0.7.

This should result over time in somewhat lower rebalancing costs,[1] and it is a bit more intuitive. In our testing, it made a negligible difference in the historical performance record.[2] We will be implementing this methodology change as of December 31st. Please let us know if you have any questions or concerns.

We are also introducing a new option for Four-Real investors. We are calling it Four-Real-CC, where "CC" stands for "Commodity-Constrained." The original, version of Four-Real (which we call 'unconstrained' for clarity but which actually constrains the cash weighting to be no more than 33%) allows the weighting in commodity indices to be as high as 100% in certain (unusual) circumstances, but in times when real interest rates are extremely low, as they are now, the commodity weight can easily exceed 60%. We believe in the methodology that produces that outcome, and for investors that own Four-Real as just one investment in a larger portfolio the heavy weighting on commodity indices is likely to be a desirable feature. We recognize, however, that some investors who have a significant proportion of their wealth in Four-Real may be uncomfortable with so high a concentration in commodities, even though commodity indices are more diversified than equity indices.

We want clients to feel comfortable about their investment in Four-Real, so we are offering the option to invest in the commodity-constrained version in which the concentration in commodities is limited to

[1] From 12/1959 to 12/2010, continuous-formula rebalancing would have resulted in 25% less turnover.
[2] From 12/1959 to 12/2010, annualized performance with the continuous functions was 9.22%, with 7.80% annualized risk, compared to 9.11% with 8.34% risk with the "old" functions.

40%. This reduces overall performance slightly, but also reduces overall risk.[3] In our view, the value of the commodity constraint from our clients' perspective should be mainly in terms of increased comfort. In normal times, it will not be terribly constraining; at the present time it would be since the current allocations are 71.4% to commodities and 28.6% to cash. Instituting the cap on commodities would change those allocations to 40% commodities and 60% cash.

Please let us know if you have any questions, or if you would like us to manage your account going forward in the "Four-Real-CC" version of the strategy. In the meantime, we will continue to manage your account with commodities unconstrained, but with the new 'continuous' formula construction.

Michael Ashton
Managing Principal
Four-Real Strategy Manager

[3] From 12/1959 to 12/2010, using the continuous-formula method, the unconstrained version of Four-Real returned a compounded 9.22% annualized return on 7.80% annualized risk, while the CC version returned 9.03% on 7.38% risk.

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