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INSIGHTS

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A RULE-BASED COMMODITY INDEX*

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A commodity index is designed as an equal-weighted set of four complementary tactics. The resulting portfolio takes advantage of well-established patterns in commodity markets, including high volatility and the relative independence of the return drivers. These conditions are ideal for achieving rebalancing gains and thusly for improving risk-adjusted performance. Index performance is compared with long commodity indexes and commodity hedge funds. The benefits of an overlay strategy is shown vis-à-vis a traditional stock/bond portfolio.

1 The rise of rule-based indexes

Over the past decade, rule-based indexes, called smart beta, have grown in popularity. Prominent examples include fundamental-weighted indexes in equities, risk parity funds, and the carry trade in currencies. The growth has been motivated by several factors: (1) relatively low costs and transparency, (2) the search for improved performance over buy-and-hold approaches, (3) the expansion of exchange-traded products, and (4) the acceptance that markets display partially repeatable patterns.

The original cap-weighted indexes such as the S&P500 did not require much trading since the constituents rarely changed. However, there can be substantial turnover in even "mostly" passive indexes. Take the case of equity mid-cap value wherein a substantial portion of the membership changes hands every year depending on the index ground rules. There is more acceptance of trading within an index.

Why commodities? Investors are turning to commodity markets to improve diversification over traditional equity and bond assets. Potential benefits include partial protection against unexpected inflationary spikes, the symmetric ability to take long or short position via futures markets, and the relative independence of return drivers. The category—"real assets"—includes oil and gas, timberland, and real estate. Since commodities play a substantial role in inflation calculations, it is natural to consider commodities along with other real-asset alternatives.

*The index was developed by DPT Capital Management, Princeton New Jersey for FTSE (All rights reserved).

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Commodity markets have been evaluated in numerous academic studies. A few examples are Bouchouev (2012), Brennan *et al.* (1997), Erb and Harvey (2006), Gorton and Rouwenhorst (2006), (2008), Miffre and Rallis (2007), and Shen *et al.* (2007). Supply/demand and inventory factors play a critical role in price formation, as compared with traditional asset prices for equities and bonds—which are a function of future cash flows from earnings or dividends, risk premiums, and the risk-free rate. The resulting patterns in commodity prices are well established. Section 3 reviews general characteristics of commodity markets. The rule-based index is described in Section 4, along with back tests, and comparisons with other commodity indexes and active funds. Section 5 discusses the advantages of an overlay version of the index in conjunction with a traditional stock/bond portfolio.

2 The role of indexes for alternative assets

Given the increasing emphasis on alternatives, such as private equity and hedge funds, by leading institutional investors, there is a need for indexes that "track" performance for asset categories in the alternative universe. Herein, we define a tracking index as a well-posed, transparent tactic, or portfolio of tactics over liquid securities. In our view, the goal of a tracking index is to mimic the decision processes of portfolio managers in the respective domain, absent the high fees of the active managers.

The approach is sometimes called hedge fund smart beta, employing policy rules for achieving alpha-like performance. In contrast to statistical replicators (Amenc *et al.*, 2010; Hasanhodzic and Lo, 2007), we focus on fundamental tracking indexes as ones that match up with the core decision processes that portfolio managers employ within their designated domain (Fung and Hsieh, 2007). In this situation, index performance should approximate the median, after-fee return of managers over longer term horizons, but not necessarily short periods such as days or weeks.

For alternative assets, most current indexes measure the median return of managers who self reference within a category. For example, commodity-trading advisers (CTAs) nowadays go beyond commodities, trading currencies, bonds, and equity futures. For this case, the subcategory of hedge funds is "quantitative or symmetric global macro". However, there is no ready way to invest in this type of index, except in the most rudimentary fashion with a few of the managers who are willing to open up their doors. The elite managers rarely allow inflows from new investors. Thus, the median return index is not readily investible. Also, several authors suggest that the historical performance of hedge funds is overestimated due to causes such as self-reporting biases (Aiken *et al.*, 2011; Fung and Hsieh, 2009; Roncali and Weisang, 2011; Williamson, 2012).

Passive and rule-based index serves multiple purposes. First, they provide a benchmark for active managers. An active manager should be compared with a suitable index, especially over longer time periods. After all, the active manager should be paid for excess performance. These benchmarks are readily available for equity and bond funds. The absolute benchmarks that are common in hedge fund land can be misleading and have not shown themselves to be as useful as possible, given the losses encountered by most hedge funds in 2008; Figure 1 shows that most hedge fund categories lost capital during the 2008 crash (Mulvey, 2012a, 2012b).

Second, institutional investors may wish to invest in the tracking index in order to reduce costs and to focus their investment expertise in other domains. It can be difficult for large investors to find a sufficient number of superior active fund managers

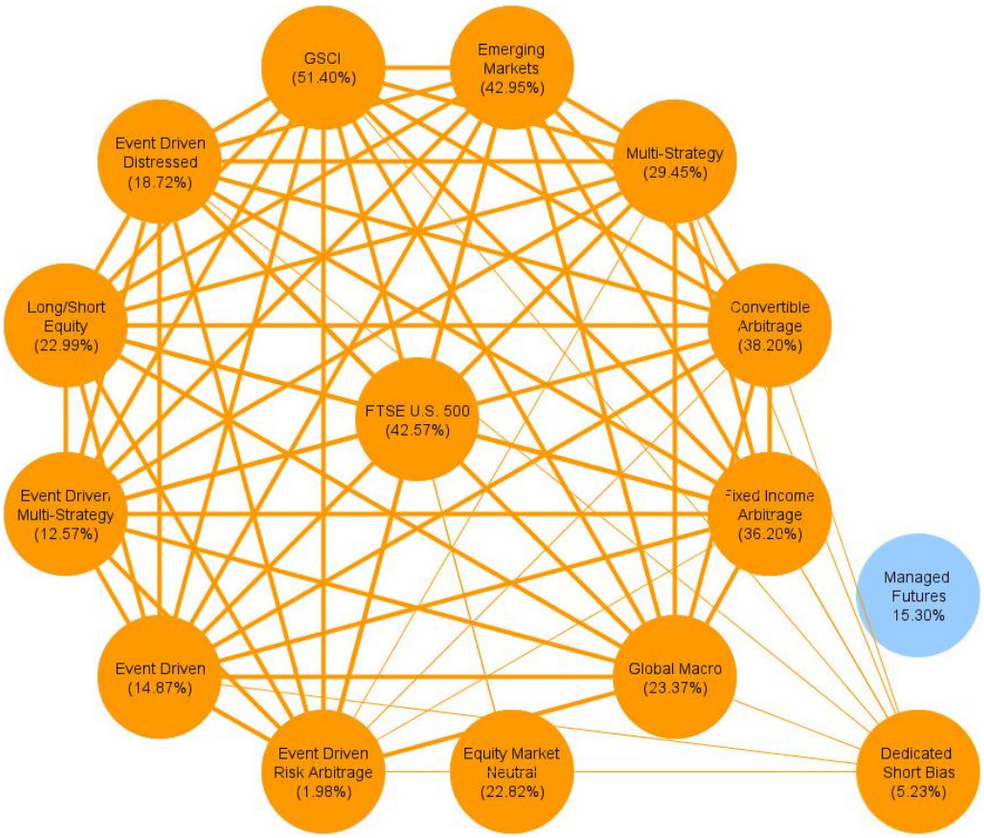

Figure 1 The performance of hedge funds and other asset categories during the 2008 crash period (correlation is indicated by thickness of the lines). Most subcategories lost capital during this period.

that beat the after-fee performance of an index. Hence, if you cannot beat an index, join it.

Last, the index, if constructed reliably, may help the asset allocation process. For example, it could be employed for rebalancing the portfolio to the target allocation percentages when price drifts occur in the corresponding illiquid assets. Alternatively, the index can be used for opportunistic trades, especially when transaction costs are low.

3 Characteristics of commodity markets

As distinct from stocks, bonds, and related financial instruments, commodities occupy a critical link of the consumption supply chain—either as intermediate or final products. Supply and demand relationships make it difficult to ascertain if a commodity is overpriced or underpriced based solely on discounted cash flow projections. Even commodities that are not consumed, such as gold and silver, are difficult to price. Behavioral issues, supply and demand, and inventory factors affect the market prices—both spot and prices on futures contract (e.g., Bouchouev, 2012; Brennan *et al.*, 1997; Dempster *et al.*, 2012; Gorton *et al.*, 2006, 2008).

Investors who wish to add commodity exposure cannot easily purchase the physical commodity due to storage costs, constraints on availability, and related issues. Notable exceptions are select metals, including gold, silver, and platinum; exchanged traded products that own these metals

can be bought or shorted. In most cases, however, commodity futures markets are employed—along with the issues involving the roll returns. These futures markets possess novel features such as a term structure determined by inventory levels and other factors, rather than dictated by arbitrage relationships.

The volatility of commodity prices can be relatively large and as a consequence exchanges will set daily price limits during periods of extreme volatility—in which case the price may move its limit without trading. Volatility occurs for idiosyncratic reasons. For example, a severe weather event such as a deep freeze in Florida will cause much higher prices for orange juice in a short time period. If the supply constraint is deemed to be temporary and inventory is low, the near month contracts will increase much more in price than further out months. This backwardation reverts to the normal conditions as time passes. The shape of the term structure has been explained in terms of inventory (e.g., Gorton *et al.*, 2008), and by means of hedging arguments (e.g., Mulvey, 2012a).

A second characteristic of commodity prices is related to the actions of the various parties within the commodity supply chain. Due to a variety of causes, such as diffusion of information (Hong and Stein, 1999; Rouwenhorst, 1998), the prices of commodities will trend in one direction or the other—higher or lower—over time. These patterns are quite modest for individual commodities: perhaps 2–4% return per year for trend following tactics, with high volatility—20% to over 40% annual. The slow trending patterns have existed for at least six decades and are likely to continue in the future.

We will see that these characteristics—high volatility, ability to take long and short positions in liquid markets, partial protection against inflationary risks, and modest price trends—can be combined within a rebalanced portfolio of commodity tactics possessing desirable characteristics.

4 The commodity index: A portfolio of four tactics

The performance goals are: to provide positive returns when commodity prices increase, protect a portion of the downside when commodity prices are plunging—mostly during crash periods, and partially hedge unexpected inflation risks. For simplicity and to reduce data mining, the index consists of an equal-weighted portfolio of four established tactics. Two of the tactics are long only, whereas two are long short.

What are the problems of long commodities indexes? The first issue involves large drawdowns. The performance of long commodity funds has been hampered by sharp losses occurring during crash periods such as 2008. Two popular indexes in terms of assets under management—the Goldman Sachs Commodity Index and the Dow Jones UBS Indexes—lost over 50% each during the 2008 crash (Figures 1 and 2). Unfortunately, this time period was particularly difficult due to severe losses in most assets at exactly the same time (Figure 1). Commodity prices often plunge during economic contractions and decreases in demand expectations.

A second issue with long commodity funds involves roll returns, caused by the shape of the commodity term structure. Over the past decade, the curve has become steeper on average—and is predominately in contango nowadays for many commodities. Thus, the use of long futures contracts has led to losses relative to the spot index—roll losses. Figure 2 shows the wealth path for the spot index and the investible index (excess return excludes interest rates on the margin assets). The excess return series indicates the performance that

Figure 2 Wealth path of GSCI spot index and the investable "equivalent" fund (The spot index has been much outperforming the investible index over the past few years).

investors receive, assuming that T-bill interest rates are zero—similar to today's environment.

In contrast to long commodity funds, many long–short commodity hedge funds have performed well during past financial crises. Lintner (1983) in a famous early paper demonstrates the benefits of commodity hedge funds. In 2008, the sole hedge fund category with positive median returns was managed futures (Figure 1), which includes commodity and CTA hedge funds (Mulvey, 2012a; Jeanneret *et al.*, 2011).

Why do commodity hedge funds outperform during economic crashes? These funds employ trend following and related tactics. Trending tactics can be considered as a purchase of an option on large price swings, sometimes called regime changes—which often occur during economic crises. Second, commodity investors take advantage of the symmetric ability to go long or short. Since futures markets consist of both buyers and sellers, it is just as easy to secure a short position as a long position. In contrast, many risk-bearing securities, such as owning individual stocks, can be expensive and difficult to short during crises periods—even if the investor had the good fortune to anticipate the crash.

A prime property of commodity markets is their ability to hedge producer and consumer risks. Commodity prices are part of inflationary formulae—directly or indirectly. Thus, purchasing commodities, all else being equal, will reduce the risk of loss under higher inflation in the future (Erb and Harvey, 2006; Greer, 2000; Greer *et al.*, 2013). This property was evident during the past bout of inflation over 1969 to 1981 when inflation and commodity prices soared, especially energy prices. Likewise, owning energy-linked commodities would be valuable during a severe shortage of oil, for example, caused by a war or terrorist attack in the Middle East or elsewhere (Dempster *et al.*, 2012).

A related concern involves scarcity in a world with finite resources and expanding population pressure. Of course, the supply chain responds to higher prices over time by discovering and investing in new sources of vital raw materials. The dynamic tension between supply and demand gives rise to price patterns over extended time periods, as discussed in the previous section. Again due to behavioral and related causes, prices follow in a stochastic fashion trending or drifting markets. These price patterns are captured by trend following tactics, leading to

modest positive expected growth values with high volatility.

Our commodity index employs the futures markets, due to liquidity, low transaction costs, and the ease of assessing market prices. For a fund based on a rebalanced portfolio of tactics over futures markets, performance can be attributed to three elements: (1) return on individual tactics, (2) rebalancing gains, and (3) return on the margin assets. Typically, the third element involves investing in a riskless asset—T-bills. As an alternative (Section 5) an investor can supply a portfolio of stocks and bonds for the margin account to enhance total performance.

The second element, rebalancing gains, occurs whenever the investor resets her portfolio to the target proportions on a regular basis (fixed-mix rebalancing). The difference in return of a buy-and-hold portfolio and a rebalanced portfolio is defined as rebalancing profits. Dempster *et al.* (2003), Luenberger (2009), Mulvey *et al.* (2007), and Mulvey and Kim (2008) provide extensive research on the sources and extent of rebalancing gains.

The degree of rebalancing profit depends on several factors, including the volatility of each asset, the correlation of returns between assets, and expected returns of assets over the horizon. Rebalancing gains are highest when volatility is high, correlation is close to zero, and the expected return is positive for each asset. As a design goal, we seek commodity tactics that have positive expected returns, modest or even high level of volatility, and low correlation to each other. Note that due to high volatility, the individual tactics may possess low or modest Sharpe ratios.

Concurrent with achieving rebalancing gains, we are interested in the hedging properties of commodities with respect to inflation, weather, and supply shocks. To this end, we employ the following four tactics: (1) a long-only momentum tactic; (2) a long-only term structure tactic; (3) a trend following tactic; and (4) a price breakout tactic.

The long momentum tactic focuses on commodities that have increased in price over a look-back period. Accordingly, on the rebalancing date, we rank commodities based on their recent performance. A typical horizon is 80 trading days. For our index and for simplicity, we select commodities at the top of the list and equally weight them. For example, we observe 18 commodities for the evaluation, selecting the top eight for the tactic, again equally weighted. (A reasonable alternative is to weigh the selected commodities by volatility—investing less in the more volatile commodities.) See Miffre and Rallis (2007) and Shen *et al.* (2007) for causes of momentum in commodities. As mentioned, the momentum tactic takes only long positions.

The second tactic, term structure, focuses on the shape of the commodity futures curve. Here, commodities are ranked according to their respective slopes, i.e., the ratio of the price of the further out month to the near month contracts. If the slope is positive, the curve is in contango. Otherwise, the curve is in backwardation. (More complicated shapes such as humps are possible, but are ignored in this straightforward version of the tactic.) The idea is to favor commodities in backwardation, so as the maximize roll gains (or minimize roll losses) to the degree possible. Another way to consider the tactic is to buy commodities when inventory is low and expected profits are relatively high. This tactic is long only, with equal weights on the eight selected commodities.

The third tactic employs classical trend following rules. Here, on the rebalancing day, the current price is compared with a moving average of historical prices. If the current price is above the moving average, the investor buys

the commodity, whereas if the current price is below the moving average, the investor sells the commodity. The tactic is long short, taking advantage of long-term price patterns. Individual commodities are equally weighted within the tactic.

A similar tactic to trend following is price breakout. Here, the rule is to go long when the current price exceeds all prices over a designated lookback period, or go short when the current price is below all prices seen over the same lookback period. Otherwise, the tactic keeps the same position—long or short—as from the previous period. As with the previous three tactics, the chosen individual commodities are equally weighted. The breakout tactic is long short and has return patterns similar to the previous trend following tactic.

At the portfolio level, each of the four tactics is equally weighted on a monthly time step. We discuss two versions: a Target 100 index (25% each tactic) and a Target 80 index (20% each tactic).

First, we present the excess return of the Target 100 commodity index—without reference to return on assets in the margin account—over two periods (ending May 16, 2013):

Start date	1/15/2002	1/31/1992
Annual geometric returns	8.62%	6.95%
Volatility	12.9%	11.3%
Max drawdown	20.5%	21.7%

These empirical results are consistent with the previously discussed patterns in commodity prices and rebalancing gains. The investor receives performance equal to these excess values plus performance on margin assets (Section 5).

The concept of blending two long tactics with two long–short tactics is based on the premise that the former tactics will perform well during increasing commodity price periods, whereas the latter tactics will help protect the investor from sharp drawdown periods such as the one that occurred in 2008 and increase during commodity price spikes.

Table 1 Comparing drawdown (daily) of the index versus long-only commodity funds during the 2008 crash period (2/19/08 to 2/19/09).

Target 100	−3.4%
Target 80	−2.5%
GSCI (long only)	−60.4%
DJUBS (long only)	−46.7%
Rogers international commodities (long only)	−53.8%
Credit Suisse commodity benchmark (long only)	−51.5%

Long-term investors should understand the importance of avoiding large drawdowns. Table 1 shows the situation during the 2008 crash period. Compare the long indexes with the long–short indexes and the target commodity indexes. Mulvey *et al.* (2011) and many others suggest that it is critical for long-term investors to minimize their portfolio drawdown. Otherwise, investors will fall behind required growth targets and have considerable difficulty in catching up.

The historical performance during the 2008 crash illustrates a common phenomenon—the positive return of managed futures and commodity hedge funds during periods of crises. For example, the S&P Commodity Trading Strategy performed in accordance with these past results—over +19% return. In contrast, the long commodity funds experienced large drawdowns—between 46% and 60% losses over the 1-year period. By construction, our target indexes provide an equal mix of two long and two long short tactics, the return for these funds lies between the two.

Table 2 Performance statistics (January 15, 2002 to May 16, 2013).

	Buy-and-hold	Rebalance equal (1.16)	Rebalance equal (1.7)
Geometric returns	8.73%	9.91%	13.9%
Volatility	15.0%	15.0%	22.0%
Max drawdown	32.5%	23.5%	32.5%

A second significant feature involves the advantages of portfolio rebalancing. Table 2 shows the benefits of rebalancing the four-tactic portfolio versus the equivalent buy-and-hold portfolio. To render a fair comparison, we first equalize the volatility of the monthly rebalanced (fixed mix) portfolio—with the average leverage equal to 1.16 for fixed-mix solution. Next, we set the two max drawdown values equal (column 4, Table 2). The rebalanced portfolio provides higher returns for an equal level of risk.

Next, we describe empirical results of our two commodity indexes versus several long-only competitors—GSCI, DJUBS, and Rogers Commodity Index, and long-short funds—the S&P Commodity Trading System (CTS), HFRX, and Credit Suisse. Table 3 shows the performance of these indexes over three recent periods—3, 5, or 6 years prior to May 20, 2013. Note that the two indexes, Target 80 and 100, had superior performance during the 2008 crash, which thereby preserved the investor's capital during the crash—unlike the long commodity funds.

The importance of minimizing drawdown is once again emphasized (Table 3). Even with strong gains in long commodities over the recent 3-year horizon, the longer holding period returns (6 years) remain well below the respective high water marks for the long commodity indexes. The relationship between large drawdown values and low long-term growth is vividly shown with

Table 3 Performance of target commodity index and competitors (Total holding period returns, ending May 20, 2013).

	6 Years (%)	5 Years (%)	3 Years (%)
Target 100	54.4	20.2	11.1
Target 80	41.3	16.7	9.1
GSCI	−24	−53.3	14.1
DJUSB	3.6	−35.0	20.1
S&P CTS	−3.9	−9.2	−22.2
Rogers C.	1.7	−32.5	21.8
HFRX	−8.2	−18.8	−6.4
Credit Suisse	5.7	−31.2	21.2

the Goldman Sachs Commodity Index, which remains well below its peak value occurring in early 2008. The large drawdown is significant due to the fact that equities and other assets were experiencing large losses at the exact time. Clearly, there was severe contagion—high correlation—between long commodity and stock prices during the 2008 crash.

Next, we compare the Target 100 commodity index with the DJUBS index on weekly basis over a 10-year period. The tracking error is 1.84% weekly (13.3% annual), with 4.3% (annual) return above the DJUBS index—information ratio = 0.32. The wealth path of the commodity index is shown in Figure 3. Compare this index with the Dow Jones UBS long commodity index. Clearly, the large drawdown in 2008 had a significant impact. Also, compare the index with the NewEdge CTA index. Here, the index did not increase noticeably over the past few years, even though commodity prices had been increasing for period 2009–2010. Bhardwaj *et al.* (2008) discuss the underperformance of CTAs, especially during periods between crashes.

In Table 4, we evaluate the performance of the Target 100 index by reference to traditional assets:

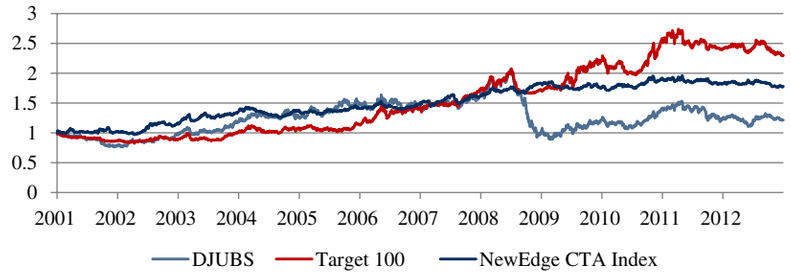

Figure 3 Wealth path for Target 100 commodity index and long DJUBS index and NewEdge CTA index.

Table 4 Performance of Target 100 index and traditional assets (January 31, 1992 to December 31, 2012).

	Target 100	SP500	Composite bonds	T-bills
Geo return	6.95%	8.29%	6.6%	3.2%
Volatility	11.3%	14.8%	5.8%	0.6%
Sharpe ratio	0.35	0.36	0.62	0.38
Drawdown	17.7%	51.0%	9.4%	0%
Return/DD	0.39	0.16	0.70	NA
RMS (DD)	7.2%	17.1%	2.7%	0%
Return/RMS (DD)	0.55	0.31	1.34	NA
Corr. w/SP500	0.129	1.0	0.11	0.06

stocks, bonds, and cash (T-bills). The commodity index return is roughly comparable to stocks and bonds, with drawdown values between the two. While bonds outperformed stocks under the Sharpe and drawdown measures, most financial experts do not expect bonds to continue this pattern going forward due to today's low interest rates. While there is confidence that inflation will remain low for the near term, a number of risks exist that might change the dynamics so that inflation could increase over the longer term—3 to 7 years. In this case, commodities will provide increased performance, along with high volatility (adding to rebalancing gains).

Another useful risk measure is the root mean square of drawdown values (Ulcer index). This risk measure evaluates both the maximum drawdown and the length of the drawdown and is popular in commodity and CTA hedge funds.

The commodity index measures solely the excess return of the futures markets. In practice, an investor will receive excess return *plus* performance on the assets residing in the margin account. Typically, the investor uses T-bills for margin. In this situation, the total return of the Target 100 commodity index—excess return + T-bills—improves to 10.4%, with the same volatility (11.3%) and drawdown numbers (17.25%). However, the current level of T-bills—close to zero—means that the total and excess return will be roughly equal for the foreseeable future. The next section shows that the investor can improve upon this situation by employing the commodity index as an overlay to a standard stock/bond portfolio.

5 The commodity index as an overlay strategy

Commodities provide a potential source of diversification benefits under normal circumstances. As we have seen, however, long commodity funds are hindered by sharp drawdowns associated with reductions in economic activity—remember the 2008 performance when the major indexes (GSCI and DJUBS) fell 50–60%—and by roll losses.

In contrast, the presented commodity index gives rise to much lower drawdown, while preserving a portion of the benefits of long biased commodity funds. To show the impact of these relationships, we start with a traditional stock bonds mixture (50/50) as our core portfolio—rebalanced monthly (column 2, Table 5).

Next, we combine the commodity index as an overlay to the 50/50 stock/bond portfolio. Since futures markets are employed in the index, there is no borrowing costs, either explicit or implicit, for the integrated portfolio.

Since the commodity index return is relatively independent of stock and bond performance (correlation less than 0.15, Table 4), the combined portfolio has the desirable additive property. Also, Table 5 and Figure 4 show a significant feature of the combining the index with the core 50/50 portfolio: the modest increase in total drawdown—for example, moving from 28% to 29.5% when linking 50% commodities to 50/50 stock/bond portfolio. While overall volatility increased to 10.8%, this level is roughly comparable to a 60/40 stock/bond mix.

For long-term investors, the ratio of return per max drawdown is a good risk-adjusted evaluator. Herein, the higher levels of the commodity index in a combined portfolio provide higher risk-adjusted performance; the drawdown values are modest due to the independence of return between equities and bonds and the commodity index. Note that all of the risk-adjusted measures—Sharpe, returns/DD, and return/RMS

Table 5 Historical performance: Adding Target 100 index to 50/50 stock/bond mix (January 31, 1992 to December 31, 2012).

Stocks/bonds/commodity index:

	50/50/0	50/50/25	50/50/50	50/50/75
Geo return	7.75%	9.65%	11.5%	13.3%
Volatility	8.2%	9.2%	10.8%	12.8%
Sharpe ratio	0.57	0.72	0.79	0.80
Drawdown	28.0%	28.2%	29.5%	31.7%
Return/DD	0.28	0.34	0.39	0.42
RMS (DD)	5.77%	5.95%	6.55%	7.6%
Return/RMS (DD)	0.82	1.1	1.3	1.34
Corr w/SP500	0.938	0.883	0.786	0.69

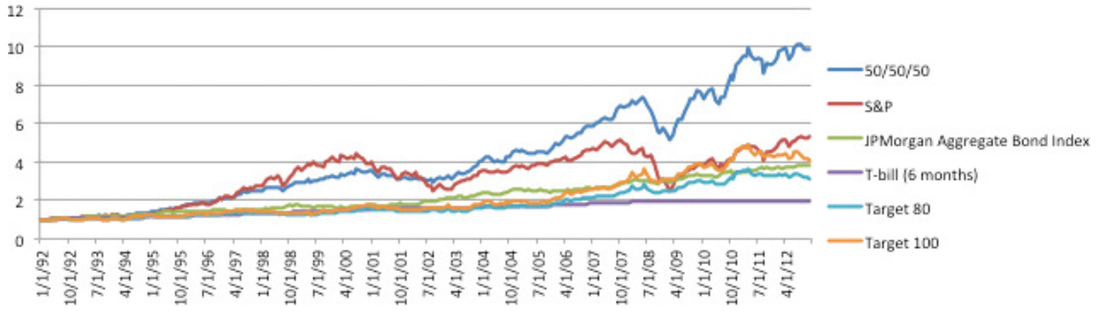

Figure 4 Combining Target 100 commodity index with 50/50 stock/bond mix.

(DD)—increase as a function of the level of the overlay. The correlation of the combined portfolio with the SP500 index drops as well.

6 Conclusions

In the future, the shifts to alternative assets will likely increase as the primary asset pillars—stocks and bonds—encounter headwinds and as institutional investors strive to meet growing liabilities and goals from deficit positions. We propose that rule-based indexes provide utility for select categories within the alternative universe. These smart beta strategies should be designed to complement the performance of traditional markets—thus improving diversification benefits. Likewise, these indexes can be good proxies for active managers. An index has much lower costs than typical alternative asset managers.

To this end, we constructed a commodity index via a portfolio of four tactics. The approach serves several functions. As a transparent index, it provides a benchmark for actively managed commodity funds. Investors can make their choice: take a low-cost index, or invest in an active fund with higher fees. We showed that the index takes advantage of long-standing properties of commodity prices: slowly moving trends in prices, high volatility, and relative independence of the return factors. By resetting the investments each month to the allocation targets—equal weights in our case, the index harvests rebalancing gains, in addition to the return of individual tactics. Also, since commodity future markets are employed, the investor can link this index to a core portfolio without borrowing costs. The portfolio model must consider risk allocation, accordingly.

Going forward, we expect other alternative assets can be "tracked" by rule-based indexes. For example, we have conducted preliminary work in the private equity arena (Ling, 2010). As with commodity funds, there are advantages of a tracking index in private equity for asset allocation and related tasks. As another example, Jurek and Stafford (2011) developed an option strategy to meet or exceed the return of a median hedge fund. These rule-based indexes and their underlying tactics are a significant next step in the world of index investing.

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