Commodity Futures as an Asset Class:
Using Insurance-Providing Index Construction as a Vehicle for Superior Risk Sharing

Coleman Long, CFA
Gabrielle Perregaux
James Wesner, CFA

Kellogg School of Management
Analytical Finance Practicum

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Executive Summary

Commodity futures indexes, like the Goldman Sachs Commodity Index and the Dow Jones/AIG, provide several important benefits for a diversified investor. These indexes offer a hedge against unexpected inflation, very low correlations with other assets classes, and the promise of long-term returns rivaling those of equities. However, the weighting schemes currently used to construct these index products are not representative of commodities as insurance-providing asset class.

To fully expose investors to the risk-sharing opportunities available in commodity futures, we propose using an insurance model to guide index construction. This will lead to products that better represent the risk sharing and inflation hedging opportunities available in commodity futures.

This paper has two primary objectives. The first is to identify and explain the source of the benefits from investing in commodities as an asset class. The second is to use these insights to suggest a new framework for practitioners and other researchers to improve the risk-sharing properties of commodity futures index products.

I. Should Commodity Futures be Considered an Asset Class?

Commodity futures do not fit neatly into the traditional definition of asset class. However, when viewed from the perspective of investor needs, it is useful to classify commodity futures as an asset class.

What constitutes an asset class?

Before we begin our assessment of the benefits of investing in commodity futures, we must first address whether a derivatives-based investment should be viewed as an asset class.

The common practice is to group individual securities into assets classes with similar characteristics (market cap, book/price ratio, how they are traded, liquidity, or risk characteristics) so that they will be more highly correlated with each other than with the

securities in different asset classes. As a result, asset classes are often clearly distinctive in their expected return, volatility, or correlation with other asset classes. [1]

Three broad categories of asset classes are Fixed Income, Equities, and Alternative Investments. These broad categories can be split into more specific asset classes. For instance, fixed income can be subdivided into government, corporate, mortgages, domestic and foreign bonds. Equities can be further divided into domestic, foreign, small cap, mid cap, large cap, value and growth. Alternative Investments have subcategories of real estate, private equities, and hedge funds.

Under this traditional view of asset classes, it is not clear whether commodity futures should be considered an asset class. Although commodity futures have very low correlations with the established asset classes (see table below), they also have very little correlation with each other. In fact, the average correlation among the individual commodity futures in the GSCI, the most widely tracked commodity futures index, has been -0.09 from 1982 to 2004.[2]

Correlation of Commodities Futures with Stocks & Bonds (1970-2004)			
	Stocks	Bonds	T-Bills
Monthly	-0.04	-0.04	-0.02
Quarterly	-0.28	-0.07	0.00
1-Year	-0.14	-0.30	-0.03
5-Year	-0.38	-0.13	-0.03

Derivatives, which include commodity futures, are not typically viewed as an asset class. Derivatives are primarily used to gain exposure to one of the traditional asset classes indirectly. For example, futures, options and swaps are used to construct synthetic equity and fixed income positions.

[1] Haugen, Robert A. "Modern Investment Theory" 5th Edition, pg 177.
[2] Harvey, Campbell R. and Erb, Claude B., "The Tactical and Strategic Value of Commodity Futures" (February 11, 2005).

However, **it may be appropriate to group certain derivative securities into an asset class based on investor needs.** If a certain group of investors would like to take similar positions in a collection of derivative securities that have similar characteristics, it would be convenient to create an investible pool of those securities and treat them as an asset class.

An example would be futures contracts on Foreign Exchange. Investors who live in the US and are concerned that the US dollar will depreciate against the Euro may hold a long position in Euro futures, while those living in European countries take the short position (*See Fisher Black, "Equilibrium Exchange Rate Hedging," who shows that in equilibrium investors will hold the market portfolio, domestic risk free asset and a hedge portfolio of FX positions*[3]). Instead of every investor trading in futures contracts, it may be more convenient to create an investible futures index of each important foreign exchange currency, with the index manager responsible for trading in the underlying futures contracts and rolling them over.

Another example would be an investible commodity price inflation index that is created using futures contracts on commodity prices. In this case, the institutional and other individual investors would provide insurance to those who need it. The importance of creating an index as an insurance-providing vehicle (and receiving a premium for doing so) is the underlying rationale behind our analysis of the role of commodity futures as an asset class.

II. Benefits of Investing in Commodity Futures

[3] Black, Fisher. "Equilibrium Exchange Rate Hedging." The Journal of Finance. July 1990

The benefits of investing in commodity futures include diversification with other asset classes, inflation hedging, and a potential for positive excess return.

The past performance characteristics of commodities highlight that this asset class has been a valuable part of an investor's diversified portfolio. Not only has the asset class provided strong stand-alone returns, but it has also displayed diversification benefits with other asset classes, and has been shown to hedge against inflation. Combined, these factors help explain the positive effects that commodities have when added to an investor's diversified portfolio.

Favorable Long-Term Performance

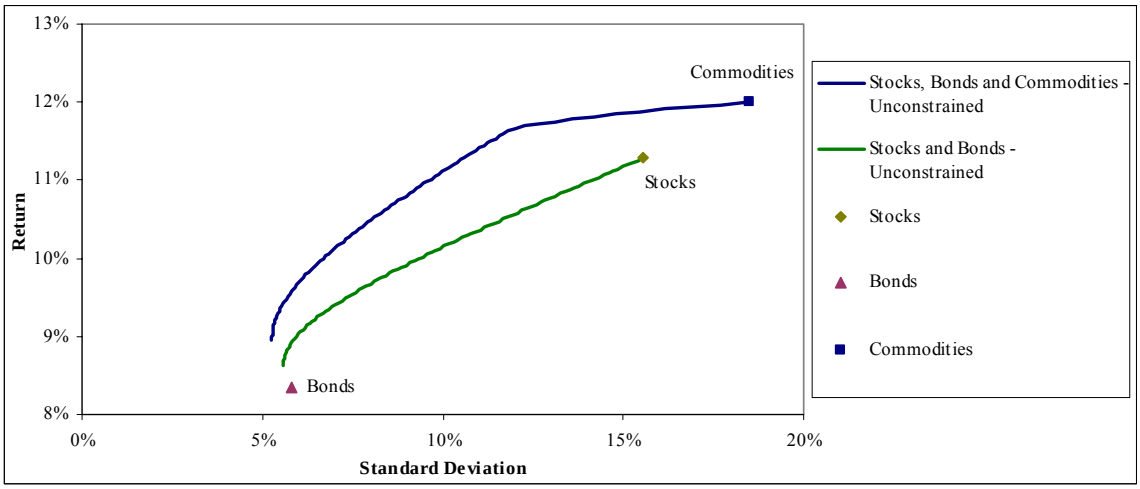
Commodities futures, as represented by the Goldman Sachs Commodities Index (GSCI), have generated returns similar to equities over the past 35 years with comparable risk. While past performance is not necessarily a predictor of future returns, these numbers are particularly compelling in that the period includes the long bear market for commodities which lasted nearly two decades, beginning in the early 1980's.

Historical Performance Characteristics
January 1970 - December 2004: Annualized Statistics

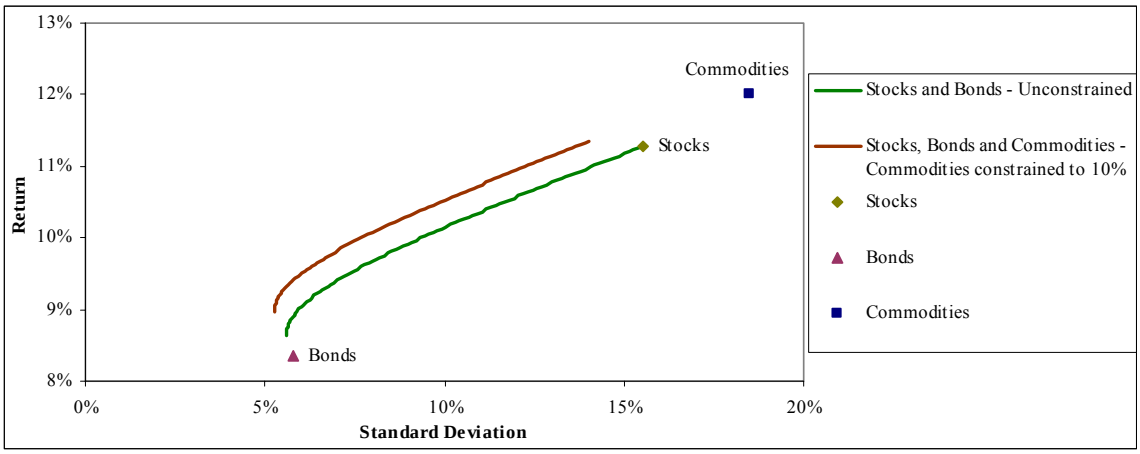
	Return	Standard Deviation	Sharpe Ratio
Stocks	11.28%	15.54%	0.33
Bonds	8.50%	5.79%	0.41
Commodities - GSCI	12.00%	18.51%	0.32

Diversification Benefits

Historically, commodity futures collectively have had low correlations with stocks and bonds (see Section I). The benefit of this low correlation is most relevant at the portfolio level. For example, when commodity futures are added to a 60/40 stock and bond portfolio, these varying return streams can greatly reduce volatility on the portfolio level. The first frontier below shows the benefits that adding commodities futures provide to the portfolio by pushing the frontier out, making available lower risk portfolios for a respective return level. While the unconstrained portfolio highlights the diversification benefits, it does not reflect the more limited allocation that investor typically give to commodities.



Constraining the allocation of the commodities futures asset class to 10% reflects the more realizable benefits of allocating a piece of the portfolio to commodities. Even small allocations to commodities provide clear, meaningful risk reduction.



The benefits are further highlighted by examining the effects on a particular portfolio – see table below. When starting with a 60/40 base portfolio on the stock and bond frontier (green line), moving over to the constrained frontier (red line) while keeping the return level constant results in a portfolio with risk levels reduced from 9.83% to 8.08%. While the benefits are compelling a more appropriate comparison may be to proportionally reduce the stock and bond holdings to arrive at the 54% stock, 36% bond and 10% commodity level. Again this portfolio is more consistent with an investor's realistic holdings. This portfolio also sees significant risk reduction of 88bps with increased return of 26bps compared to the base portfolio.

Addition of Commodities to Traditional Portfolios		
	Return	Risk
Portfolio A - Base Portfolio (60%/40%)	10.51%	9.83%
Portfolio B - Constant Return (50%/40%/10%)	10.51%	8.39%
Portfolio C - Proportional Allocation (54%/36%/10%)	10.66%	8.95%

While this in itself is an important feature, what the investor may care more about is whether the benefits of low correlation hold during times of extremely poor performance in the traditional asset classes. Gorton and Rouwenhorst find that the

diversification benefits of commodity futures actually increase during lowest returns for stocks and for bonds:[4]

- During the 5% of months with worst equity market performance, stocks experienced an average loss of 8.98% while commodity futures experienced a gain of 1.03%, **which was greater than their average monthly return of 0.89% during the full sample.**

- During the 1% of months with the worst equity market performance, stocks experienced a loss of 13.87%, while commodity futures returned an average of 2.38%.

Gorton and Rouwenhorst find that diversification benefits of commodity futures remain quite strong during times of significant downturn in the equity markets, which is when they are most useful to an equity-heavy portfolio.

Holding the view that commodities will be added to a balanced portfolio, our studies again examined the benefits of commodities on the portfolio level. Consistent with Gorton's findings with individual assets classes, commodities displayed strong diversifying performance during periods of drastic downward moves in the traditional base portfolio.

- For the 5% of months with the worst performance of the 60%/40% portfolio, **commodities returned 2.39% to help offset the -5.49% returned by the base portfolio**.

Inflation Hedging

A commodity index provides an inflation hedge, because commodities collectively have a positive correlation with both inflation, and more importantly, with unexpected inflation.

[4] Rouwenhorst, K. Geert and Gorton, Gary B., "Facts and Fantasies about Commodity Futures" (February 28, 2005). Yale ICF Working Paper No. 04-20.

Commodities have long been viewed as a hedge against inflation. Periods of rising inflation can depress bond and stock returns, the two asset classes that dominate most diversified portfolios. Since the market incorporates expected inflation into stock and bond prices, it is the *unexpected* component of inflation that poses a more significant risk to the investor. There are two ways to define unexpected inflation: the actual rate of inflation minus the previous month's Treasury bill rate; or simply the change in the rate of inflation. In our calculations, we use the former method.

The table below depicts how various asset classes correlate with inflation, and more importantly, with unexpected inflation:

Quarterly Corrleations with Inflation January 1970 - December 2004		
	Inflation	Unexpected Inflation
Stocks	-0.22	-0.23
Bonds	-0.18	-0.35
Commodities Futures	0.19	0.22

The data shows that stocks and bond returns are negatively correlated with both inflation and unexpected inflation, indicating that increases in inflation rates are associated with below-trend returns in these traditional asset classes. On the other hand, an index of commodity futures has had positive correlations with both types of inflation.

While a commodity futures index has historically been an effective hedge against inflation, a more detailed understanding of what drives the positive correlation with unexpected inflation is needed to determine the best way to utilize commodities as an inflation hedge. Part of the answer can be found by examining the behavior characteristics of the individual commodities making up the index.

The very low correlation among individual commodity futures suggests that within a long-only index, there will be a significant number of commodities that are not supplying inflation protection.

Within the commodity futures asset class, there is extremely low correlation between the individual commodities. When aggregated into an index, this low correlation results in a diversification return, which is a product of the reduced volatility that accompanies the combination of various volatile components. The low correlations also highlight the issue that the various commodities do not display similar behavioral characteristics, most notably, greatly varying degrees of inflation hedging. For example, over the past 20 years, the degree of correlation to unexpected inflation has ranged from 0.39 for Unleaded Gas to -0.12 for Sugar.

Correlation Matrix
January 1985 - December 2004

	Return	Standard Deviation	Crude Oil	Heating Oil	Unleaded Gas	Natural Gas	Live Cattle	Lean Hogs	Corn	Oats	Soybeans	Wheat	Cocoa	Coffee	Cotton	Orange Juice	Sugar	Copper	Gold	Platinum	Silver	*Unexpected Inflation*
Crude Oil	2.52%	35.05%	1.00																			
Heating Oil	2.68%	40.22%	0.84	1.00																		
Unleaded Gas	2.37%	40.78%	0.78	0.61	1.00																	
Natural Gas	4.46%	50.72%	0.28	0.38	0.20	1.00																
Live Cattle	1.50%	16.84%	0.09	0.20	0.17	0.14	1.00															
Lean Hogs	0.30%	34.85%	0.12	0.01	0.21	(0.03)	(0.05)	1.00														
Corn	-1.36%	25.74%	(0.32)	(0.30)	(0.10)	0.06	(0.04)	0.08	1.00													
Oats	-0.71%	36.91%	(0.07)	(0.02)	0.00	(0.01)	(0.14)	(0.10)	0.60	1.00												
Soybeans	-0.22%	22.26%	(0.16)	(0.15)	(0.02)	(0.02)	(0.05)	0.15	0.70	0.48	1.00											
Wheat	-0.61%	24.58%	(0.18)	(0.03)	(0.14)	0.04	0.14	(0.29)	0.46	0.49	0.27	1.00										
Cocoa	-1.40%	30.21%	0.17	0.08	0.11	0.11	(0.03)	(0.18)	0.06	0.18	0.02	0.24	1.00									
Coffee	-1.57%	41.89%	0.04	0.00	(0.07)	(0.14)	(0.08)	(0.07)	0.04	0.03	0.09	0.02	0.21	1.00								
Cotton	-1.93%	30.87%	(0.14)	(0.07)	0.04	(0.06)	(0.08)	0.20	0.15	(0.04)	0.19	(0.04)	(0.11)	(0.17)	1.00							
Orange Juice	-3.05%	31.07%	(0.14)	(0.13)	(0.09)	(0.06)	(0.01)	(0.11)	0.09	0.20	0.01	0.08	0.17	(0.18)	(0.12)	1.00						
Sugar	3.96%	43.85%	(0.18)	(0.11)	(0.22)	0.01	(0.08)	(0.12)	0.05	0.04	0.15	0.05	0.01	(0.05)	0.15	0.10	1.00					
Copper	4.77%	26.24%	0.10	0.10	0.07	0.04	(0.13)	(0.06)	(0.02)	0.04	0.13	0.07	0.09	0.29	0.19	(0.13)	0.21	1.00				
Gold	1.75%	13.21%	0.32	0.37	0.12	0.15	(0.01)	(0.04)	(0.11)	0.09	0.09	0.09	0.10	0.02	(0.07)	0.07	(0.02)	0.25	1.00			
Platinum	0.08%	0.21%	(0.03)	(0.03)	0.00	0.15	0.17	0.11	0.02	(0.01)	0.11	0.04	0.03	0.06	0.13	(0.01)	0.25	0.15	0.37	1.00		
Silver	0.34%	23.52%	0.00	(0.04)	0.03	(0.09)	0.05	(0.03)	0.20	0.15	0.15	0.10	(0.06)	(0.07)	(0.02)	0.14	(0.01)	0.14	0.37	0.35	1.00	
Unexpected Inflation			*0.29*	*0.12*	***0.39***	*(0.06)*	*0.22*	*0.14*	*0.08*	*0.02*	*0.20*	*0.02*	*0.09*	*0.10*	*(0.05)*	*(0.01)*	***(0.12)***	*0.05*	*0.10*	*0.04*	*0.20*	*1.00*

*Note the average correlation among the individual commodities is 0.06. This includes the high correlations that the energy commodities have among each other.

The implication is that going long a group of commodity futures with low correlations among individual commodities will consistently exposure investors to some commodities that not only fail to supply inflation protection, but are actually delivering negative returns when unexpected inflation occurs. Essentially, going long all of these largely uncorrelated positions will lead to some canceling out of the expected inflation

hedging benefits. **This begs the question of whether there is a common, identifiable attribute that could more effectively group the expected return properties of commodity futures into an investible index.**

III. How to Invest in Commodities

An investor has several options to gain exposure to commodities: through the spot commodity market, commodity futures, or ownership of firms that invest in or produce commodities. Of these options, commodity futures are the most effective method of capturing the risk-reduction benefits associated with commodity investing.

So what is the best method to gain exposure to commodities and receive the benefits we identified in the previous section? We outline the basic methods to gain commodity exposure, and describe why, from a portfolio risk perspective, investing in commodity futures is extremely attractive.

Instead of using the futures market, an investor could gain more direct access to commodities through the spot market, by directly purchasing commodities like gold or oil. However, this direct method comes with the risks of substantial storage costs. The financial and logistical burden of storage makes owning and selling the spot commodity a more cumbersome choice for a portfolio manager trying to efficiently manage risk across a myriad of positions.

To avoid the carrying costs of the spot market, investors are often better served investing in commodity futures contracts. These individual contracts, which are traded on various exchanges, represent an obligation to purchase a commodity at a certain price on a certain date. To gain the benefits of portfolio diversification among different futures

investments, an investor can go long an index of commodities futures such as the Goldman Sachs Commodity Index, or the Dow Jones-AIG Commodity Index. From the investor's perspective, these products provide convenient access to the diversification benefits of commodity futures through just one long position. The investor then lets the index manager (Goldman Sachs), determine the commodity weights and the proper re-balancing procedure throughout the year.

Intuitively, investing in the stocks of publicly traded companies that produce commodities would seem to be another good method for gaining exposure to the benefits of commodity investing. However, by investing in large equity firms, even when deemed a "pure play" commodity producer, the investor loses a key benefit of commodity investing: the negative correlation with the stock market. Gorton and Rouwenhorst demonstrate that the diversification benefits are significantly greater for an equally-weighted commodity futures index than for an investment in commodity producing stocks.[5] From 1962 to 2003, the correlation of "pure play" commodity stocks with the S&P 500 was 0.57, indicating a much lower diversification benefit than that found in a commodity futures index, which consistently offers negative correlations with the broader stock markets.

To put the different methods of commodity investing into a real-world perspective, we interviewed Will McLean, the Chief Investment Officer of Northwestern University endowment. He noted that roughly half of the top 30 university endowments are invested in commodities in one form or another. A typical investment profile for a large endowment like Northwestern University could include 3% invested in

[5] Rouwenhorst, K. Geert and Gorton, Gary B., "Facts and Fantasies about Commodity Futures" (February 28, 2005). Yale ICF Working Paper No. 04-20.

commodities (with 1% of which invested in timber), 6% in private equity companies investing in energy or other commodities, and 2.5% invested in hedge funds that are invested in commodities.[6]

Commodity indexes most likely to be used by endowments and other institutional investors include the GSCI, the Dow Jones/AIG, or the Rogers International Commodity Index[7]. The GSCI, which is the most popular commodity index, concerns some of the institutional investors we spoke with due to its high weighting in energy, which was over 75% as of June 2005.[8] For investors concerned about too much energy exposure, the Rogers Index and Dow Jones/AIG are attractive options due to a more even allocation among commodity sectors.

IV: Insurance Model as Explanation of Commodity Futures Returns

The insurance model creates a framework for understanding the source of returns from commodity futures investing. Investors in commodity futures expect a positive return for supplying insurance to price hedgers. Price insurance is provided by investors going long backwardated futures contracts, or by shorting contangoed contracts. This framework allows for more effective grouping of commodity futures based on investor needs.

To understand the source of commodity futures returns, we must understand the motivation of both the long and the short position of each futures contract. Using an insurance model will help to clarify the role of commodity futures for both the buyer and the seller of a futures contract.

[6] Interview with William McLean, CIO of Northwestern Endowment. May 20, 2005.
[7] See www.rogersrawmaterials.com/page1.html for an overview of the index construction.
[8] For current weightings of the GSCI, see www.gs.com/gsci

Price insurance to spot commodity producers

For a firm like Chevron that produces and sells a spot commodity (oil), selling oil in the futures market is an effective way to protect the firm against significant downturns in oil prices. Thus, a short position in the futures market provides a clear price-insurance benefit to Chevron, the commodity producing firm that is long the spot commodity. But what is the incentive to take a long position in an insurance providing futures contract?

The long position must be compensated for providing this price insurance to the seller. As a result, the agreed upon futures price is expected to increase over time to benefit the long futures position for supplying insurance to the risk-averse commodity producer.

When the futures markets are dominated by risk-averse commodity producers who are going short futures positions (or "net short"), the term structure is typically backwardated. Backwardation occurs when the spot price is greater than the futures price. This should make intuitive sense, as the oil producing firm, Chevron in our example, is willing to sell at a future price lower than the spot price as part of the cost of receiving future price insurance.

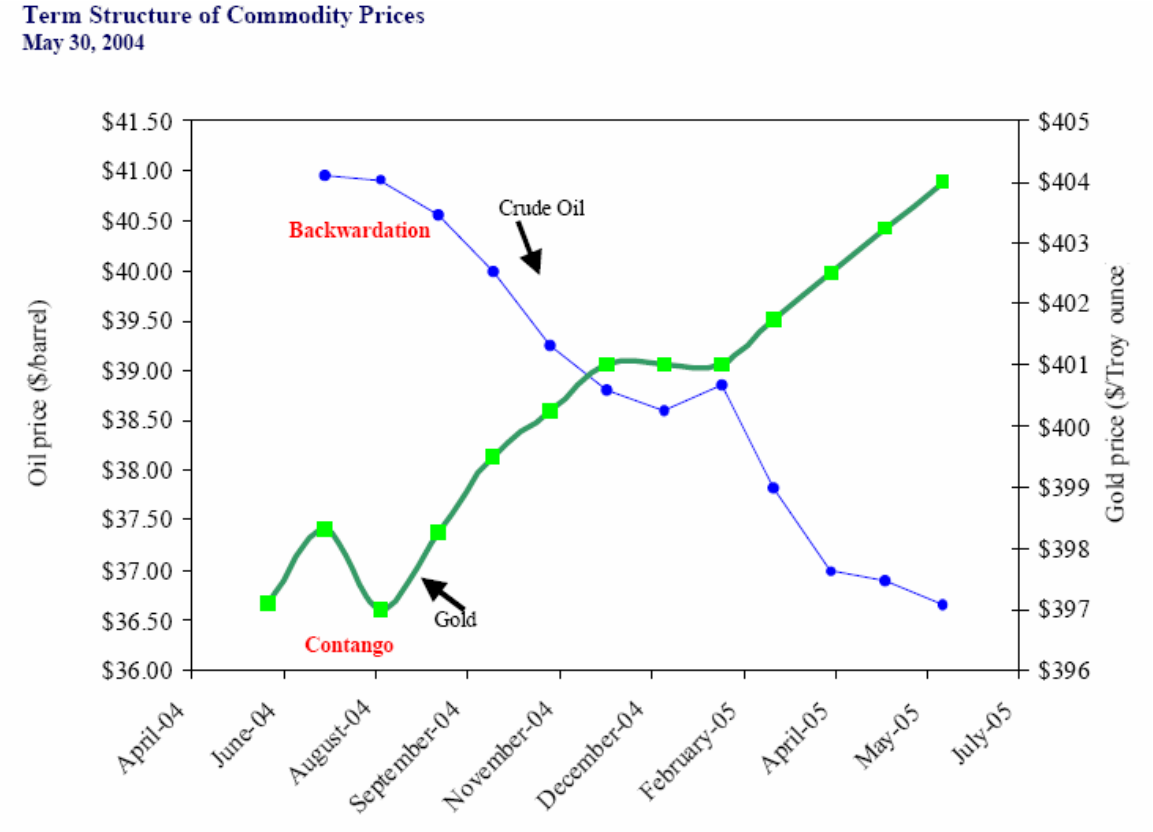
The key insight from the investor's point of view is that **excess returns, as measured by the change in futures prices, are earned by supplying price insurance**. When the futures term structure is backwardated, an investor supplies insurance by taking a long position in the futures market. In this example, the term structure is being set by the net hedging pressure created by the short positions of commodity producers seeking price protection.

Price insurance to spot commodity consumers

But what about the situation where the futures market is dominated by consumers of commodities, who are short the commodity in the spot market? For example, Ford, as a buyer of steel, is concerned that steel prices will increase in the future. To hedge against the chance of a severe price increase, Ford (who is short steel in the spot market), will hedge its position by buying (going long) steel futures contracts. When the futures market is "net long" these price-hedging commodity consumers like Ford, investors can supply them insurance by going short the commodity futures market. The incentive for supplying insurance through short positions in contangoed markets comes from the expectation of an excess return through a decrease in futures prices.

When the futures market is, as in this example, net long the price hedging commodity consumers, the term structure of the commodity futures will be in contango. Contango depicts the situation where the futures price is higher than the current spot price. Again, this should make intuitive sense. The commodity consumer in the spot market is willing to go long a position in the futures market at a slightly higher price (compared to the spot market) as part of the cost of buying price insurance against extreme price increase.

The graphic below gives an example of both a backwardated (crude oil) and contangoed (Gold) commodity futures as of May 2004.



The insurance model allows the investor to use the term-structure of the futures market to better identify insurance-providing opportunities that should lead to excess returns.

Additional benefits to insurance model: better inflation hedging

In addition to receiving excess returns, investors using the insurance model are also in a better position to hedge against unexpected inflation. Erb and Harvey found that from 1982-2003, the average roll returns (which are earned from supplying price insurance), have explained 67% of the cross-sectional differences among individual commodities' inflation betas. This suggests that excess return earned from supplying

price insurance (going long backwardated futures, or going short contagoed futures) has been "highly correlated with realized unexpected inflation betas."[9]

V. Current Commodity Indexes: Weighting and Representation

The three major commodity futures index products each utilize different weighting schemes: production based (GSCI), a combination of liquidity and production weighted (Dow Jones-AIG), and equally weighted (CRB). The weighting methods are an indicator of the "representativeness" of an index.

An index should be:

1. **Representative:** It should reflect the broad range of investment opportunities available within the asset class.

2. **Investible**: Investors must be able to create a trading portfolio that tracks the index. The index should contain securities that are liquid and of investment-grade quality.

3. **Transparent**. The methodology should be clear and consistent, so that those benchmarking to or investing in the index can understand the risks of the product.

We begin our assessment of the three main commodity futures indexes by examining how representative their weighting schemes are. The three main commodity indexes currently on the market are the Goldman Sachs Commodity Index (GSCI), the Dow Jones-AIG Commodity Index (DJ-AIGC), and the Reuters/Jefferies CRB Commodity Index (CRB).

Goldman Sachs Commodity Index (GSCI)

[9] Harvey, Campbell R. and Erb, Claude B., "The Tactical and Strategic Value of Commodity Futures" (February 11, 2005).

The GSCI is a "production weighted" commodity futures index that is marketed to investors as a benchmark for investment performance in the commodity markets comparable to the S&P 500 equity index. Individual commodity futures qualify for inclusion in the GSCI on the basis of their liquidity. Then the index weighting of each commodity is determined by the spot commodity's average quantity of world production over the last five years of available data. This production weighting methodology has led to over a 75% weight in energy futures as of June 2005.[10] As of June 2005, the GSCI contained 24 commodities from all commodity sectors.

Of the three indexes, the GSCI is the most widely tracked by investors, garnering over 85% of the combined open interest of the three indices.

Dow Jones AIG Commodity Index (DJ-AIG)

The second most-widely tracked commodity futures index is the DJ-AIG. The DJ-AIG is composed of futures contracts on 19 physical commodities. The commodity futures are weighted primarily by liquidity data, which is defined as the relative amount of trading activity of a particular commodity future. The index also relies, but to a lesser degree, on dollar-adjusted production data to weight some of it futures.[11]

DJ-AIG places caps on upper and lower bounds on the weighting of any single commodity. For instance, no related group of commodities (e.g., energy, precious metals, livestock and grains) can constitute more than 33% of the index. Also, no single commodity may constitute less than 2% of the index. Due to these restrictions, the DJ-

[10] www.gs.com/gsci/#economic
[11] www.djindexes.com/mdsidx/index.cfm?event=showAigIntro

AIG had limited its energy exposure to 33% of the total index (compared to 75% weighting of the GSCI) in 2005.

Reuters CRB Futures Index

The Reuters/Jefferies CRB Index, is an equally-weighted index of 17 commodity futures. The CRB follows a monthly rebalancing schedule to maintain its equal commodity weightings.

Frequency of Rebalancing

The Dow Jones AIG and the GSCI are both rebalanced yearly instead of monthly (such as with the CRB Index), which studies have shown to cause a loss of 1.5% of return when compared to monthly rebalancing. In general, indexes that rebalance at least monthly, have on average, a 2% annual return advantage.[12]

VI. Why current products fail to capture benefits of commodity futures

Current commodity futures indexes are not representative of the broad range of risk sharing and inflation hedging opportunities available to the commodity investor. By weighting indexes based on relative importance in the economy, GSCI and Dow Jones/AIG have created products that systematically exclude opportunities for risk sharing and inflation hedging.

The weighting schemes of currently-available indexes fail to capture the risk sharing opportunities available in the commodity futures markets, and are therefore not truly representative of commodity futures as an asset class.

[12] Seamans Capital Management. "Commodity Indexes Overview and Analysis" July 2003.

As discussed in section V, both the GSCI and the Dow Jones AIG indexes are comprised of a collection of long-only positions that are selected and weighted based, in part, on the commodity's relative importance in the economy. Investors are comfortable with this story, as production-based weightings appear to be analogous to the market-cap weightings used in equity index funds like the S&P 500 and the Russell 1000. However, when the role of commodities is viewed in the context of the insurance model (see section IV), we find these weightings schemes to be inappropriate for investors seeking exposure to commodity futures benefits by supplying price insurance to hedgers.

The insurance model shows that commodity futures create investment opportunities that are driven by the term structure of the futures. In this context, the relative importance of the individual commodity futures should not be determined by world production statistics of the underlying spot, or by the amount open interest on the commodity futures markets. **Instead, the weighting of the commodity future should be determined by the nature of who is supplying or demanding the futures, as evidenced by the term structure.** A representative commodity futures index, therefore, should reflect, as broadly as possible, all of the insurance-supplying opportunities available to the commodities investor.

As outlined section IV, commodity futures in a backwardated state reflect opportunities for long-positions to supply insurance, and in return receive a positive roll returns which are highly correlated with positive inflation beta. Conversely, commodity futures that are in contango should be shorted by an investor seeking to gain exposure to these benefits of supplying insurance.

By utilizing a long-only structure and ignoring persistent term-structure properties, both the GSCI and the DJ/AIG devote a sizeable portion of their indexes to long positions in commodity futures that have demonstrated persistent contango status. This represents an opportunity lost for investors seeking to supply price insurance. For instance, on June 6, 2005**, 89% of the GSCI was long commodity futures that were in contango**.

Term Structure of GSCI Components (June 6, 2005)

Commodity	Type	Ticker	Nearest Term Future	Next Nearest Term	(Nearest Term Future)/(Next Nearest Term)	Contango or Backwardated?	Relative Weight in GSCI**	Exchange
Crude Oil	Energy	CL	54.49	55.69	0.978	C	29.21%	NYM
Brent Crude Oil	Energy	LCO	53.67	54.58	0.983	C	14.53%	IPE
Unleaded Gas	Energy	HU	152.95	153.59	0.996	C	8.48%	NYM
Heating Oil	Energy	HO	161.65	162.68	0.994	C	8.83%	NYM
Gas Oil	Energy	LGO	507.25	510.00	0.995	C	4.84%	IPE
Natural Gas	Energy	NG	7.12	7.20	0.990	C	9.24%	NYM
Aluminum	Industrial Metals	IA	1763.50	1770.50	0.996	C	2.65%	LME
Copper	Industrial Metals	IC	3468.00	3396.00	1.021	B	2.35%	LME
Lead	Industrial Metals	IL	999.00	987.00	1.012	B	0.29%	LME
Nickel	Industrial Metals	IN	17170.00	16850.00	1.019	B	0.87%	LME
Zinc	Industrial Metals	IZ	1299.50	1300.50	0.999	C	0.54%	LME
Gold	Precious Metals	GC	426.50	427.30	0.998	C	1.65%	CMX
Silver	Precious Metals	SI	7.52	7.54	0.997	C	0.20%	CMX
Wheat	Agriculture	W	322.50	322.25	1.001	B	2.47%	CBT
Red Wheat	Agriculture	KW	326.00	334.00	0.976	C	0.89%	KBT
Corn	Agriculture	C	220.75	229.75	0.961	C	2.46%	CBT
Soybeans	Agriculture	S	677.75	680.25	0.996	C	1.89%	CBT
Cotton	Agriculture	CT	47.37	50.00	0.947	C	0.96%	NYC
Sugar	Agriculture	SB	8.83	8.92	0.990	C	1.22%	CSC
Coffee	Agriculture	KC	124.10	127.35	0.974	C	0.89%	CSC
Cocoa	Agriculture	CC	1421.00	1446.00	0.983	C	0.21%	CSC
Live Cattle	Livestock	LC	85.30	83.58	1.021	B	2.74%	CME
Feeder Cattle	Livestock	FC	113.25	112.00	1.011	B	0.76%	CME
Lean Hogs	Livestock	LH	68.58	68.40	1.003	B	1.84%	CME
% of GSCI in contango		**89%**						

** Based on Bloomberg closing prices.*
***Relative weights as of June 3, 2005 (source: Goldman Sachs)*

For an investor seeking an index to gain broad exposure to the risk sharing and inflation hedging aspects of commodity futures, a long position in the GSCI at this point would be an inappropriate option.

VII. Index Investibility & Transparency Standards

The three indexes all apply rigorous investibility and transparency requirements. We have identified some key criteria that should be industry standards for creating products suitable for (and marketable to) institutional investors.

Although the three indexes differ in weighting schemes, they all apply robust investibility and transparency standards that are useful guidelines when constructing an index that are suitable for institutional investors. All three address the transparency criteria by making their index construction manuals and policies available to the public on their respective websites. As for the issue of investibility, all three apply liquidity and quality standards to any contract considered for the index. For example, to meet the liquidity and quality standards of the GSCI, a contract must:

- Have a set expiration or term, and be available to trade at least 5 months prior to its expiration
- Be denominated in US dollars and must be traded through a facility that has its dominant place of business in a country that belongs to the OECD (Organization for Economic Cooperation and Development)
- Have Daily Contract Reference Prices[13] for at least two years prior to consideration for index inclusion and the contract must have Daily Contract Reference Prices published between 10AM and 4PM Eastern time on each Contract Business Day[14].
- Have volume data available for at least three months prior to consideration for inclusion in the index.
- Whichever facility a contract is traded through, that facility must make price quotes available to members, participants and Goldman Sachs (if Goldman is not a member), and cannot be a single-dealer platform.

[13] GSCI MANUAL 2005 EDITION: "Daily Contract Reference Price" With respect to each Contract Expiration and Contract Business Day, the price of the relevant Contract, expressed in U.S. dollars, that is generally used by participants in the related cash or over-the-counter market as a benchmark for transactions related to such Contract.

[14] GSCI MANUAL 2005 EDITION: "Contract Business Day" A day on which the Trading Facility on or through which a Designated Contract Expiration is traded is scheduled to be open for trading for at least three hours.

- Have a Total Dollar Value Traded[15] of at least 15 billion US dollars over an annual calculation period.

No matter what weighting scheme is utilized for index construction, it is critically important to adopt investibility and transparency standards, similar to those of the GSCI, as it is the market leader in terms of open interest, and, in effect, the current standard setter. Furthermore, a superior new weighting scheme, in terms of better representing investor needs, will be irrelevant to important market participants if it fails to sufficiently address liquidity and transparency standards set by the market leaders.

For a more detailed overview of the process and standards used by Goldman Sachs, please see Appendix A.

Section XIII: Our Proposed Index

We propose an insurance providing index, reweighted monthly, that goes long backwardated futures, and short contangoed positions.

We propose the creation of an index that weights positions in commodity futures based on how they can maximize investors' exposure to insurance providing opportunities. This will be accomplished by using term structure analysis to go long backwardated futures, while going short contangoed positions.

Although beyond the scope of this paper, the concept can be developed further to create more precise positions based on the relative levels of backwardation and contango. Such a product would weight the "more backwardated" long positions more heavily than the long positions that are not as backwardated. Level of backwardation could be

[15] GSCI MANUAL 2005 EDITION: "Total Dollar Value Traded" For any Annual Observation Period or Interim Calculation Period and with respect to a given Contract, the Total Quantity Traded of such Contract over such period (and annualized), as the case may be, multiplied by the Average Contract Reference Price for such period of such Contract.

measured on two dimensions: the slope of the term structure, reflecting the intensity of the hedging pressure, and the level of recent roll returns, which is also a proxy of how much insurance was provided. Similarly, the short positions could also be weighted more or less heavily based on how much they are in contango.

Besides being representative, this index must also be investible and transparent. Our proposed index will utilize the liquidity, quality, and transparency standards outlined in Section XII, to address any investibility or transparency concerns. The index will be rebalanced monthly, as futures positions are rolled forward.

Section IX: Data Analysis

"Insurance providing" portfolios offer better return and diversification benefits than a comparable long-only strategy. There may be some tradeoff, however, in the level of unexpected insurance protection provided.

We tested our insurance providing strategies against an equally weighted, long-only portfolio of 18 commodity futures that represent the range of commodities typically found in the three leading indexes.[16] These strategies were backtested against this long-only benchmark from 1983-2000.

Two different techniques were used to identify the insurance providing opportunities for each commodity future: the term structure and previous excess return.

Strategy 1: Term structure as an indicator of insurance opportunities.

We first used the term structure to identify, each month, whether a commodity was backwardated, or in contango. The term structure signal was simply the ratio of the

[16] Futures data was supplied from Futures Industry Institute Database

cash spot price divided by the nearest term futures price. If this ratio of spot to nearby futures price was greater than one, the future was labeled as backwardated, and we took a long position for that month. If this ratio was less than one, we took a short position, assuming contango.

The term-structure method was tested in three ways: using the current term structure; the average of the previous 6-month term-structure ratios; and the average of the previous12-month term structure ratios. Below is a summary of how our three versions of this long-short index faired against its long-only benchmark:

Performance of Long/Short - Term Structure Strategy
Utilizing periodic term structure ratios
February 1983 - December 2000: Annualized Summary Statistics

	Return	Standard Deviation	Sharpe Ratio	ρ to Stocks	ρ to Bonds	ρ to 60%/40% Blend	ρ to Unexpected Inflation	p-value
Long/Short (Term 1-mo)	4.53%	6.50%	0.70	0.01	-0.09	-0.01	-0.07	0.59
Long/Short (Term 6-mo)	5.37%	7.20%	0.75	0.01	0.01	0.01	-0.04	0.52
Long/Short (Term 12-mo)	4.66%	7.50%	0.62	0.01	-0.06	0.00	-0.03	0.61
Control Index (1-mo.)	2.15%	9.97%	0.22	0.02	-0.18	-0.01	0.09	-

All three term structure strategies (1, 6, and 12 month) earned superior excess returns compared to the long-only strategy. What makes the numbers more compelling, is that the superior return did not sacrifice diversification benefits with stocks (all three strategies had essentially zero correlation with the S&P 500, similar to the benchmark), as well as zero correlation with a traditional balanced portfolio of 60% stocks and 40% bonds.

The only tradeoff with this strategy seemed to be with unexpected inflation. All three variations of the term-structure strategy had slightly negative correlations with

unexpected inflation, while the long only strategy had the slight positive correlation typically seen with commodity products.

Another concern was that the returns of all these strategies, while beating the long only index, were statistically insignificant, as judged by p-values of the two tailed test with the benchmark returns. One explanation is that although the term structure is the most direct method to determine backwardation and contango, positions that had a spot/futures ratio of very close to one may not have been generating meaningful information about insurance opportunities that were distinct from the long-only strategy. In the future, more sophisticated weighting schemes could address this issue.

Strategy 2: Excess Return as a Proxy for Term Structure

We also used recent excess returns as a proxy for identifying insurance providing opportunities. Since insurance providers are rewarded with excess returns, as measured by the change in futures prices, we used recent positive excess returns as a signal of backwardation, and went long commodities having positive excess returns. Conversely, we viewed recent negative excess returns as a sign of contango, and went short commodities with a negative excess returns. To more thoroughly test this strategy, we used excess returns for the previous 1, 6, and 12 month periods as proxies for backwardation/contango.

The chart below summarizes the results of using excess returns as a proxy for insurance providing opportunities:

Performance of Long/Short - Excess Return Strategy
Utilizing previous period returns
February 1983 - December 2000: Annualized Summary Statistics

	Return	Standard Deviation	Sharpe Ratio	ρ to Stocks	ρ to Bonds	ρ to 60%/40% Blend	ρ to Unexpected Inflation	p-value
Long/Short (1-mo.)	2.75%	9.09%	0.30	-0.19	-0.01	-0.18	-0.03	0.78
Long/Short (6-mo.)	4.14%	7.66%	0.54	-0.08	-0.01	-0.08	-0.14	0.69
Long/Short (12-mo.)	7.64%	7.95%	0.96	-0.1	-0.06	-0.10	0.00	0.09
Control Index (1-mo.)	2.15%	9.97%	0.22	0.02	-0.18	-0.01	0.09	-

All three excess return methods (previous month, previous 6-month average, and previous 12-month average) delivered superior excess returns compared to its long only benchmark. More importantly, the returns did not sacrifice the diversification benefits with other asset classes, as all three executions of this strategy were negatively correlated with the S&P 500 benchmark, compared to a slightly positive correlation for the long-only control group.

The diversification with fixed income was also negative, but not quite as low as the long-only. However, when viewed in a traditional portfolio context (60/40 blend of stocks and bonds), the excess return strategy delivered superior diversification benefits, with a more negative correlation to a diversified benchmark than the long-only strategy.

Despite the return and diversification benefits of the using excess return as a proxy for insurance opportunities, there are two issues of concern. First, is that the correlation with unexpected inflation was slightly negative for the current and 6 month long-short strategy, and essentially zero for the 12-month. For this period at least (1982-2000), the excess return strategy did not provide a significant hedge against inflation.

It should be noted that the 12-month average excess return strategy, which delivered the largest return benefits and gave up the least amount of unexpected inflation

hedging, was the only strategy whose returns were statistically different from its benchmark at the 90% confidence level.

Section X: Conclusion

An insurance model is an effective first step in rethinking the role of commodities as an asset class. Future research should examine more precise ways of measuring net hedging, exposure to high inflationary environments, and the transaction costs of maintaining such a strategy.

This analysis of commodities as an asset class asks the investor to reconsider traditional views of how an index can best represent the benefits of investing in commodity futures. Our initial findings indicate that using signals to determine net hedging pressure provides an opportunity for a superior risk-sharing vehicle, for investors willing to break from the long-only standard of traditional commodity indexes.

Our analysis should be viewed as a first step towards determining the most appropriate weighting scheme that is representative of an insurance providing strategy. Future research might explore a multi-factor model that more precisely identifies the scale and scope of hedging pressure than a simple term-structure or excess return strategy. The techniques used in our analysis (previous excess return and term structure calculations), while effective on a high level, could be refined to create products that deliver an even more distinct benefit from the long-only strategies currently in the market.

Additional studies might also explore more how an insurance-providing portfolio performs during periods of significant unexpected inflation. In our short time-frame, our

long-short strategies were not sufficiently exposed to enough inflationary shocks to determine if, in fact, inflation hedging actually decreases as a result of this strategy.

Developing an insurance-providing commodity index has significant implications for global risk management. Insurance-based indexes are an efficient way to connect firms looking for way to hedge their pricing risk with large institutional investors willing to supply that type of insurance. Commodity intensive firms are therefore able to limit a potentially severe industry specific risk, while institutional investors are provided with a better way to manage their portfolio risks.

Appendix A: Index Construction Details for the GSCI

The Goldman Sachs Commodity Index - GSCI

The composition of the GSCI throughout a year period is determined in the following way:

1) Check generally eligibility requirements
2) Determine commodity contract weight
3) Check commodity weights monthly against Total Volume Multiple threshold

The following gives an explanation of the GSCI's main eligibility requirements that are critical to creating any liquid and marketable commodity index.

1) A contract must be on a physical commodity but cannot be on a financial commodity such as currencies interest rates, etc. The commodity contracts do not need to require physical delivery.
2) A contract must have a set expiration or term, and must be available to trade at least 5 months prior to its expiration
3) A contract must be denominated in US dollars and must be traded through a facility that has its dominant place of business in a country that belongs to the OECD (Organization for Economic Cooperation and Development)
4) A contract must have had Daily Contract Reference Prices[17] for at least two years prior to consideration for index inclusion and the contract must have Daily Contract Reference Prices published between 10AM and 4PM Eastern time on each Contract Business Day[18].
5) A contract must have volume data available for at least three months prior to consideration for inclusion in the index.
6) Whichever facility a contract is traded through, that facility must make price quotes available to members, participants and Goldman Sachs (if Goldman is not a member), cannot be a single-dealer platform
7) A commodity must have a Total Dollar Value Traded[19] of at least 15 billion US dollars over an annual calculation period.

Commodity Addition to GSCI

[17] FROM GSCI MANUAL 2005 EDITION: "Daily Contract Reference Price" With respect to each Contract Expiration and Contract Business Day, the price of the relevant Contract, expressed in U.S. dollars, that is generally used by participants in the related cash or over-the-counter market as a benchmark for transactions related to such Contract.

[18] FROM GSCI MANUAL 2005 EDITION: "Contract Business Day" A day on which the Trading Facility on or through which a Designated Contract Expiration is traded is scheduled to be open for trading for at least three hours.

[19] FROM GSCI MANUAL 2005 EDITION: "Total Dollar Value Traded" For any Annual Observation Period or Interim Calculation Period and with respect to a given Contract, the Total Quantity Traded of such Contract over such period (and annualized), as the case may be, multiplied by the Average Contract Reference Price for such period of such Contract.

Commodity contracts at the beginning of the GSCI life cycle, are filtered through the above criteria initially and then must pass through more layers of calculations to find its position within the index. We will walk through more details of this process using a Gold contract after having passed the eligibility criteria phase. If there are two or more Gold contracts eligible, the contracts with the highest Total Quantity Traded (TQT)[20] will be considered eligible first. Once Gold contracts are selected, a production weighting must be applied. First Gold's World Production Quantity (WPQ) is calculated which is equal to the Total World Production (TWP) of Gold over a five year period. A five year period is used to smooth out any aberrant periods. From this, Gold's World Production Average (WPA) is calculated as the Gold World Production Average divided by 5. Now the Gold contract can be assigned a Contract Production Weight as follows:

$$CPW = \frac{\text{Percentage TQT} * WPA}{1{,}000{,}000}$$

The threshold for adding this Gold contract into the GSCI is the Trading Volume Multiple (TVM). The TVM for this Gold contract is calculated using the following formula (where Σ_k is the sum over all k Gold contracts currently included in the GSCI):

$$TVM = \frac{TQT * \Sigma_k(CPW_k * ACRP_k{}^{21})}{ISL^{22} * CPW}$$

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[20] FROM GSCI MANUAL 2005 EDITION: "Total Quantity Traded" With respect to any Contract, the total quantity traded in such Contract during the relevant Annual Calculation Period or Interim Calculation Period (and annualized),as the case may be, expressed in physical units.

[21] FROM GSCI MANUAL 2005 EDITION: "Average Contract Reference Price" For any Annual Observation Period and with respect to a particular Contract , the average of the Daily Contract Reference Prices for the First Nearby Contract Expiration on the last day of each month during that Annual Observation Period on which such price is available.

[22] FROM GSCI MANUAL 2005 EDITION: "Investment Support Level" The targeted amount of investment in the GSCI and related indices, expressed in U.S. dollars, that Goldman Sachs, in consultation with the Policy Committee, reasonably believes may need to be supported by liquidity in the relevant Designated Contracts, based on the estimated aggregate outstanding level of investment in GSCI-related investments.

The TVM threshold (designated by Goldman Sachs) is the upper limit to calculate how many contracts of Gold can be added into the GSCI. Throughout the month, the TVM for Gold is calculated and checked against Gold's TVM threshold so that any adjustment to contract weightings can be made. The Goldman Sachs Policy Committee meets formally on an annual basis to determine calculation of the GSCI, effectiveness of the GSCI to measure commodity futures market performance and if there is a need to change the composition or GSCI methodology.[i] Below is the layout of the GSCI:

Table 1: GSCI Components and Dollar Weights (%)(June 6, 2005)

Energy	**75.14**	**Industrial Metals**	**6.65**	**Precious Metals**	**1.87**	**Agriculture**	**10.96**	**Livestock**	**5.38**
Crude Oil	28.90	Aluminium	2.62	Gold	1.66	Wheat	2.47	Live Cattle	2.75
Brent Crude Oil	14.45	Copper	2.35	Silver	0.20	Red Wheat	0.89	Feeder Cattle	0.77
Unleaded Gas	8.32	Lead	0.29			Corn	2.49	Lean Hogs	1.86
Heating Oil	8.91	Nickel	0.86			Soybeans	1.89		
GasOil	4.99	Zinc	0.53			Cotton	0.94		
Natural Gas	9.56					Sugar	1.21		
						Coffee	0.88		
						Cocoa	0.21		

(SOURCE: http://www.gs.com/gsci/)

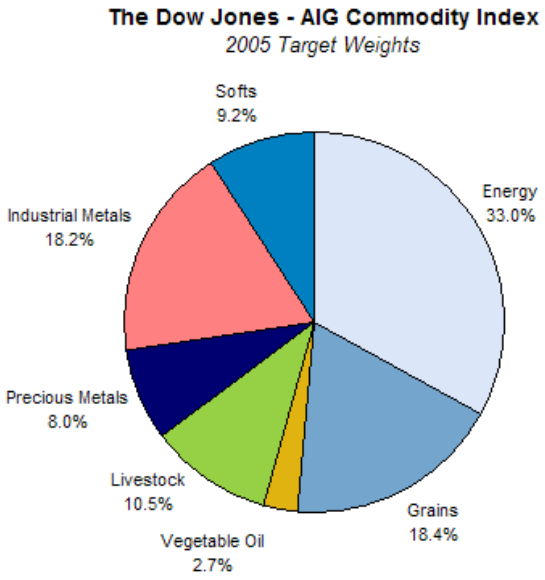
Appendix B: Index Details for Dow Jones-AIG

The Dow Jones-AIG

The Dow Jones AIG Commodity Index is comprised of 19 commodities that are traded on US exchanges except for Aluminum, Nickel and Zinc which are traded on the London Metal Exchange. Each commodity's weighting is based upon liquidity or trading activity of that commodity. Like the GSCI, there is a small component of the Dow Jones-AIG that relies on production data. All data that is used to calculate relevant contract weightings is averaged over a five year period, also similar to the GSCI. An oversight committee meets annually to determine the composition of the Dow Jones-AIG based on several inclusion rules such as :

- "No related group of commodities (e.g., energy, precious metals, livestock and grains) may constitute more than 33% of the index as of the annual re-weightings of the components."
- "No single commodity may constitute less than 2% of the index."

The Dow Jones-AIG is most heavily weighted on Energy at 33% of the overall composition, followed by Grains at 18.4% and Industrial Metals at 18.2%.[ii]



(SOURCE: http://www.djindexes.com/mdsidx/index.cfm?event=showAigIntro)

Appendix C: Index Details: Reuters/Jefferies CRB Index

The Reuters/Jefferies CRB Index, like the Dow Jones-AIG is comprised of 19 commodity futures. The CRB maintains a fixed percentage of 33% weighted on petroleum (including crude oil, unleaded gasoline, and heating oil). Unlike the Dow Jones-AIG and the GSCI, the CRB commodity futures index is equally weighted on each commodity within a particular sector:

Group II	Natural Gas	6%	Jan-Dec	NYMEX
	Corn	6%	Mar, May, Jul, Sep, Dec	CBOT
	Soybeans	6%	Jan, Mar, May, Jul, Nov	CBOT
	Live Cattle	6%	Feb, Apr, Jun, Aug, Oct, Dec	CME
	Gold	6%	Feb, Apr, Jun, Aug, Dec	COMEX
	Aluminum	6%	Mar, Jun, Sep, Dec	LME
	Copper	6%	Mar, May, Jul, Sep, Dec	COMEX

(SOURCE: Reuters/Jefferies CRB Index – May 2005 Manual)

The CRB follows a monthly rebalancing schedule to maintain sufficient commodity weightings.[iii]

[i] GSCI Manual – 2005 Edition.

[ii] http://www.djindexes.com/mdsidx/index.cfm?event=showAigIntro

[iii] Reuters/Jefferies CRB Index Manual – May 2005.