

Commodities and Equities: A “Market of One”?

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Abstract

Amidst a sharp rise in commodity investing, many have asked whether commodities nowadays move in sync with traditional financial assets. We provide evidence that challenges this idea. Using dynamic correlation and recursive cointegration techniques, we find that the relation between the prices of, and the returns on, investable commodity and U.S. equity indices has not changed significantly in the last fifteen years. We also find no evidence of a secular increase in co-movement between the returns on passive commodity- and equity-investments during periods of extreme returns.

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“As more money has chased (...) risky assets, correlations have risen. By the same logic, at moments when investors become risk-averse and want to cut their positions, these asset classes tend to fall together. The effect can be particularly dramatic if the asset classes are small – as in commodities. (...) This marching-in-step has been described (...) as a ‘market of one’.” The Economist, March 8, 2007.

1 Introduction

In the past decade, investors have sought an ever greater exposure to commodity prices - by directly purchasing commodities, taking outright positions in commodity futures, or acquiring stakes in exchange-traded commodity funds (ETFs) and in commodity index funds. This pattern has accelerated in the last few years. To wit, Standard and Poor’s GSCI commodity index was created by Goldman Sachs in 1991. As recently as 1999, the sums invested in investment vehicles tracking this index were estimated at less than 5 billion dollars. As of 2007, however, investments linked to the GSCI or to one of five other prominent commodity indices exceed 100 billion dollars. In a similar vein, the first-ever commodity ETF (streetTRACKS Gold Shares) was started in November 2004. Its market capitalization now exceeds 13 billion dollars, and it has been joined by numerous commodity ETF competitors.

One naturally wonders whether this sharp increase in investor appetite for commodities has had a significant impact on the pricing of related financial instruments. For example, because much of the new commodity exposure has been achieved through direct or indirect participation in futures markets, it should be reflected in the magnitude and composition of commodity futures trading. Haigh, Harris, Overdahl, and Robe (2007; henceforth, HHOR) confirm this intuition, using proprietary data on trader positions in the world’s largest-volume futures contract on a physical commodity – the New York Mercantile Exchange’s WTI sweet crude oil futures. HHOR establish that this greater market participation by commodity swap dealers and hedge funds has been accompanied by a change in the relation between crude oil futures prices at different maturities and greater price efficiency. Specifically, the prices of one-year and two-year futures have become cointegrated with the price of near-month futures, for the first time ever, since mid-2004.

Whereas the prices of different-maturity commodity futures have become much more closely linked, we use dynamic correlation and recursive cointegration techniques to show that the degree of co-movement between benchmark commodity- and equity-investment returns has not changed

materially over the course of the last fifteen years. In particular, notwithstanding the surge in commodity investment, the already very low correlation between the rates of return on passive investments in these two asset classes has become negative in the last five years. Our results are similar in spirit to the finding that, despite increased capital flows to emerging markets in the years following their financial liberalization and despite greater integration with world equity markets, cross-market return correlations did not increase enough to diminish the benefit, to U.S. investors, of diversifying into emerging-market stocks (Bekaert & Harvey, 2000; Carrieri, Errunza, & Hogan, 2007).

We use Standard and Poor's S&P 500 return and GSCI total return data to proxy for the rates of return on representative unlevered investments in, respectively, U.S. equities and commodities (we obtain qualitatively similar results with two other widely-used indices: Dow Jones' DJIA equity and DJ-AIGTR commodity indices¹). Because much of the commodity investment boom is still quite new, any change in pricing relationships is likely to be a recent phenomenon. HHOR, for example, do not find pricing efficiency changes across crude oil futures maturities until late 2003 (for one-year contracts) or mid-2004 (for two-year contracts). It is therefore especially important to utilize recent data. Accordingly, we use daily, weekly and monthly returns from January 15th, 1991 (when GSCI products first became available) to July 2nd, 2007.

To identify possible changes in the co-movements between the asset return series, we run all of our analyses on the entire sample period and then focus in particular on three successive five-year sub-periods: June 1992 through May 1997; June 1997 through May 2002; and, June 2002 through June 2007. The first subperiod predates the commodity investment boom, while the third subperiod overlaps with that boom. These two subperiods, however, correspond to times of economic expansion. The second subperiod allows us to assess the relation between commodities and equities during the stock-market bubble and its immediate aftermath – including an economic contraction, as defined by the National Bureau of Economic Research (NBER).

We find statistically significant differences in the means and standard deviations of the rates of returns across the two asset classes and, for each asset class, across the three sub-periods. In

¹Unlike the GSCI, the DJ-AIG commodity index is specifically designed to provide a “diversified benchmark for the commodity futures market.” In particular, it assigns a weight of only about 30% to energy commodities, including about 13% to the WTI return. By comparison, as of mid-July, 2007, the GSCI assigned a weight of more than 70% to energy commodities, including 36% to crude oil (WTI nearby contract). Other GSCI competitors include the Deutsche Bank Liquid Commodity Index, Rogers International Commodity Index, and Reuters-CRB.

contrast, we find only small differences in cross-asset correlations for the three sub-periods. The simple correlation between equities and commodities, which was slightly positive between 1992 and 1997, becomes slightly negative between 2002 and 2007. We obtain qualitatively similar results at all return frequencies.²

Notwithstanding the relative constancy of the simple cross-correlations across our three sub-periods, we find that rolling measures of the correlation between the equity and commodity return series fluctuate substantially, in cyclical fashion, throughout the sample period. The *pattern* of cyclical fluctuations, however, does not appear to change during the entire sample period. We confirm these findings using the dynamic conditional correlation (DCC) methodology proposed by Engle (2002). On the one hand, the range of values taken by these DCC estimates is quite wide; weekly values, for example, can be as low as -0.5 or as high as $+0.5$. On the other hand, most of the time, the DCC estimates are close to 0. What is more important, we find no evidence of a secular increase in correlations in the last few years.

Correlation estimates are relevant for short-term investors. For long-term investors, however, the key issue is whether there exist long-term common trends between the prices of commodity and equity investment even though these prices may diverge in the short term (Kasa, 1992). To answer this question, we apply recursive cointegration techniques (Johansen, 1988, 1991; Johansen & Juselius, 1990) to examine the stability and the possible strengthening over time of the relation between equity- and commodity-investment price series. This analysis complements our other results: except for a period in the late 1990's, we find little statistical evidence of cointegration – even in the last five years. That is, equity and commodity investment vehicles are not correlated over long horizons and, hence, substantial gains can still be achieved by diversifying portfolios across the two asset classes.

Even though there is little evidence of any structural shift in correlation and cointegration levels, a logical follow-up question is whether financial markets might have become a "market of one" *during extreme events*. Hartmann, Straetmans, & de Vries (2004), for example, find evidence of cross-asset extreme linkages in the case of bond and equity returns from the G-5 countries. Using a different approach, Solnik & Longin (2001) provide evidence that international equity-market

²In the case of monthly returns, the correlation drops from 0.27 in 1992-1997 (statistically significantly different from zero at the 5% confidence level) down to -0.24 in 2002-2007 (10% significance level). In the case of daily and weekly returns, the simple cross-correlation levels also fall from one sub-period to the next, but they are never statistically significantly different from zero.

correlations do not jump during periods of high volatility but do increase during bear markets.

For commodities, we identify the days, weeks or months during which the returns on equity indices were at least one or two standard deviations away from their means, and then analyze the contemporaneous returns on investable commodity indices. Contrary to the extant findings on linkages between other asset markets, we find little relation between exceptionally large returns on commodities and equities. This is true for the whole sample period as well as for all three of the five-year sub-periods; for positive as well as for negative exceptional returns; and, for periods of stock market upturns as well as for downturns.

In sum, the lack of greater return co-movement across equities and commodities suggests that commodities should retain their role as a portfolio diversification tool. The import of this conclusion cannot be overstated, since academics and practitioners have long called for substantial allocations to commodities as an asset class for the purposes of return generation and portfolio diversification.³

The remainder of the paper proceeds as follows. Section 2 describes the data. Section 3 presents the correlation analyses. Section 4 shows the robustness of our results to alternative methodological choices. Section 5 concludes.

2 Data and descriptive statistics

This section discusses the data and provides summary statistics for our various return series.

2.1 Returns data

We take an investor-perspective on the relation between commodities and traditional financial investments. To assess short-term correlations, we use daily, weekly, and monthly total returns on four widely used commodity and equity indices. We focus on results for weekly (Tuesday to Tuesday) holding-period returns, while also providing a discussion of our main findings for daily and monthly returns. To analyze long-term cointegration, we use the Tuesday close prices for the same four indices.

³See, e.g., Ankrum & Hensel (1993), Froot (1995), Huberman (1995), and Satyanarayan & Varangis (1996) for early work on how commodities help reduce an investor's unconditional portfolio risk. Erb & Harvey (2006), Gorton & Rouwenhorst (2006), Huang & Zhong (2006) and Miffre & Rallis (2007) provide additional evidence on the strategic and tactical values of commodity investments. These newer papers data series end in 2004 or, in one case, 2005.

For equities, we use Standard and Poor’s S&P 500 index; in robustness checks, we use Dow-Jones’s DJIA index.⁴ For commodities, we focus on the unlevered return on Standard and Poor’s S&P GSCI (formerly, the Goldman Sachs Commodity Index), i.e., the return on a “fully collateralized commodity futures investment that is rolled forward from the fifth to the ninth business day of each month.” While the GSCI includes twenty-four nearby commodity futures contracts, it is heavily weighted toward energy. For robustness checks, we use total (unlevered) returns on the second most widely used investable benchmark, Dow-Jones’s DJ-AIG commodity index (henceforth, DJ-AIG). This rolling index, which is composed of futures contracts on nineteen physical commodities, was designed to provide a “diversified benchmark for the commodity futures market.”

We also analyze potential changes in the relation between the rates of returns on various types of commodities. For this purpose, we use daily, weekly, and monthly total returns on several investable sub-indices representing key components of the GSCI: Energy, Non-Energy, Industrial Metals, Precious Metals, Agriculture, and Livestock.

We obtain the return series from Bridge-CRB (GSCI, DJ-AIG, S&P 500 and DJIA) or Bloomberg (GSCI sub-indices). Our data cover more than sixteen years from January 15, 1991 to July 2, 2007. We also provide results for three successive five-year subperiods: June 2, 1992 to May 27, 1997; June 3, 1997 to May 28, 2002; and, May 28, 2002 to July 2, 2007.

2.2 Returns on Equity and Commodity Indices: Summary statistics

Table 1 presents some descriptive statistics for the two equity- and the two commodity-return series. Panels A to D show weekly returns; E to H, daily returns; and I to L, monthly returns. For weekly returns, Table 1A presents statistics for the entire sample period, while Tables 1B, 1C and 1D present the corresponding statistics for each of the three successive five-year subperiods. The other eight panels are organized in similar fashion for daily (E to H) and monthly (I to L) returns.

From January 1991 through mid-2007, the mean weekly total rate of return on the GSCI was 0.14% (or 7.55% in annualized terms), with a minimum of -13.57% and a maximum of 8.09%. The typical rate of return varies sharply across the sample period: it averaged 0.14% in 1992-1997 (7.58 % annualized); 0.0038% in 1997-2002 (or a mere 0.20% annualized); and, 0.28% in 2002-2007

⁴In the current draft, we use returns on both of these equity indices that are exclusive of dividends. This approach leads to an underestimation of the expected returns on equity investments (Shoven & Sialm, 2000). However, to the extent that large U.S. corporations smooth dividend payments over time (Allen & Michaely, 2002), the correlation estimates that are the focus of our paper should be essentially unaffected.

(15.63% annualized). The corresponding figures are very similar for DJ-AIG total return index – except for the first subperiod (1992-1997), when the average return was 0.21% for the DJ-AIG *versus* 0.14% for the GSCI. Figure 1, which plots the levels of the four indices, indeed shows that the GSCI did not start appreciating until the end of 1996.

During the sample period, the mean weekly rate of return on the S&P 500 was notably higher than that on commodities: 0.20% for the whole period (or 11.20% in annualized terms), with a minimum of -11.46% and a maximum of 13.17%. Notably, the lowest weekly rate of return on the two equity indices is found in the third sub-period *versus* in the second sub-period for the commodity indices. In the same vein, the median weekly rate of return on the S&P GSCI was negative (-0.24% on the GSCI and -0.13% on the DJ-AIG) between June 1997 and May 2002, whereas the S&P 500 equity index had its highest median weekly rate of return during the same period (+0.37%). These observations suggest that equities and commodities do not move together, a topic to which we will turn in the next Subsection.

Consistent with the fact that the DJ-AIG is by construction more diversified than is the GSCI, the standard deviation of the weekly rates of return is much lower higher for the DJ-AIG (1.77% for the whole sample) than for the GSCI (2.63%). This pattern of approximately 45% greater GSCI volatility is observed in all three sub-periods: 1.80% *vs.* 1.26% in 1992-1997; 2.77% *vs.* 1.85% in 1997-2002; and, 3.18% *vs.* 2.18% in 2002-2007. Standard deviations increase throughout the sample for commodities, while they peak in the second sub-period for equities. Interestingly, the standard deviations of the equity returns always fall within those of the two commodity returns, with the DJ-AIG (*GSCI*) volatility playing the role of a lower (*upper*) bound.

Panels E to L show similar patterns for daily and monthly returns that Panels A to D showed for weekly returns, i.e.:

- Between 1991 and 2007, the rates of return on commodity indices were significantly lower than those on equity indices. However, this rank-ordering fluctuates dramatically over the course of that entire period. For example, equity returns trounce commodity returns in 1997-2002, but commodity returns are almost double equity returns in 2002-2007.
- The rates of return on equities are somewhat more volatile than those on a well-diversified basket of commodities (represented by the DJ-AIG), except in the last five years (2002-2007).
- The rates of return on the GSCI are the most volatile throughout the entire sample period. Of note, the GSCI returns are approximately 40-50% more volatile than those on the DJ-AIG.

2.3 Simple Cross-Asset Correlations

Figure 1 gives some preliminary insights into the co-movements between the commodity and equity indices. This graph allows the reader to visualize which sub-periods help determine the co-movements between the index returns that are summarized by the correlations presented in Table 2. In particular, it suggests a high correlation between the two equity indices; a positive, but somewhat weaker, correlation between the two commodity indices; and, a weak or possibly negative correlation between the equity and commodity indices, especially during the second sub-period (June 1997 through May 2002).

Table 2 quantifies these first impressions by providing an overview of the simple correlations between the two four benchmark asset-return series. This summary table is helpful for the interpretation of the empirical results in Section 3. As in Table 1, Panels A to D are for weekly returns; E to H, daily returns; and I to L, monthly returns. For weekly returns, Table 2A presents statistics for the entire sample period, while Tables 2B, 2C and 2D present the corresponding statistics for each of the three successive five-year subperiods. The other eight panels are organized in similar fashion for daily (E to H) and monthly (I to L) returns.

As one would expect, the simple correlation between the returns on the DJIA and S&P 500 equity indices is very high (more than 0.92 from 1991 to 2007), especially in the last five years (0.97). Likewise, the rates of return on the two commodity indices are strongly positively correlated. At all three return frequencies, the simple correlation is 0.89 for the whole sample; it is strongest in the second sub-period (0.94) and is slightly weaker in 1992-1997 (between 0.85 and 0.89, depending on the return frequency).

In sharp contrast, equity-commodity cross-correlations are typically very low or even negative:

- In the case of daily returns, Tables 2E to 2H show that the rates of return on the commodity indices exhibit very little correlation with either of the equity returns, with the coefficient estimates ranging from -0.08 to 0.01 depending on the index pair and the time period.
- For weekly and monthly returns, equity-commodity correlations are slightly larger in absolute value, yet often are not statistically significantly different from zero. The only statistically significant correlations are observed for monthly returns, and only for the GSCI. While the GSCI's correlation with the S&P 500 and the DJIA was 0.27 in 1992-1997 (statistically significantly positive at the 5% level), this correlation became statistically significantly negative

in 2002-2007 (-0.25 with the DJIA and -0.3 with the S&P 500). For weekly returns, Table 2B and 2C shows that the “highest” weekly correlations, between 0.06 and 0.14 depending on the index, were observed in the first (1992-1997) and second (1997-2002) sub-periods.

In short, despite a commonly-expressed view that both equity and commodity *prices* have boomed since 2003, the correlation between commodity and equity *returns* is almost nil in our third subperiod – indeed, the total returns on the GSCI are negatively correlated with the returns on both equity indices during that period between June 2002 and July 2007. Figure 1 suggests that, to the extent that the return correlations were at all positive prior to 2002, the likely reasons are joint run-ups in commodity and equity prices in 1995-1997 and again in the eighteen month period from late 1998 through Spring 2000.

2.4 Returns on Specific Categories of Commodities

2.4.1 Summary Statistics

Tables 3 provides summary statistics for the unlevered (total) rates of return on six investable sub-indices representing key components of the S&P GSCI index. Table 3A presents statistics for the entire sample period; Tables 3B, 3C and 3D, for each of our three successive five-year subperiods. The table focuses on weekly returns for the sake of brevity.

Table 3 shows that, over then entire sample period, individuals who invested in Energy and Metal sub-indices experienced greater average returns (but also more volatility) than investors in other commodity sub-indices. Panels B to D of the same table, however, show that the commodity performance rankings vary significantly from period to period. Industrial and Precious Metals, for example, both lag all other commodity sub-indices between 1992 and 1997, but are ahead of all but Energy between 2002 and 2007. In a similar vein, Agriculture outperforms all other sub-indices in 1992-1997 but is the worst performer in 2002-2007.

2.4.2 Simple Correlations

Table 4 shows the simple correlations between the weekly unlevered rates of return on the S&P 500 equity index, the S&P GSCI, and six narrow commodity benchmarks: the GSCI Energy, Non-Energy, Industrial Metals, Precious Metals, Agriculture, and Livestock investable indices. Again, Table 4A presents statistics for the entire sample period, while Tables 4B, 4C and 4D present the

corresponding statistics for each of our three successive five-year subperiods.

Four patterns emerge from Table 4.

- Weekly equity returns exhibit very little correlation with the returns on *any* of the commodity sub-indices. The highest individual correlation is for Industrial Metals, but even that figure is not statistically significantly different from zero. It is a mere 0.13 over the whole sample (Table 4A), peaking at 0.18 in 2002-2007 (Table 4D). All the other cross-correlations are less than 0.12, and quite a few are slightly negative.
- There is no evidence of a material increase, over time, of the correlation between the returns on equities and those on either the Agriculture or the Livestock sub-indices.
- Consistent with the fact that the GSCI is a value-weighted index and is consequently heavily weighted toward energy (as energy contracts make up the world's largest commodity futures markets), the unlevered returns on the GSCI and on the Energy sub-index are very highly positively correlated – between 0.94 and 0.98 depending on the sample period. In contrast, the correlation between the returns on the entire GSCI index and those on the Non-Energy sub-index range from 0.38 to 0.41 depending on the sub-period.
- The returns on the Non-Energy sub-index are strongly positively correlated with the returns on all the other GSCI sub-indices (but not with the Energy sub-index). This finding suggests the possibility of a common economic variable driving the returns on most types of commodities.

3 Short-Term Co-Movements

Tables 1 and 3 show that the unconditional return volatilities vary a lot over time. In particular, the weekly rates of return on equities were 50% more volatile in the third subperiod (2002-2007, Table 1D) than in the first (1992-1997, Table 1B). Even more strikingly, the standard deviation of the returns on commodity investments almost doubled over the course of the sample period.

In contrast, although the unconditional correlations between the rates of returns on equity and commodity investments fluctuate somewhat from sub-period to sub-period, Table 2 suggests that these fluctuations are quite mild and that the correlations are always close to zero. Put

differently, our analysis in Section 2 seems to suggest that commodity returns exhibit consistently low correlations with their equity counterparts.

Before concluding that commodities provide a good hedge for equity portfolios, however, one should account for possible time variations in these correlation measures. In this Section, we provide estimates of the intensity of co-movements (or the lack thereof) that account for time variations in the various moments of the return series.

3.1 Methodology

Measuring the relationship between variables at various points in time, rather than using a single correlation coefficient over the entire sample period, provides information on the evolution of the relationship over time. For this purpose, simple correlation measures such as rolling historical correlations and exponential smoothing are widely used in the literature.

Rolling historical correlations take into account the time-varying nature of the relationship between variables straightforwardly, by calculating the correlation at any point in time as the estimate for a specified window (say, k observations) that does not overlap with the full sample. The correlation is first estimated over the sub-period 1 to k , then over the sub-period 2 to $k + 1$, and so on. The rolling historical correlation estimator is thus:

$$\hat{\rho}_{12,t+1} = \frac{\sum_{s=t-k}^t x_{1,s}x_{2,s}}{\sqrt{\left(\sum_{s=t-k}^t x_{1,s}^2\right)\left(\sum_{s=t-k}^t x_{2,s}^2\right)}} \quad (1)$$

where x_1 and x_2 are the deviations from the means of the two random variables of interest, with mean zero.

Although this simple estimation technique provides some information on the evolution of relationship between two variables, it suffers from assigning an equal weight to all observation in the estimation window and zero weight to older observations. It also raises the issue of window-length determination. On the one hand, if the window is too narrow, one runs the risk of ignoring important observations in the data by giving zero weight to these observations. On the other hand, if the window is too wide, old observations will be given weight even though they may not be relevant to the analysis.

To overcome these problems, exponential smoothing techniques assign declining weights to older

observations based on a parameter, λ , without any prior determination on the amount of past data to be used in the analysis. The exponential-smoothing estimator can be written as

$$\hat{\rho}_{12,t+1} = \frac{\sum_{s=1}^t \lambda^{t-s} x_{1,s} x_{2,s}}{\sqrt{\left(\sum_{s=1}^t \lambda^{t-s} x_{1,s}^2\right) \left(\sum_{s=1}^t \lambda^{t-s} x_{2,s}^2\right)}} \quad (2)$$

One drawback of this second approach is that the user must adopt an *ad hoc* approach to choose smoothing parameter λ . In our analysis, we follow Engle (2002) and set $\lambda = 0.94$ for weekly returns. We use the same value for monthly returns, and set $\lambda = 0.98$ for daily returns. More importantly, like the rolling historical correlation, the exponential-smoothing technique cannot adequately account for changes in volatility. The sensitivity of the estimated correlation to volatility changes restricts inferences about the true nature of the relationship between variables. Since the estimated correlations are subject to volatility shocks, interpreting these correlations becomes more difficult especially during high volatility periods.

The Dynamic Conditional Correlation methodology (DCC) developed by Engle (2002) helps to remedy this problem. The DCC model is based on a two-steps approach to estimating the time-varying correlation between two series. In the first step, time-varying variances are estimated using a GARCH model. In the second step, a time-varying correlation matrix is estimated using the standardized residuals from the first-stage estimation.

More formally, consider a $n \times 1$ vector of normally-distributed with mean zero returns series r_t of n assets are assumed the have the following structure:

$$r_t \sim N(0, D_t R_t D_t) \quad (3)$$

where D_t is a diagonal matrix given by $D_t = \text{diag} \sqrt{E(r_{it}^2)}$ and R_t is a $n \times n$ time-varying correlation matrix. The log-likelihood of the DCC estimate is given by :

$$L = -\frac{1}{2} \sum_{t=1}^T (n \log(2\pi) + 2 \log(|D_t|) + \log(|R_t|) + \varepsilon' R_t^{-1} \varepsilon) \quad (4)$$

In essence, the log-likelihood function has two components: the volatility part, which contains terms in D_t ; and the correlation part, which contains terms in R_t . In the first stage of the estimation, n univariate GARCH(1,1) estimates are obtained, which produces consistent estimates of time-varying variances (D_t). In the second stage, the correlation part of the log-likelihood function is maximized, conditional on the estimated D_t from the first stage.

We use rolling historical correlation, exponential smoother with 0.94 smoothing parameter, dynamic conditional correlation by log-likelihood for integrated process and dynamic conditional correlation with integrated moving average estimation to analyze the dynamic properties of the relevant variables.

3.2 Equities and Commodities

Figures 2 to 5 plot the estimates of the time-varying correlation between the unlevered rates of return on investable equity and commodity indices over the sample period. Figure 2, 3, 4, and 5 provide information on the correlations between, respectively, the S&P 500 and GSCI; S&P 500 and DJ-AIG; DJIA and GSCI; and, DJIA and DJ-AIG. Figure 6 provides similar plots for the correlation between the two equity indices (S&P 500 and DJIA). Finally, for Figures 2 and 3, three panels are provided: Figures 2A and 3A are for weekly returns; Figures 2B and 3AB, for daily returns; and Figures 2C and 3C, for monthly returns.

Each Figure contains four plots, one for each of the estimation methods outlined above: rolling historical correlation; exponential smoother with smoothing parameter 0.94; dynamic conditional correlation (DCC) with integrated moving average estimation; and, DCC by log-likelihood for integrated process. The straight line running through each graph shows the relevant simple correlation from Table 2, which is not an average of any of the four time-varying correlation estimates.

Several facts are immediately apparent.

- The correlation between equity and commodity returns fluctuates notably over time. This finding is robust to the choice of equity-commodity indices – the correlation time-patterns are the same for all four pairs.
- There is little evidence that correlations are any higher after 2002 than they used to be prior to 2002. If anything, consistent with the results obtained with simple correlations (see Table 2, in particular Table 2D), the time-varying correlation graphs show that correlations are lower since 2002 than before.
- Notwithstanding some amount of fluctuation over time, the correlations between equities and commodities are not often greater than 0.3. In contrast, Figure 6 shows that the correlation between the two equity indices is very high, typically well above 0.9.

In sum, equity-commodity return pairwise correlations fluctuate over the sample period. Quite often, the correlation estimates are even negative. This result underlines the importance of accurate measures of co-movement between asset returns that are needed for long-term portfolio investments.⁵ Second,

3.3 Commodity Sub-Indices

Figures 7 and 8 complement the analysis of the previous subsection, by plotting estimates of the time-varying correlations between the unlevered rates of return on benchmark equity indices and on specific categories of investable commodity indices. Figure 7 focuses on the difference between “Energy” and “Non-Energy” commodity baskets. Figure 8 refines Figure 7 by breaking down the Non-Energy index further into several investable sub-indices: Precious Metals, Industrial Metals, Agriculture, and Livestock. All of the plots in Figures 7 and 8 are directly comparable, in that they are all drawn using dynamic conditional correlations estimated by log-likelihood for integrated process (Engle, 2002).

Figures 7 and 8 highlight four facts:

- There is a substantial amount of time variation in the correlations between returns on equities and on both the energy and non-energy commodity sub-indices. Depending on the time period, these correlations fluctuate between -0.45 and 0.45. By contrast, the unconditional correlations are close to zero across the entire sample period.
- While the Energy and Non-Energy sub-indices do not move in close sync, they are sufficiently positively correlated that investors do not benefit from a consistently low correlation between equities and commodities.
- Figure 8 suggests, however, that indices based on more narrow categories of commodities exhibit less correlation with equities than the overall non-energy index – raising questions about possible diversification strategies.

⁵In a recent study of the diversification benefits offered by real estate investment trusts, regular and inflation-indexed bonds, commodities, and international bonds and equities, Huang & Zhong (2006) argue that the DCC model outperforms several other widely-used correlation structures (unconditional correlation; rolling correlation; and, constant correlation) in helping determine how investors should rebalance their portfolios in the presence of substantial time variations in cross-asset correlations.

- Finally, and importantly for the purpose of the present paper, it is readily apparent from both Figures 7 and 8 that there is no obvious secular pattern toward an increase in correlations in the last few years.

3.4 Long-term Co-Movements: Recursive Cointegration Analysis

The foregoing analysis indicates that the correlations between the equity and commodity return series may have fallen amidst the commodity investment boom. The very fact that these correlation estimates fluctuate significantly over time, however, is evidence of their short-term nature. If there is a reason to suspect that equity and commodity return should move together in the long run, however, a complementary technique is required.

A large volume of research evaluates the extent to which *prices* from different financial markets are inter-connected, by employing time-series techniques that are appropriate for non-stationary and cointegrated data. We follow the approach taken in many recent papers on applied cointegration analysis, and use Johansen’s multivariate approach (Johansen, 1988, 1991; Johansen & Juselius, 1990).⁶ In a nutshell, the procedure entails two steps: the first step identifies a possible long-term equilibrium relationship between asset prices; the second step estimates dynamic correlations within an error correction model. In other words, common stochastic trends between time series are identified, prior to calculating correlations.

The existence of a long-term cointegrating vector for equity and commodity prices would imply that these prices should not drift away from each other but, instead, revert to their long-run joint equilibrium. Figure 9, however, suggests that there is no such vector. The figure shows the R-1 form of the trace statistic, recursively calculated and scaled by the 5% critical value. The dark blue line gives the estimate calculated using data from the whole sample (i.e., from January 1991 through July 2007).⁷ Except for three years in the late 1990’s, when the scaled trace statistic exceeded 1, there is no evidence of a long-term cointegrating vector. The red, green and black lines, which plot estimates obtained with data from three successive sub-periods (respectively 1992-1997, 1997-2002, and 2002-2007), confirm the result.

⁶Examples of such studies include Bremnes et al. (1997), Diamandis et al. (2000), Bessler & Yang (2003), Haigh & Bessler (2004), Yang et al. (2004), and HHOR (2007).

⁷We utilize weekly price data from the year prior to a given estimation period to start the recursive procedure for that period. Our results are robust to using more weeks for the prior period.

4 Extreme Events

The previous Section provides evidence that neither the average levels of correlation between equity and commodity returns, nor the pattern of variation of these correlations over time, have been qualitatively very different in the last five years than in the previous ten years. The widespread perception that financial markets nowadays move much more in lock-step, however, could be due not as much to changes in average levels and patterns but, instead, to the joint behavior of financial markets on “stressful days.” That idea is the topic of this Section.

To assess whether cross-asset extreme linkages exist in the case of commodities, we identify the days and weeks during which the returns on the benchmark S&P 500 equity index was at least one or two standard deviations above or below its sample mean, and then analyze the contemporaneous unlevered returns on the benchmark investable commodity index, the S&P GSCI. Implicit in our approach is the notion that, if changes in extreme linkages have taken place because of commodity investment flows, then the fact that equity markets are much larger than commodity markets suggests that ripple effects are more likely to emanate from the former than from the latter. For the same reason, liquidity problems or panic reactions should be more likely to spread from stock to commodity markets than the reverse.

As in the rest of the paper, we look at joint commodity-equity return behaviors for the whole sample as well as for three successive sub-periods. Tables 5 and 6 summarize our findings for weekly and daily returns, respectively. Table 5A (*resp.* 6A) tallies the episodes when the weekly (*resp.* *daily*) return on the S&P 500 equity index was “large,” i.e., at least one standard deviation away from its mean during a given period. Table 5B (*resp.* 6A) tallies what happens on weeks (*resp.* *days*) of “extreme” stock returns, i.e., when these returns were at least two standard deviations away from the relevant mean. Tables 5 and 6 show in italics the number of times when the unlevered return on the GSCI index was positive or negative, for a given direction of the large (Tables 5A and 6A) or extreme (Tables 5B and 6B) S&P 500 return. It also shows in Bold the number of times when the contemporaneous GSCI return itself was also more than one (Tables 5A and 6A) or two (Tables 5B and 6B) standard deviations away from its own sample mean.

For the sake of brevity, we focus on weekly results (Table 5) as the daily results are qualitatively similar (Table 6). Between January 15, 1991 and July 2, 2007, there were 116 weeks (65 + 51) when the rate of return on the S&P 500 equity index was below its sample mean by one standard deviation or more, and 20 weeks (14 + 6) when the same return was below its mean by more than

two standard deviation. During the 116 weeks of large poor returns, the total return on the GSCI was positive (though not necessarily large or extreme) 65 times, and negative the other 51 times. Of those 65 times, the GSCI return deviated from its mean by more than one standard deviation a total of 33 times – 15 below the mean but 18 above the mean. In other words, when the S&P 500 drops a lot, it is not clear which way the GSCI return will go – neither in terms of its sign nor in comparison to its mean. A similar pattern emerges when equities do very well. To wit, in the 87 weeks when the S&P 500 return exceeded its sample mean by one standard deviation or more, the GSCI total return was positive only 49 times. Likewise, in the 14 weeks when the S&P 500 return exceeded its mean by more than two standard deviation, the GSCI total return was equally likely to be extremely bad or extremely good (2 in each case).

In sum, contrary to extant findings that there exist extreme linkages between other asset markets (Hartmann et al., 2004; Solnik & Longin, 2001, for example), we find little relation between exceptionally large returns on commodities and equities. This negative result holds for the whole sample period as well as for all three of the five-year sub-periods; for positive as well as for negative exceptional returns; and, for periods of stock market upturns as well as for downturns.

5 Conclusion

Amidst a sharp rise in commodity investing, many have asked whether commodities nowadays move in sync with traditional financial assets. We provide evidence that challenges this idea. Using dynamic correlation and recursive cointegration techniques, we find that the relation between the returns on investable commodity and equity indices has not changed significantly in the last fifteen years. We also find no evidence of an increase in co-movement during periods of extreme returns.

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Table 1A: Weekly Rates of Return (% , January 1991 through June 2007)

	DJIA	S&P500	DJAIG	GSCI
Mean	0.2172	0.2043	0.1527	0.1401
Median	0.2832	0.3417	0.1620	0.1869
Maximum	12.6934	13.1729	5.5331	8.0874
Minimum	-9.0967	-11.4591	-7.1159	-13.5768
Std. Dev.	2.1283	2.1465	1.7693	2.6256
Skewness	0.1264	0.0365	-0.1671	-0.4418
Kurtosis	6.6784	6.8592	3.9934	4.8996
Jarque-Bera	486.57	533.25	39.32	157.09
Probability	0.0000	0.0000	0.0000	0.0000
Sum	186.60	175.51	131.21	120.38
Sum Sq. Dev.	3886.29	3953.23	2685.92	5914.67
Observations	859	859	859	859

Table 1B: Weekly Rates of Return (% , June 1992 through May 1997)

	DJIA	S&P500	DJAIG	GSCI
Mean	0.3134	0.2886	0.2059	0.1406
Median	0.3377	0.3507	0.2267	0.1426
Maximum	3.9070	4.2835	3.5734	5.4858
Minimum	-4.2337	-4.0290	-4.1213	-8.7976
Std. Dev.	1.5352	1.4419	1.2607	1.7976
Skewness	-0.2377	-0.2167	-0.2073	-0.2975
Kurtosis	3.2046	3.3696	3.2926	5.1457
Jarque-Bera	2.91	3.53	2.80	53.92
Probability	0.2329	0.1713	0.2466	0.0000
Sum	81.79	75.33	53.73	36.71
Sum Sq. Dev.	612.75	540.59	413.26	840.19
Observations	261	261	261	261

Table 1C: Weekly Rates of Return (% , June 1997 through May 2002)

	DJIA	S&P500	DJAIG	GSCI
Mean	0.1479	0.1237	0.0054	0.0038
Median	0.1553	0.3680	-0.1309	-0.2446
Maximum	11.1719	9.9121	4.8857	7.3270
Minimum	-9.0114	-9.0214	-7.1159	-13.5768
Std. Dev.	2.5491	2.6004	1.8459	2.7737
Skewness	0.0222	-0.0828	0.1018	-0.2096
Kurtosis	4.3983	3.5515	3.3542	4.3768
Jarque-Bera Probability	21.29 0.0000	3.61 0.1649	1.82 0.4036	22.52 0.0000
Sum	38.61	32.29	1.42	0.98
Sum Sq. Dev.	1689.41	1758.13	885.86	2000.22
Observations	261	261	261	261

Table 1D: Weekly Rates of Return (% , June 2002 through June 2007)

	DJIA	S&P500	DJAIG	GSCI
Mean	0.1288	0.1477	0.2796	0.2797
Median	0.2808	0.2899	0.4041	0.5931
Maximum	12.6934	13.1729	5.5331	8.0874
Minimum	-9.0967	-11.4591	-6.8533	-11.5571
Std. Dev.	2.2230	2.2814	2.1751	3.1787
Skewness	0.4657	0.3161	-0.2912	-0.4796
Kurtosis	9.6357	10.6177	3.2844	3.4686
Jarque-Bera Probability	497.64 0.0000	647.59 0.0000	4.65 0.0976	12.63 0.0018
Sum	34.27	39.28	74.38	74.41
Sum Sq. Dev.	1309.59	1379.31	1253.71	2677.64
Observations	266	266	266	266

Note: Panels A to D of Table 1 provide summary statistics for the **weekly** unlevered rates of return on the Dow Jones Industrial Average (DJIA) and the S&P 500 equity indices (excluding dividends), as well as on the Dow Jones DJAIG and S&P GSCI commodity indices (total return). Table 1A uses sample moments computed using weekly rates of returns from January 15, 1991 to July 2, 2007. Tables 1B, 1C and 1D provide the corresponding moments for three successive sub-periods: June 2, 1992 to May 27, 1997; June 3, 1997 to May 28, 2002; and, May 28, 2002 to July 2, 2007.

Table 1E: Daily Rates of Return (% , January 1991 through June 2007)

	DJIA	S&P500	DJAIG	GSCI
Mean	0.0445	0.0420	0.0321	0.0303
Median	0.0493	0.0432	0.0409	0.0255
Maximum	6.3481	5.7327	4.9708	6.7875
Minimum	-7.1838	-6.8657	-8.7461	-16.8332
Std. Dev.	0.9748	0.9908	0.8082	1.2221
Skewness	-0.1375	-0.0229	-0.2205	-0.5839
Kurtosis	7.7874	7.0196	7.8342	13.6844
Jarque-Bera Probability	3949.3880 0.0000	2775.3450 0.0000	4047.1260 0.0000	19840.5100 0.0000
Sum	183.2575	172.9735	132.2827	124.8540
Sum Sq. Dev.	3915.8330	4045.3370	2691.4810	6154.5540
Observations	4122	4122	4122	4122

Table 1F: Daily Rates of Return (% , June 1992 through May 1997)

	DJIA	S&P500	DJAIG	GSCI
Mean	0.0630	0.0564	0.0369	0.0280
Median	0.0628	0.0340	0.0436	0.0336
Maximum	3.0237	2.9413	2.4805	4.5893
Minimum	-3.9272	-3.6586	-2.1651	-3.1393
Std. Dev.	0.7075	0.6772	0.5461	0.8126
Skewness	-0.1858	-0.1661	-0.0142	0.1209
Kurtosis	5.0376	5.1314	4.0010	5.2066
Jarque-Bera Probability	277.2312 0.0000	300.7142 0.0000	64.8062 0.0000	318.4454 0.0000
Sum	97.7661	87.4742	57.2297	43.4310
Sum Sq. Dev.	775.9610	710.7535	462.2372	1023.4540
Observations	1551	1551	1551	1551

Table 1G: Daily Rates of Return (% , June 1997 through May 2002)

	DJIA	S&P500	DJAIG	GSCI
Mean	0.0319	0.0266	0.0008	0.0011
Median	0.0459	0.0213	0.0184	-0.0200
Maximum	4.9806	5.1152	3.6442	5.1678
Minimum	-7.1838	-6.8657	-4.1623	-8.7615
Std. Dev.	1.2328	1.2817	0.8187	1.2743
Skewness	-0.3656	-0.1029	-0.0226	-0.3207
Kurtosis	6.2711	5.3566	4.2561	5.4302
Jarque-Bera	584.6756	291.2239	82.2176	328.7772
Probability	0.0000	0.0000	0.0000	0.0000
Sum	39.8126	33.2163	1.0302	1.3347
Sum Sq. Dev.	1896.5620	2050.2240	836.4447	2026.6790
Observations	1249	1249	1249	1249

Table 1H: Daily Rates of Return (% , June 2002 through June 2007)

	DJIA	S&P500	DJAIG	GSCI
Mean	0.0283	0.0318	0.0593	0.0615
Median	0.0421	0.0724	0.0654	0.0568
Maximum	6.3481	5.7327	4.9708	6.7875
Minimum	-4.6404	-4.1536	-3.1367	-4.6386
Std. Dev.	0.9593	0.9801	0.9956	1.4362
Skewness	0.3631	0.2352	0.0820	0.0984
Kurtosis	7.7919	6.7087	3.6572	3.4278
Jarque-Bera	1242.9730	739.5595	24.2807	11.7322
Probability	0.0000	0.0000	0.0000	0.0028
Sum	35.9109	40.3620	75.2526	78.0620
Sum Sq. Dev.	1167.8020	1219.1030	1257.7940	2617.3870
Observations	1270	1270	1270	1270

Note: Panels E to H of Table 1 provide summary statistics for the **daily** unlevered rates of return on the Dow Jones Industrial Average (DJIA) and the S&P 500 equity indices (excluding dividends), as well as on the Dow Jones DJAIG and S&P GSCI commodity indices (total return). Table 1E uses sample moments computed using daily rates of return from January 15, 1991 to July 2, 2007. Tables 1F, 1G and 1H provide the corresponding moments for three successive sub-periods: June 2, 1992 to May 27, 1997; June 3, 1997 to May 28, 2002; and, May 28, 2002 to July 2, 2007.

Table 1I: Monthly Rates of Return (% , January 1991 through June 2007)

	DJIA	S&P500	DJAIG	GSCI
Mean	0.8895	0.8276	0.6919	0.6489
Median	1.1688	1.1096	0.7190	0.7152
Maximum	10.6047	11.1588	10.2253	16.8927
Minimum	-15.1320	-14.5797	-7.5449	-14.4111
Std. Dev.	3.9834	3.8955	3.4936	5.3449
Skewness	-0.5001	-0.4993	0.0874	0.1213
Kurtosis	4.3711	4.0633	3.0579	3.4304
Jarque-Bera Probability	23.6415 0.0000	17.4662 0.0002	0.2785 0.8700	2.0038 0.3672
Sum	175.2332	163.0347	136.3046	127.8250
Sum Sq. Dev.	3109.9490	2974.2250	2392.1810	5599.3680
Observations	197	197	197	197

Table 1J: Monthly Rates of Return (% , June 1992 through May 1997)

	DJIA	S&P500	DJAIG	GSCI
Mean	1.3340	1.2340	0.8874	0.5839
Median	1.6818	1.2914	0.7956	0.5829
Maximum	8.1654	7.3376	5.5783	10.2272
Minimum	-5.1164	-4.5748	-2.9493	-6.8938
Std. Dev.	2.9926	2.7441	2.0103	3.3076
Skewness	-0.1468	-0.2634	0.5515	0.3977
Kurtosis	2.6088	2.7247	2.9997	3.8888
Jarque-Bera Probability	0.5981 0.7415	0.8831 0.6430	3.0418 0.2185	3.5570 0.1689
Sum	80.0382	74.0419	53.2462	35.0365
Sum Sq. Dev.	528.3686	444.2649	238.4465	645.4881
Observations	60	60	60	60

Table 1K: Monthly Rates of Return (% , June 1997 through May 2002)

	DJIA	S&P500	DJAIG	GSCI
Mean	0.6371	0.5123	0.0422	0.0505
Median	1.0046	0.6332	-0.2609	-1.2431
Maximum	10.2479	9.6720	10.2253	16.8927
Minimum	-15.1320	-14.5797	-7.2052	-12.1674
Std. Dev.	5.1240	5.0894	4.4171	6.4019
Skewness	-0.4831	-0.4396	0.4899	0.5543
Kurtosis	3.3634	2.8556	2.5716	2.9305
Jarque-Bera Probability	2.6636 0.2640	1.9849 0.3707	2.8585 0.2395	3.0840 0.2139
Sum	38.2249	30.7350	2.5298	3.0322
Sum Sq. Dev.	1549.0840	1528.2310	1151.1450	2418.0460
Observations	60	60	60	60

Table 1L: Monthly Rates of Return (% , June 2002 through June 2007)

	DJIA	S&P500	DJAIG	GSCI
Mean	0.5608	0.6238	1.2092	1.2642
Median	0.8310	1.1096	1.6833	2.0686
Maximum	10.6047	8.6449	7.6974	15.1435
Minimum	-12.3688	-11.0024	-7.5449	-14.4111
Std. Dev.	3.6607	3.4821	3.8431	6.2502
Skewness	-0.4485	-0.6848	-0.3411	-0.3551
Kurtosis	4.9401	4.7041	2.5143	2.7910
Jarque-Bera Probability	11.6121 0.0030	12.1487 0.0023	1.7822 0.4102	1.3928 0.4984
Sum	34.2090	38.0488	73.7640	77.1149
Sum Sq. Dev.	804.0314	727.4810	886.1567	2343.9090
Observations	61	61	61	61

Note: Panels I to L of Table 1 provide summary statistics for the **monthly** unlevered rates of return on the Dow Jones Industrial Average (DJIA) and the S&P 500 equity indices (excluding dividends), as well as on the Dow Jones DJAIG and S&P GSCI commodity indices (total return). Table 1I uses sample moments computed with monthly rates of returns from January 15, 1991 to July 2, 2007. Tables 1J, 1K and 1L provide the corresponding moments for three successive sub-periods: June 2, 1992 to May 27, 1997; June 3, 1997 to May 28, 2002; and, May 28, 2002 to July 2, 2007.

Table 2A: Index-return Correlations (Weekly), January 1991 through June 2007

	DJIA	S&P500	DJAIG	GSCI
DJIA	1.0000	0.9369	0.0666	0.0077
S&P500	0.9369	1.0000	0.0807	0.0352
DJAIG	0.0666	0.0807	1.0000	0.8973
GSCI	0.0077	0.0352	0.8973	1.0000

Table 2B: Index-return Correlations (Weekly), June 1992 through May 1997

	DJIA	S&P500	DJAIG	GSCI
DJIA	1.0000	0.9193	0.1029	0.1359
S&P500	0.9193	1.0000	0.0656	0.1057
DJAIG	0.1029	0.0656	1.0000	0.8203
GSCI	0.1359	0.1057	0.8203	1.0000

Table 2C: Index-return Correlations (Weekly), June 1997 through May 2002

	DJIA	S&P500	DJAIG	GSCI
DJIA	1.0000	0.9117	0.1129	0.0776
S&P500	0.9117	1.0000	0.1241	0.1026
DJAIG	0.1129	0.1241	1.0000	0.9336
GSCI	0.0776	0.1026	0.9336	1.0000

Table 2D: Index-return Correlations (Weekly), June 2002 through June 2007

	DJIA	S&P500	DJAIG	GSCI
DJIA	1.0000	0.9753	0.0157	-0.0890
S&P500	0.9753	1.0000	0.0619	-0.0298
DJAIG	0.0157	0.0619	1.0000	0.8989
GSCI	-0.0890	-0.0298	0.8989	1.0000

Note: Panels A through D of Table 2 provide simple cross-correlation tables for the **weekly** unlevered rates of return on four investable indices: the Dow Jones Industrial Average (DJIA) and the S&P 500 equity indices, as well as on the Dow Jones DJAIG and S&P GSCI commodity indices. Table 2A uses weekly return data from January 15, 1991 to July 2, 2007. Tables 2B, 2C and 2D provide the corresponding cross-correlations for three successive sub-periods: June 2, 1992 to May 27, 1997; June 3, 1997 to May 28, 2002; and, May 28, 2002 to July 2, 2007.

Table 2E: Index-return Correlations (Daily), January 1991 through June 2007

	DJIA	S&P500	DJAIG	GSCI
DJIA	1.0000	0.9423	-0.0269	-0.0657
S&P500	0.9423	1.0000	-0.0081	-0.0412
DJAIG	-0.0269	-0.0081	1.0000	0.8973
GSCI	-0.0657	-0.0412	0.8973	1.0000

Table 2F: Index-return Correlations (Daily), June 1992 through May 1997

	DJIA	S&P500	DJAIG	GSCI
DJIA	1.0000	0.9331	-0.0333	-0.0160
S&P500	0.9331	1.0000	-0.0541	-0.0320
DJAIG	-0.0333	-0.0541	1.0000	0.8322
GSCI	-0.0160	-0.0320	0.8322	1.0000

Table 2G: Index-return Correlations (Daily), June 1997 through May 2002

	DJIA	S&P500	DJAIG	GSCI
DJIA	1.0000	0.9272	-0.0073	-0.0360
S&P500	0.9272	1.0000	0.0069	-0.0172
DJAIG	-0.0073	0.0069	1.0000	0.9205
GSCI	-0.0360	-0.0172	0.9205	1.0000

Table 2H: Index-return Correlations (Daily), June 2002 through June 2007

	DJIA	S&P500	DJAIG	GSCI
DJIA	1.0000	0.9732	-0.0050	-0.0774
S&P500	0.9732	1.0000	0.0320	-0.0322
DJAIG	-0.0050	0.0320	1.0000	0.8984
GSCI	-0.0774	-0.0322	0.8984	1.0000

Note: Panels E through H of Table 2 provide simple cross-correlation tables for the **daily** unlevered rates of return on four investable indices: the Dow Jones Industrial Average (DJIA) and the S&P 500 equity indices, as well as on the Dow Jones DJAIG and S&P GSCI commodity indices. Table 2A uses daily return data from January 15, 1991 to July 2, 2007. Tables 2B, 2C and 2D provide the corresponding cross-correlations for three successive sub-periods: June 2, 1992 to May 27, 1997; June 3, 1997 to May 28, 2002; and, May 28, 2002 to July 2, 2007.

Table 2I: Index-return Correlations (Monthly), January 1991 through June 2007

	DJIA	S&P500	DJAIG	GSCI
DJIA	1.0000	0.9246	0.0974	-0.0245
S&P500	0.9246	1.0000	0.0860	-0.0064
DJAIG	0.0974	0.0860	1.0000	0.8826
GSCI	-0.0245	-0.0064	0.8826	1.0000

Table 2J: Index-return Correlations(Monthly), June 1992 through May 1997

	DJIA	S&P500	DJAIG	GSCI
DJIA	1.0000	0.9224	0.2132	0.2690
S&P500	0.9224	1.0000	0.1493	0.2738
DJAIG	0.2132	0.1493	1.0000	0.7520
GSCI	0.2690	0.2738	0.7520	1.0000

Table 2K: Index-return Correlations (Monthly), June 1997 through May 2002

	DJIA	S&P500	DJAIG	GSCI
DJIA	1.0000	0.9042	0.1982	0.0847
S&P500	0.9042	1.0000	0.1658	0.0859
DJAIG	0.1982	0.1658	1.0000	0.9390
GSCI	0.0847	0.0859	0.9390	1.0000

Table 2L: Index-return Correlations (Monthly), June 2002 through June 2007

	DJIA	S&P500	DJAIG	GSCI
DJIA	1.0000	0.9658	-0.1014	-0.3050
S&P500	0.9658	1.0000	-0.0518	-0.2451
DJAIG	-0.1014	-0.0518	1.0000	0.8578
GSCI	-0.3050	-0.2451	0.8578	1.0000

Note: Panels I through L of Table 2 provide simple cross-correlation tables for the **monthly** unlevered rates of return on four investable indices: the Dow Jones Industrial Average (DJIA) and the S&P 500 equity indices, as well as on the Dow Jones DJAIG and S&P GSCI commodity indices. Table 2A uses monthly return data from January 15, 1991 to July 2, 2007. Tables 2B, 2C and 2D provide the corresponding cross-correlations for three successive sub-periods: June 2, 1992 to May 27, 1997; June 3, 1997 to May 28, 2002; and, May 28, 2002 to July 2, 2007. **Bolded** equity-commodity cross-correlations are statistically significant (5% level).

Table 3A: Weekly Rates of Return on Commodity Sub-Indices (% , 1991-2007)

	S&P500	GSCI	Agriculture	Energy	Ind.Metals	Livestock	NonEnergy	Prec.Metals
Mean	0.2043	0.1401	0.0133	0.2070	0.1781	0.0458	0.0633	0.1010
Median	0.3417	0.1869	0.0263	0.2504	0.0690	-0.0169	0.0409	0.0701
Maximum	13.1729	8.0874	9.2918	14.6776	9.5520	7.7185	5.4159	16.7883
Minimum	-11.4591	-13.5768	-6.6755	-21.5522	-10.0396	-11.1991	-5.1432	-11.5414
Std.Dev.	2.1465	2.6256	2.1407	4.0174	2.2845	1.8912	1.4036	1.9902
Skewness	0.0365	-0.4418	0.3357	-0.3777	0.1062	-0.1163	0.1984	0.4851
Kurtosis	6.8592	4.8996	4.0860	4.7313	4.2812	5.2488	3.7764	10.8101
Jarque-Bera	533.25	157.09	58.34	127.71	60.37	182.93	27.21	2216.89
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sum	175.51	120.38	11.44	177.84	153.01	39.32	54.40	86.78
Sum Sq.Dev.	3953.23	5914.67	3931.90	13847.80	4477.70	3068.72	1690.32	3398.35
Observations	859	859	859	859	859	859	859	859

Table 3B: Weekly Returns on Commodity Sub-Indices: Summary Statistics (1992-1997)

	S&P500	GSCI	Agriculture	Energy	Ind.Metals	Livestock	NonEnergy	Prec.Metals
Mean	0.2886	0.1406	0.2327	0.1164	0.1117	0.1292	0.1612	0.0390
Median	0.3507	0.1426	0.1975	0.0511	0.1546	0.0835	0.1217	0.1098
Maximum	4.2835	5.4858	9.2918	9.0001	5.7449	5.6271	5.0024	5.2064
Minimum	-4.0290	-8.7976	-5.6527	-14.5584	-7.5739	-3.8168	-3.0857	-6.7583
Std.Dev.	1.4419	1.7976	1.9565	3.1399	2.0259	1.6234	1.2129	1.5065
Skewness	-0.2167	-0.2975	0.4466	-0.2005	-0.2582	0.3730	0.3648	-0.0552
Kurtosis	3.3696	5.1457	5.3624	4.4955	3.7276	3.3920	4.2227	6.3861
Jarque-Bera	3.53	53.92	69.37	26.07	8.66	7.72	22.05	124.82
Probability	0.1713	0.0000	0.0000	0.0000	0.0132	0.0210	0.0000	0.0000
Sum	75.33	36.71	60.73	30.37	29.16	33.71	42.08	10.17
Sum Sq.Dev.	540.59	840.19	995.29	2563.35	1067.11	685.22	382.48	590.05
Observations	261	261	261	261	261	261	261	261

Table 3C: Weekly Rates of Return on Commodity Sub-Indices (% , 1997-2002)

	S&P500	GSCI	Agriculture	Energy	Ind.Metals	Livestock	NonEnergy	Prec.Metals
Mean	0.1237	0.0038	-0.3131	0.1730	-0.0927	-0.1463	-0.2139	0.0434
Median	0.3680	-0.2446	-0.2222	0.2061	-0.2019	-0.2020	-0.1906	-0.1531
Maximum	9.9121	7.3270	6.4484	14.6776	9.5520	7.7185	3.7125	16.7883
Minimum	-9.0214	-13.5768	-6.6755	-19.3599	-4.9850	-7.4199	-3.6260	-5.2534
Std.Dev.	2.6004	2.7737	1.9918	4.4310	1.9989	1.9978	1.2922	2.0039
Skewness	-0.0828	-0.2096	0.1291	-0.1032	0.6070	-0.0772	0.1167	2.5640
Kurtosis	3.5515	4.3768	3.2067	3.8739	4.5954	5.0011	3.0930	21.3337
Jarque-Bera	3.61	22.52	1.19	8.77	43.70	43.80	0.6864	3941.31
Probability	0.1649	0.0000	0.5516	0.0125	0.0000	0.0000	0.7095	0.0000
Sum	32.29	0.98	-81.72	45.15	-24.20	-38.18	-55.83	11.32
Sum Sq.Dev.	1758.13	2000.22	1031.46	5104.68	1038.84	1037.69	434.13	1044.09
Observations	261	261	261	261	261	261	261	261

Table 3D: Weekly Rates of Return on Commodity Sub-Indices (% , 2002-2007)

	S&P500	GSCI	Agriculture	Energy	Ind.Metals	Livestock	NonEnergy	Prec.Metals
Mean	0.1477	0.2797	0.0811	0.3316	0.5848	0.1406	0.2385	0.2977
Median	0.2899	0.5931	0.0761	0.8012	0.5525	0.1087	0.2511	0.4484
Maximum	13.1729	8.0874	8.6752	10.7600	8.3326	6.4158	5.4159	8.2064
Minimum	-11.4591	-11.5571	-6.0278	-14.8979	-10.0396	-11.1991	-5.1432	-11.5414
Std.Dev.	2.2814	3.1787	2.4719	4.2669	2.8103	2.1254	1.7109	2.4720
Skewness	0.3161	-0.4796	0.3366	-0.4394	-0.1925	-0.3727	0.0232	-0.6266
Kurtosis	10.6177	3.4686	3.4485	3.2561	3.8388	5.5486	3.2441	5.0177
Jarque-Bera	647.59	12.63	7.25	9.29	9.44	78.15	0.68	62.53
Probability	0.0000	0.0018	0.0266	0.0096	0.0089	0.0000	0.7103	0.0000
Sum	39.28	74.41	21.59	88.22	155.56	37.40	63.44	79.20
Sum Sq.Dev.	1379.31	2677.64	1619.29	4824.67	2092.88	1197.07	775.66	1619.34
Observations	266	266	266	266	266	266	266	266

Note: Table 3 provides descriptive statistics for the unlevered (“total”) weekly rates of return on the S&P 500 equity and GSCI commodity indices, as well as six investable GSCI sub-indices: Agriculture (Wheat, Red Wheat, Corn, Soybeans, Cotton, Sugar, Coffee, and Cocoa); Energy (WTI Crude Oil, Brent Crude Oil, RBOB Gas, Heating Oil, GasOil, and Natural Gas); Industrial Metals (Aluminium, Copper, Lead, Nickel, and Zinc); Precious Metals (Gold and Silver); Livestock (Live Cattle, Feeder Cattle, and Lean Hogs); and, NonEnergy. Table 3A uses sample moments computed from January 15, 1991 to July 2, 2007. Tables 3B, 3C and 3D provide the corresponding moments for three successive sub-periods: June 2, 1992 to May 27, 1997; June 3, 1997 to May 28, 2002; and, May 28, 2002 to July 2, 2007.

Table 4A: Cross-correlations of Index and Sub-index Returns, 1991-2007

	S&P500	GSCI	Agric.	Energy	Ind.Metals	Livestock	NonEnergy	Prec.Metals
S&P500	1.0000	0.0352	0.0059	0.0353	0.1283	0.0430	0.0612	-0.0137
GSCI	0.0352	1.0000	0.2778	0.9667	0.2410	0.1584	0.3799	0.2251
Agriculture	0.0059	0.2778	1.0000	0.1107	0.1344	0.0715	0.8130	0.1887
Energy	0.0353	0.9667	0.1107	1.0000	0.1402	0.0622	0.1775	0.1540
Ind.Metals	0.1283	0.2410	0.1344	0.1402	1.0000	0.0686	0.5153	0.3396
Livestock	0.0430	0.1584	0.0715	0.0622	0.0686	1.0000	0.4295	0.0436
NonEnergy	0.0612	0.3799	0.8130	0.1775	0.5153	0.4295	1.0000	0.3896
Prec.Metals	-0.0137	0.2251	0.1887	0.1540	0.3396	0.0436	0.3896	1.0000

Table 4B: Cross-correlations of Index and Sub-index Returns, 1992-1997

	S&P500	GSCI	Agric.	Energy	Ind.Metals	Livestock	NonEnergy	Prec.Metals
S&P500	1.0000	0.1057	-0.0384	0.1229	0.0313	0.0377	-0.0035	-0.0957
GSCI	0.1057	1.0000	0.3365	0.9409	0.1281	0.1932	0.4153	0.0692
Agriculture	-0.0384	0.3365	1.0000	0.0610	0.0895	0.0926	0.8353	0.2088
Energy	0.1229	0.9409	0.0610	1.0000	0.0088	0.0374	0.0949	-0.0189
Ind.Metals	0.0313	0.1281	0.0895	0.0088	1.0000	0.0365	0.3515	0.2465
Livestock	0.0377	0.1932	0.0926	0.0374	0.0365	1.0000	0.5131	0.0174
NonEnergy	-0.0035	0.4153	0.8353	0.0949	0.3515	0.5131	1.0000	0.2653
Prec.Metals	-0.0957	0.0692	0.2088	-0.0189	0.2465	0.0174	0.2653	1.0000

Table 4C: Cross-correlations of Index and Sub-index Returns, 1997-2002

	S&P500	GSCI	Agric.	Energy	Ind.Metals	Livestock	NonEnergy	Prec.Metals
S&P500	1.0000	0.1026	0.0321	0.0985	0.1532	-0.0207	0.0636	0.0016
GSCI	0.1026	1.0000	0.3210	0.9736	0.2815	0.1733	0.4076	0.1540
Agriculture	0.0321	0.3210	1.0000	0.1661	0.1121	0.1477	0.8562	0.0645
Energy	0.0985	0.9736	0.1661	1.0000	0.2040	0.0595	0.2212	0.1245
Ind.Metals	0.1532	0.2815	0.1121	0.2040	1.0000	0.0972	0.4217	0.1797
Livestock	-0.0207	0.1733	0.1477	0.0595	0.0972	1.0000	0.5327	0.1150
NonEnergy	0.0636	0.4076	0.8562	0.2212	0.4217	0.5327	1.0000	0.2403
Prec.Metals	0.0016	0.1540	0.0645	0.1245	0.1797	0.1150	0.2403	1.0000

Table 4D: Cross-correlations of Index and Sub-index Returns, 2002-2007

	S&P500	GSCI	Agric.	Energy	Ind.Metals	Livestock	NonEnergy	Prec.Metals
S&P500	1.0000	-0.0298	-0.0490	-0.0386	0.1866	0.1162	0.0733	0.0445
GSCI	-0.0298	1.0000	0.2622	0.9859	0.2825	0.1379	0.3804	0.3040
Agriculture	-0.0490	0.2622	1.0000	0.1432	0.1674	-0.0065	0.7860	0.2905
Energy	-0.0386	0.9859	0.1432	1.0000	0.1869	0.0953	0.2315	0.2243
Ind.Metals	0.1866	0.2825	0.1674	0.1869	1.0000	0.0704	0.6627	0.4896
Livestock	0.1162	0.1379	-0.0065	0.0953	0.0704	1.0000	0.2852	-0.0120
NonEnergy	0.0733	0.3804	0.7860	0.2315	0.6627	0.2852	1.0000	0.5545
Prec.Metals	0.0445	0.3040	0.2905	0.2243	0.4896	-0.0120	0.5545	1.0000

Note: Table 4 provides simple cross-correlation tables for the unlevered weekly rates of return on eight investable indices: the S&P 500 equity and GSCI commodity indices, as well as six GSCI sub-indices: Agriculture (Wheat, Red Wheat, Corn, Soybeans, Cotton, Sugar, Coffee, and Cocoa); Energy (WTI Crude Oil, Brent Crude Oil, RBOB Gas, Heating Oil, GasOil, and Natural Gas); Industrial Metals (Aluminium, Copper, Lead, Nickel, and Zinc); Precious Metals (Gold and Silver); Livestock (Live Cattle, Feeder Cattle, and Lean Hogs); and, Non-Energy. Table 4A uses sample moments computed from January 15, 1991 to July 2, 2007. Tables 4B, 4C and 4D provide the corresponding moments for three successive sub-periods: June 2, 1992 to May 27, 1997; June 3, 1997 to May 28, 2002; and, May 28, 2002 to July 2, 2007.

Table 5A: Large Weekly Co-Movements: S&P 500 *versus* GSCI

Sample	S&P 500 Down		S&P 500 Up	
	GSCI Down	GSCI Up	GSCI Down	GSCI Up
Full Sample (1991-2007)	<i>65</i> (15)	<i>51</i> (18)	<i>38</i> (10)	<i>49</i> (17)
1992-1997	<i>9</i> (0)	<i>11</i> (1)	<i>7</i> (0)	<i>8</i> (1)
1997-2002	<i>36</i> (9)	<i>23</i> (10)	<i>22</i> (6)	<i>27</i> (12)
2002-2007	<i>20</i> (6)	<i>17</i> (7)	<i>9</i> (4)	<i>14</i> (4)

Table 5B: Extreme Weekly Co-Movements: S&P 500 *versus* GSCI

Sample	S&P 500 Down		S&P 500 Up	
	GSCI Down	GSCI Up	GSCI Down	GSCI Up
Full Sample (1991-2007)	<i>14</i> (0)	<i>6</i> (0)	<i>5</i> (2)	<i>9</i> (2)
1992-1997	<i>0</i> (0)	<i>0</i> (0)	<i>0</i> (0)	<i>0</i> (0)
1997-2002	<i>10</i> (0)	<i>1</i> (0)	<i>4</i> (1)	<i>5</i> (2)
2002-2007	<i>4</i> (0)	<i>5</i> (0)	<i>1</i> (1)	<i>4</i> (0)

Note: Table 5 focuses on the episodes when the weekly return on the S&P 500 index was at least 1 standard deviation (“Large” returns, Table 5A) or at least 2 standard deviations (“Extreme” returns, Table 5B) away from its mean during a given period. Table 5 shows in *Italics* the number of times when the unlevered return on the GSCI index was positive or negative, for a given direction of the large (Table 5A) or extreme (Table 5B) S&P return. It also shows in **Bold** the number of times when the contemporaneous GSCI return itself was also more than one (Table 5A) or two (Table 5B) standard deviations away from its own sample mean. For example, the first line in Table 5A shows that, between January 15, 1991 and July 2, 2007, there were 116 weeks (65 + 51) when the rate of return on the S&P 500 equity index was below its sample mean by one standard deviation or more, while the corresponding line in Table 5B shows that there were 20 weeks (14 + 6) when the same return was below its mean by more than two standard deviation. During the 116 weeks listed in Table 5A, the total return on the GSCI was positive (though not necessarily large or extreme) 65 times, and negative the other 51 times. Of those 65 times, the GSCI return deviated from its mean by more than one standard deviation a total of 33 times – 15 below the mean and 51 above the mean).

Table 6A: Large Daily Co-Movements: S&P 500 *versus* GSCI

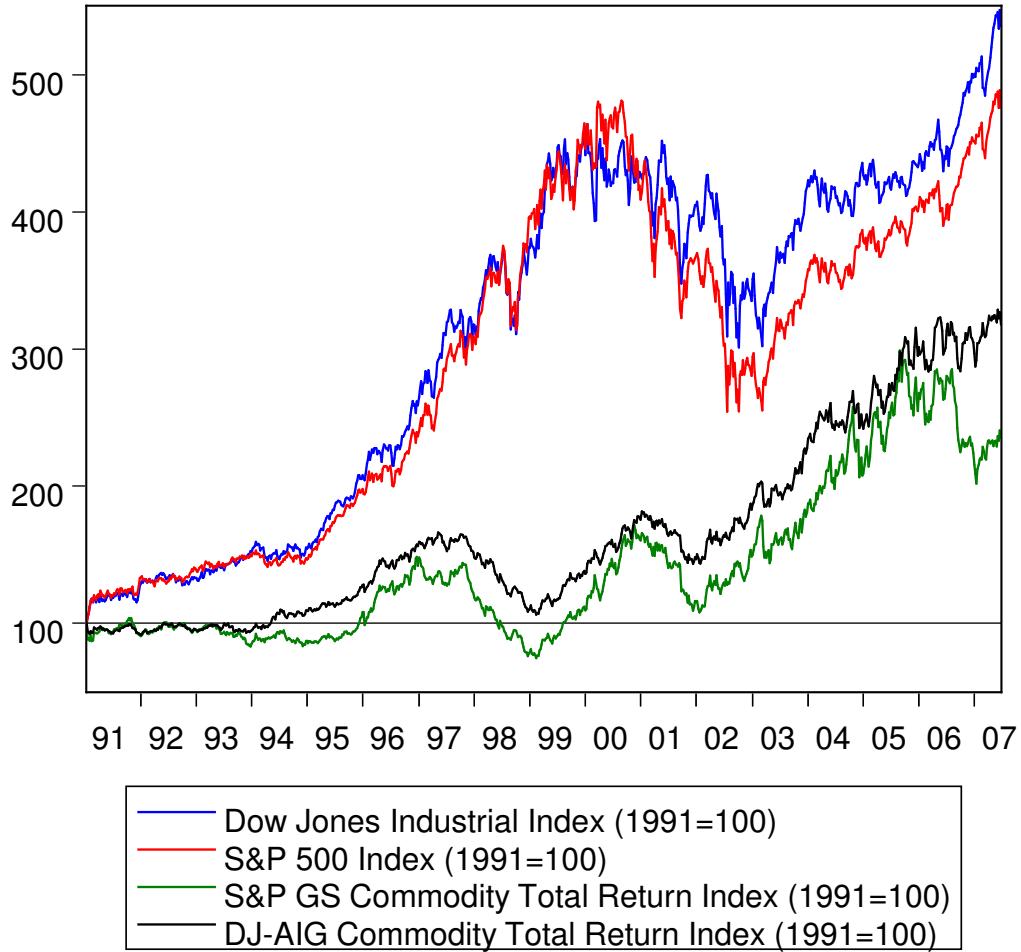
Sample	S&P 500 Down		S&P 500 Up	
	GSCI Down	GSCI Up	GSCI Down	GSCI Up
Full Sample (1991-2007)	<i>187</i> (58)	<i>162</i> (73)	<i>163</i> (72)	<i>176</i> (67)
1992-1997	<i>31</i> (7)	<i>31</i> (14)	<i>36</i> (13)	<i>34</i> (13)
1997-2002	<i>98</i> (35)	<i>80</i> (35)	<i>84</i> (36)	<i>90</i> (31)
2002-2007	<i>58</i> (16)	<i>51</i> (24)	<i>43</i> (23)	<i>52</i> (23)

Table 6B: Extreme Daily Co-Movements: S&P 500 *versus* GSCI

Sample	S&P 500 Down		S&P 500 Up	
	GSCI Down	GSCI Up	GSCI Down	GSCI Up
Full Sample (1991-2007)	<i>35</i> (5)	<i>20</i> (5)	<i>24</i> (8)	<i>33</i> (2)
1992-1997	<i>2</i> (0)	<i>2</i> (0)	<i>2</i> (1)	<i>4</i> (0)
1997-2002	<i>20</i> (4)	<i>12</i> (4)	<i>16</i> (5)	<i>19</i> (1)
2002-2007	<i>13</i> (1)	<i>6</i> (1)	<i>6</i> (2)	<i>10</i> (1)

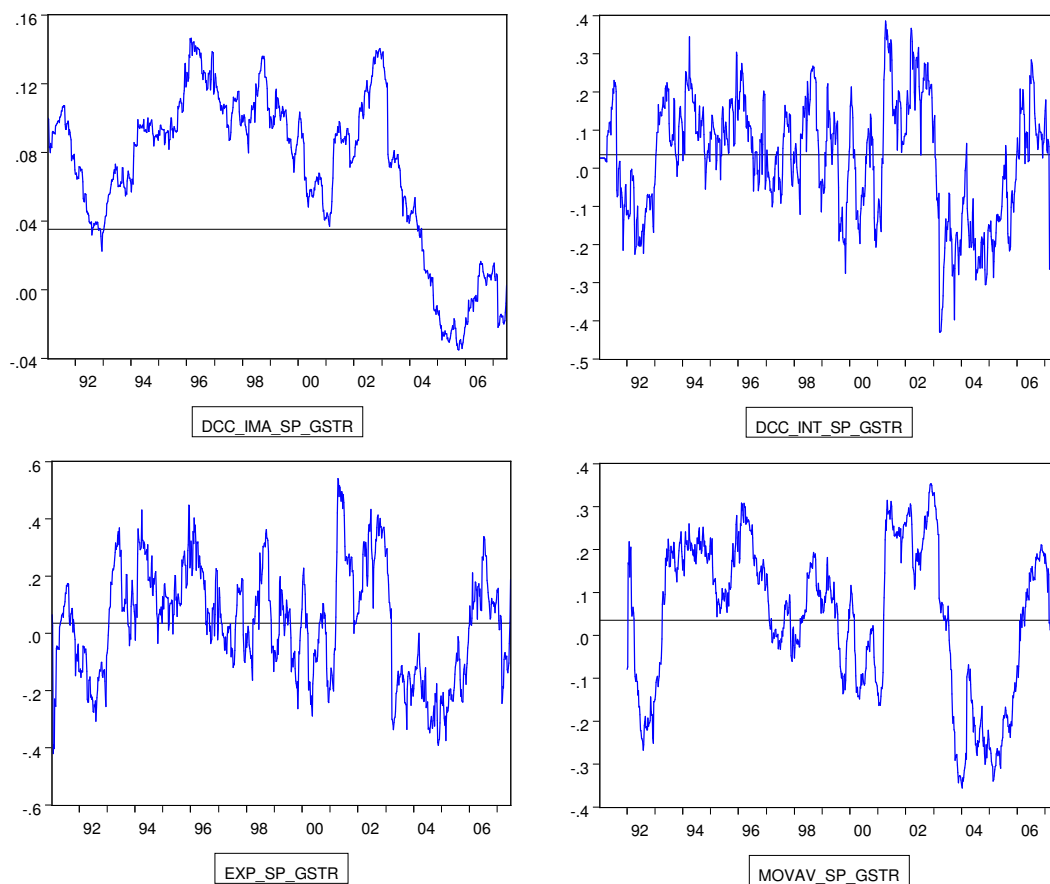
Note: Table 6 focuses on the episodes when the daily return on the S&P 500 index was at least 1 standard deviation (“Large” returns, Table 6A) or at least 2 standard deviations (“Extreme” returns, Table 6B) away from its mean during a given period. Table 6 shows in *Italics* the number of times when the unlevered return on the GSCI index was positive or negative, for a given direction of the large (Table 6A) or extreme (Table 6B) S&P return. It also shows in **Bold** the number of times when the contemporaneous GSCI return itself was also more than one (Table 6A) or two (Table 6B) standard deviations away from its own sample mean. For example, the first line in Table 6A shows that, between January 15, 1991 and July 2, 2007, there were 349 days (187 + 162) when the rate of return on the S&P 500 equity index was below its sample mean by one standard deviation or more, while the corresponding line in Table 6B shows that there were 55 days (35 + 20) when the same return was below its mean by more than two standard deviation. During the 349 days listed in Table 6A, the total return on the GSCI was positive (though not necessarily large or extreme) 187 times, and negative the other 162 times. Of those 187 times, the GSCI return deviated from its mean by more than one standard deviation a total of 131 times – 58 below the mean and 73 above the mean).

Figure 1: Major Commodity and Equity Indices, 1991-2007



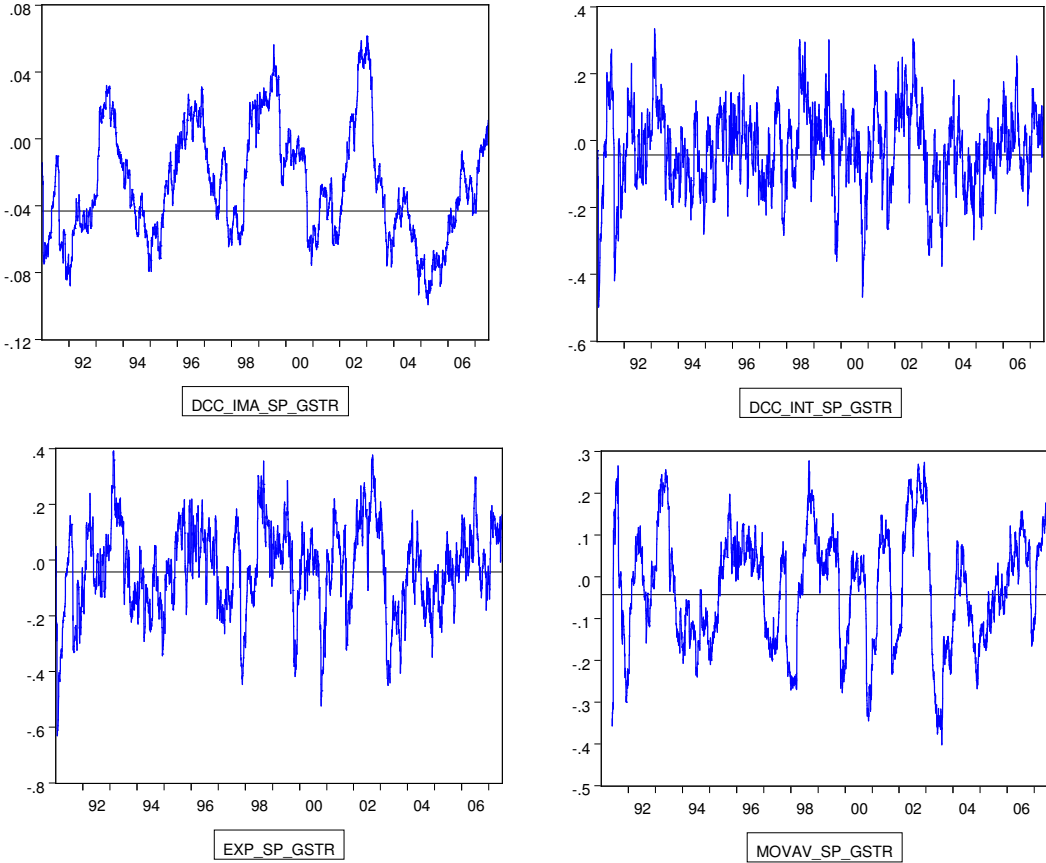
Note: Figure 1 plots the levels of four indices from January 15, 1991 to July 2, 2007: the Dow Jones Industrial Average (DJIA) and the S&P 500 equity indices, and the Dow Jones DJ-AIG and S&P GSCI commodity indices. The base level is set for January 15, 1991. The two equity indices (top two trends) appear to move closely together, as do the two commodity indices most of the time. Two exceptions are 1994-1995 and 2006-2007, when the DJ-AIG index rose while the GSCI either stagnated or outright dropped in value.

Figure 2A: Equity and Commodity Weekly Return Correlations: S&P 500 *vs.* GSCI, 1991-2007



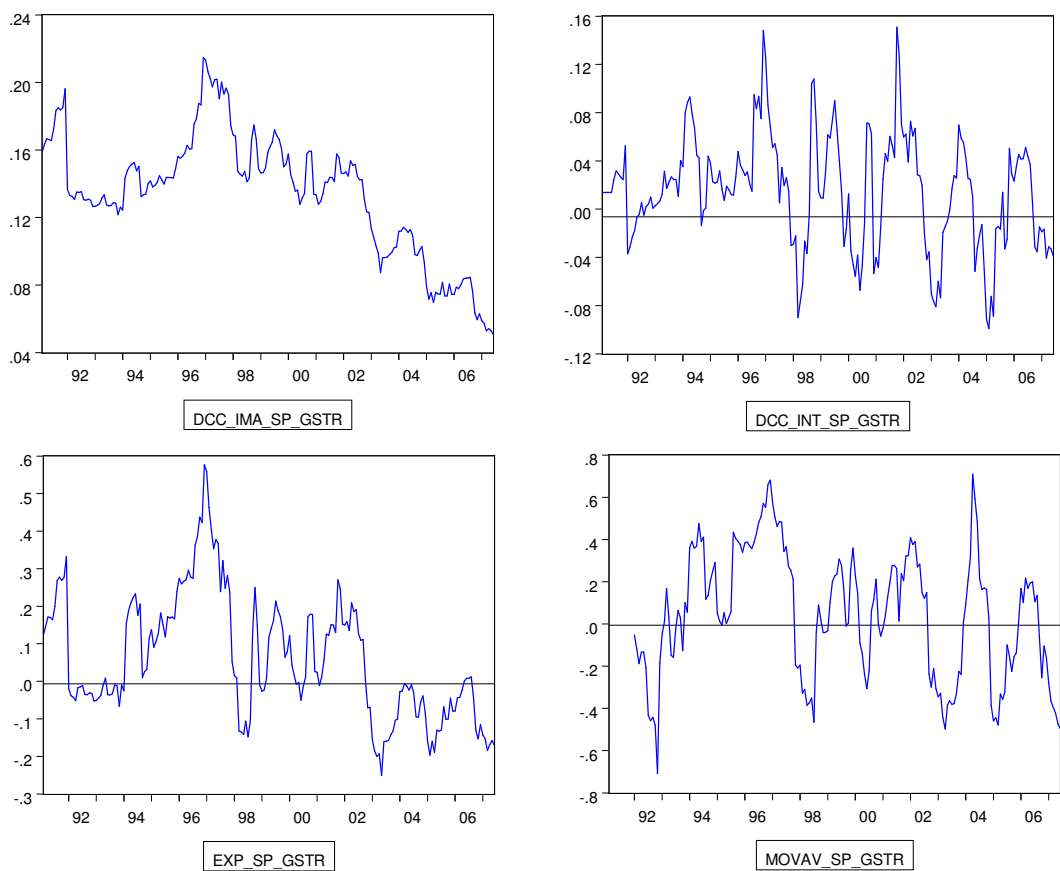
Note: Figure 2A depicts estimates of the time-varying correlation between the **weekly** unlevered rates of return on the S&P 500 (SP) and GSCI total return (GSTR) indices from January 15, 1991 to July 2, 2007. The Figure provides plots for the following four estimation methods: dynamic conditional correlation with integrated moving average estimation (top left panel) and dynamic conditional correlation by log-likelihood for integrated process (top right); rolling historical correlation (bottom left); and, exponential smoother with 0.94 smoothing parameter (bottom right). The straight line running through each graph is the unconditional correlation from Table 2A.

Figure 2B: Equity and Commodity Daily Return Correlations: S&P 500 *vs.* GSCI, 1991-2007



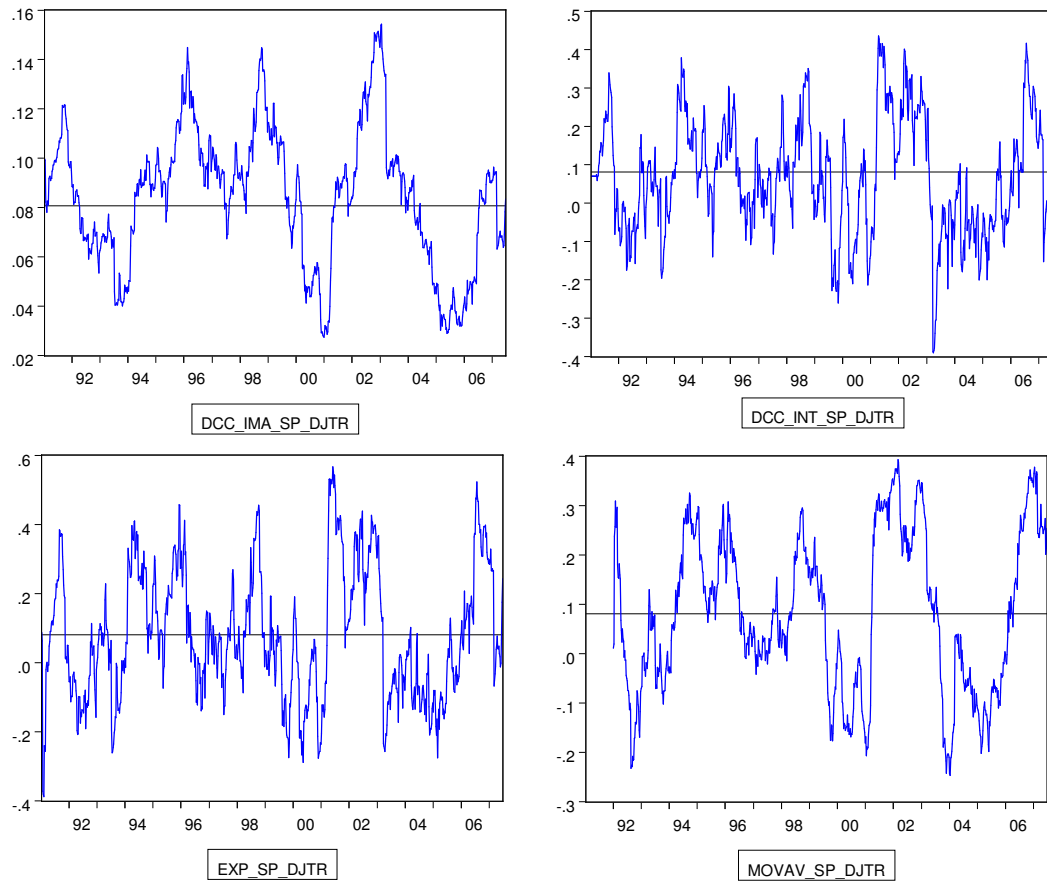
Note: Figure 2B depicts estimates of the time-varying correlation between the **daily** unlevered rates of return on the S&P 500 (SP) and GSCI total return (GSTR) indices from January 15, 1991 to July 2, 2007. The Figure provides plots for the following four estimation methods: dynamic conditional correlation with integrated moving average estimation (top left panel) and dynamic conditional correlation by log-likelihood for integrated process (top right); rolling historical correlation (bottom left); and, exponential smoother with 0.97 smoothing parameter (bottom right). The straight line running through each graph is the unconditional correlation.

Figure 2C: Equity and Commodity Monthly Return Correlations: S&P 500 *vs.* GSCI, 1991-2007



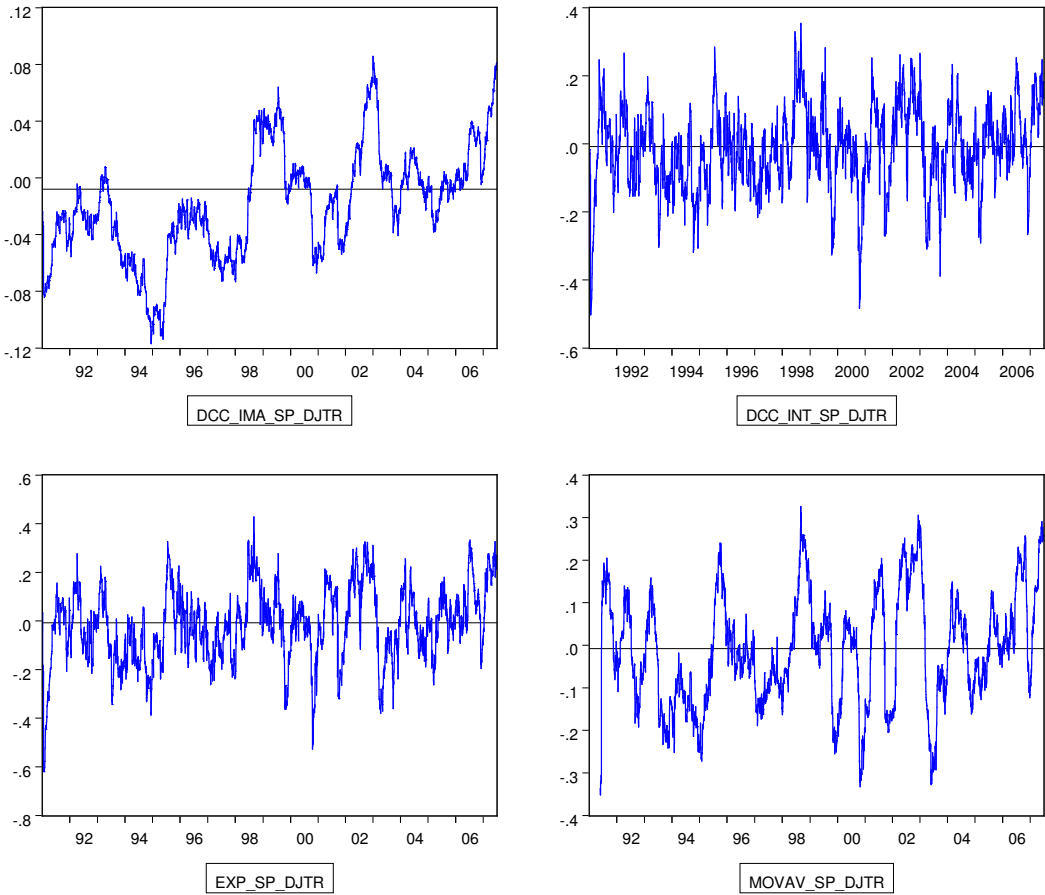
Note: Figure 2C depicts estimates of the time-varying correlation between the **monthly** unlevered rates of return on the S&P 500 (SP) and GSCI total return (GSTR) indices from January 15, 1991 to July 2, 2007. The Figure provides plots for the following four estimation methods: dynamic conditional correlation with integrated moving average estimation (top left panel) and dynamic conditional correlation by log-likelihood for integrated process (top right); rolling historical correlation (bottom left); and, exponential smoother with 0.94 smoothing parameter (bottom right). The straight line running through each graph is the unconditional correlation.

Figure 3A: Equity and Commodity Weekly Return Correlations: S&P 500 *vs.* DJ-AIG, 1991-2007



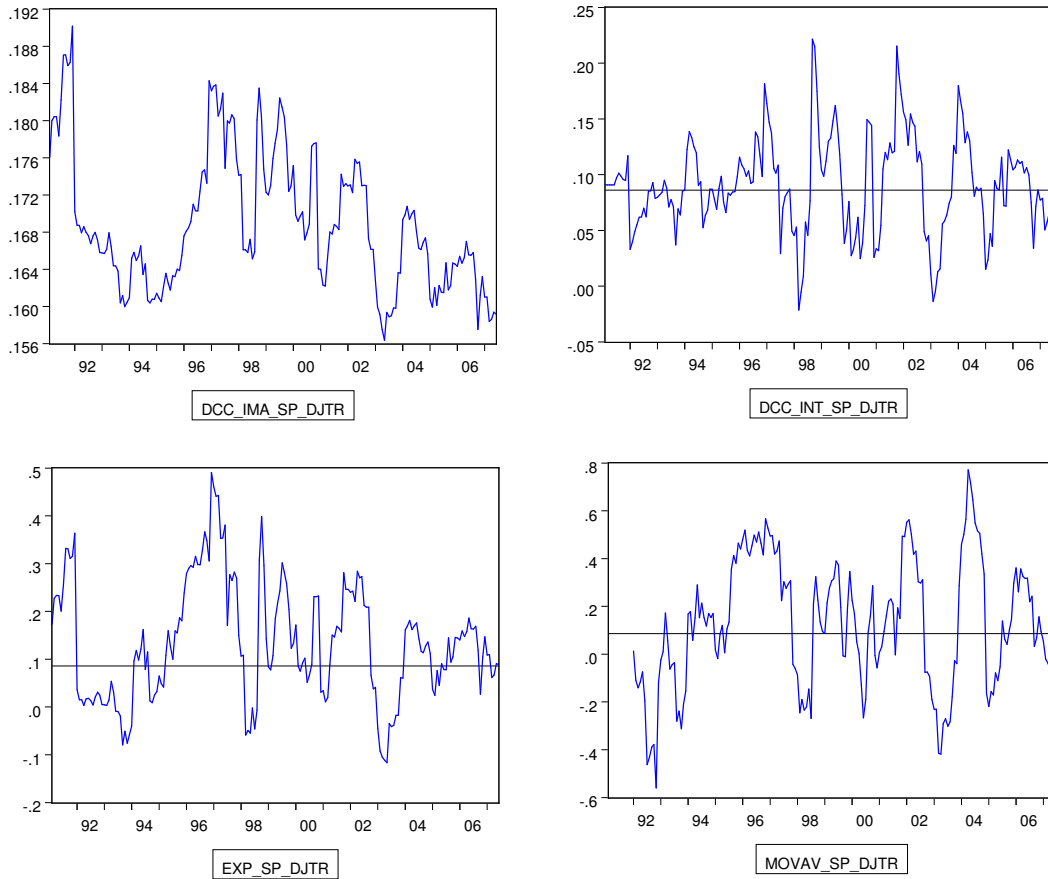
Note: Figure 3A depicts the time-varying estimates of the correlation between the **weekly** unlevered rates of return on the S&P 500 (SP) and DJ-AIGCI total return (DJTR) indices from January 15, 1991 to July 2, 2007. The Figure provides plots for the following four estimation methods: dynamic conditional correlation with integrated moving average estimation (top left panel) and dynamic conditional correlation by log-likelihood for integrated process (top right); rolling historical correlation (bottom left); and, exponential smoother with 0.94 smoothing parameter (bottom right). The straight line running through each graph is the unconditional correlation.

Figure 3B: Equity and Commodity Daily Return Correlations: S&P 500 vs. DJ-AIG, 1991-2007



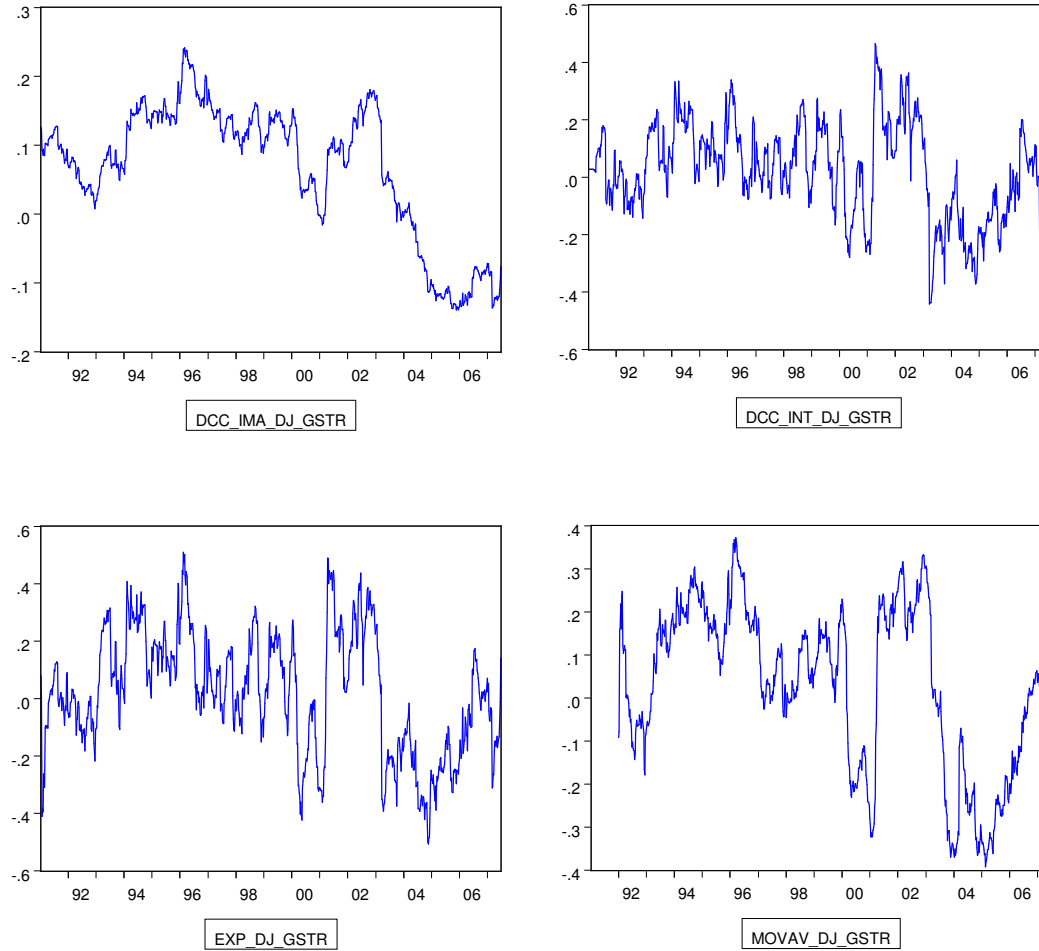
Note: Figure 3B depicts the time-varying estimates of the correlation between the **monthly** unlevered rates of return on the S&P 500 (SP) and DJ-AIGCI total return (DJTR) indices from January 15, 1991 to July 2, 2007. The Figure provides plots for the following four estimation methods: dynamic conditional correlation with integrated moving average estimation (top left panel) and dynamic conditional correlation by log-likelihood for integrated process (top right); rolling historical correlation (bottom left); and, exponential smoother with 0.97 smoothing parameter (bottom right). The straight line running through each graph is the unconditional correlation from Table 2A.

Figure 3C: Equity and Commodity Monthly Return Correlations: S&P 500 *vs.* DJ-AIG, 1991-2007



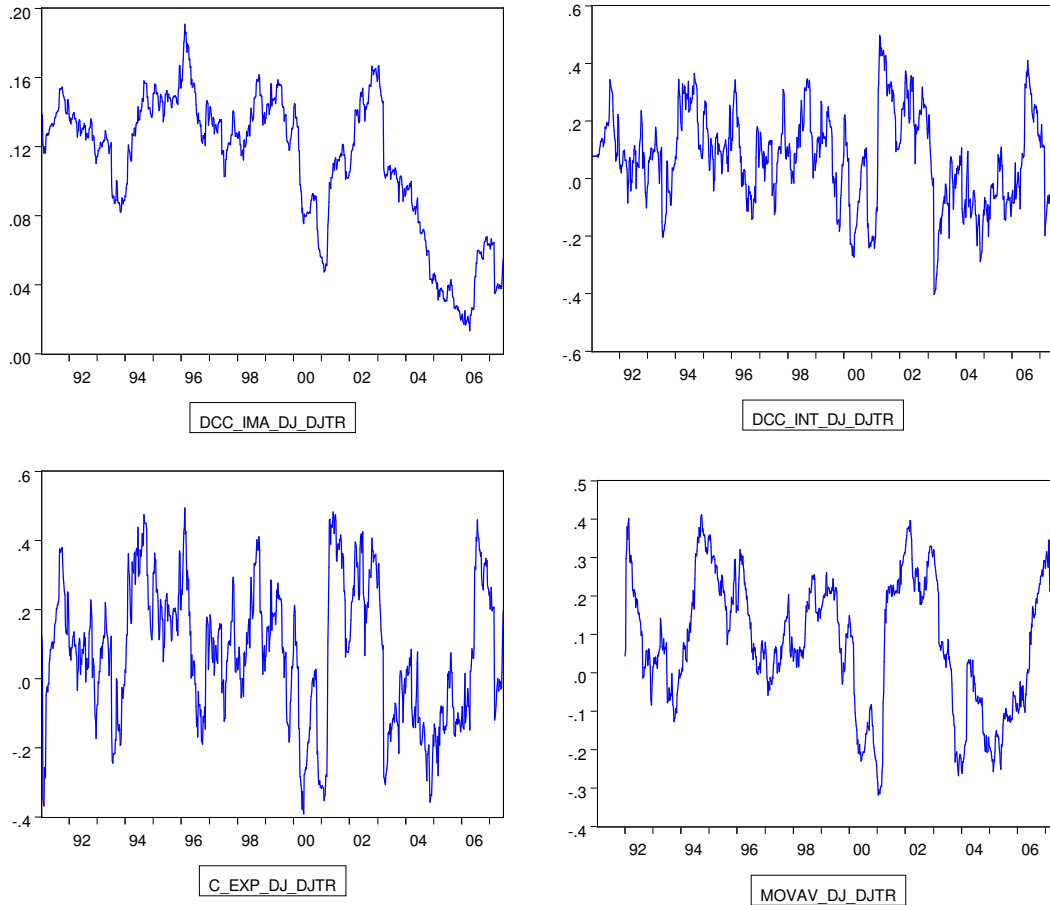
Note: Figure 3C depicts the time-varying estimates of the correlation between the **monthly** unlevered rates of return on the S&P 500 (SP) and DJ-AIGCI total return (DJTR) indices from January 15, 1991 to July 2, 2007. The Figure provides plots for the following four estimation methods: dynamic conditional correlation with integrated moving average estimation (top left panel) and dynamic conditional correlation by log-likelihood for integrated process (top right); rolling historical correlation (bottom left); and, exponential smoother with 0.94 smoothing parameter (bottom right). The straight line running through each graph is the unconditional correlation.

Figure 4: Equity and Commodity Weekly Return Correlations: DJIA vs. GSCI, 1991-2007



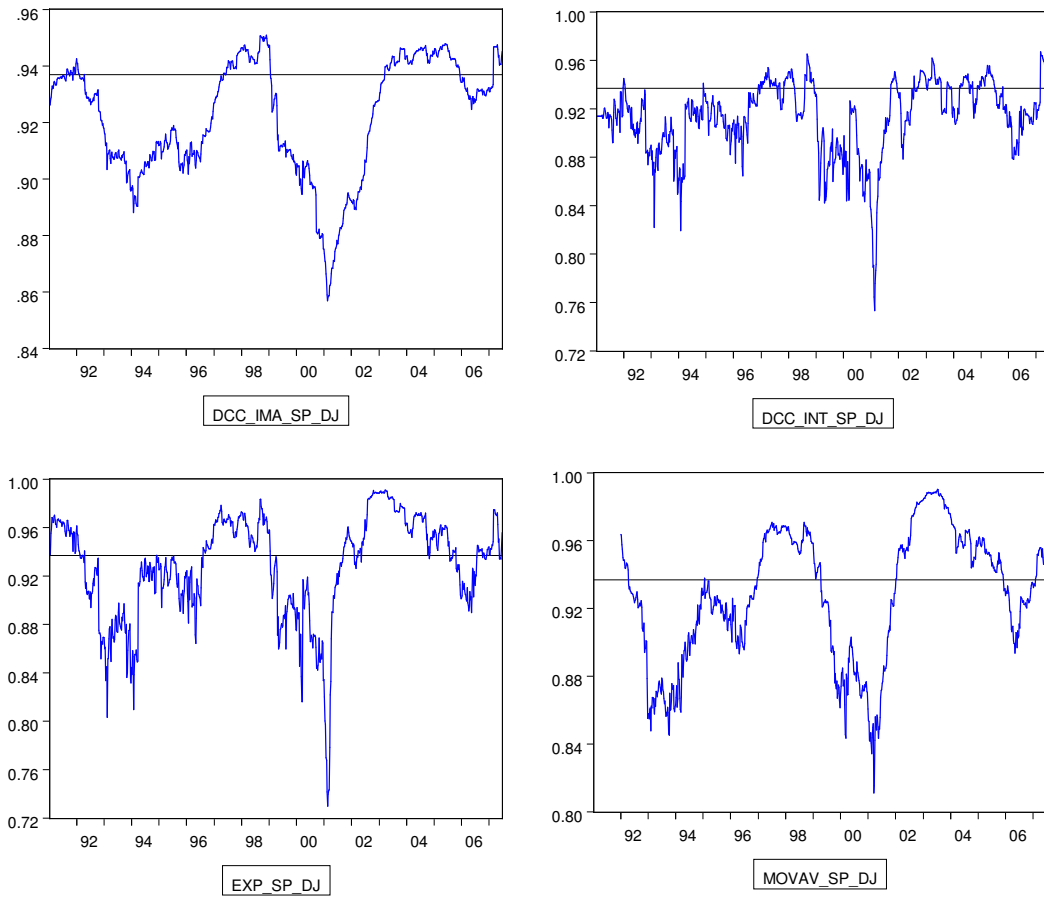
Note: Figure 4 depicts estimates of the time-varying correlation between the unlevered rates of return on the Dow Jones Industrial Average (DJ) and GSCI total return (GSTR) indices from January 15, 1991 to July 2, 2007. The Figure provides plots for the following four estimation methods: dynamic conditional correlation with integrated moving average estimation (top left panel) and dynamic conditional correlation by log-likelihood for integrated process (top right); rolling historical correlation (bottom left); and, exponential smoother with 0.94 smoothing parameter (bottom right). The straight line running through each graph is the unconditional correlation from Table 2A.

Figure 5: Equity and Commodity Weekly Return Correlations: DJIA vs. DJ-AIG, 1991-2007



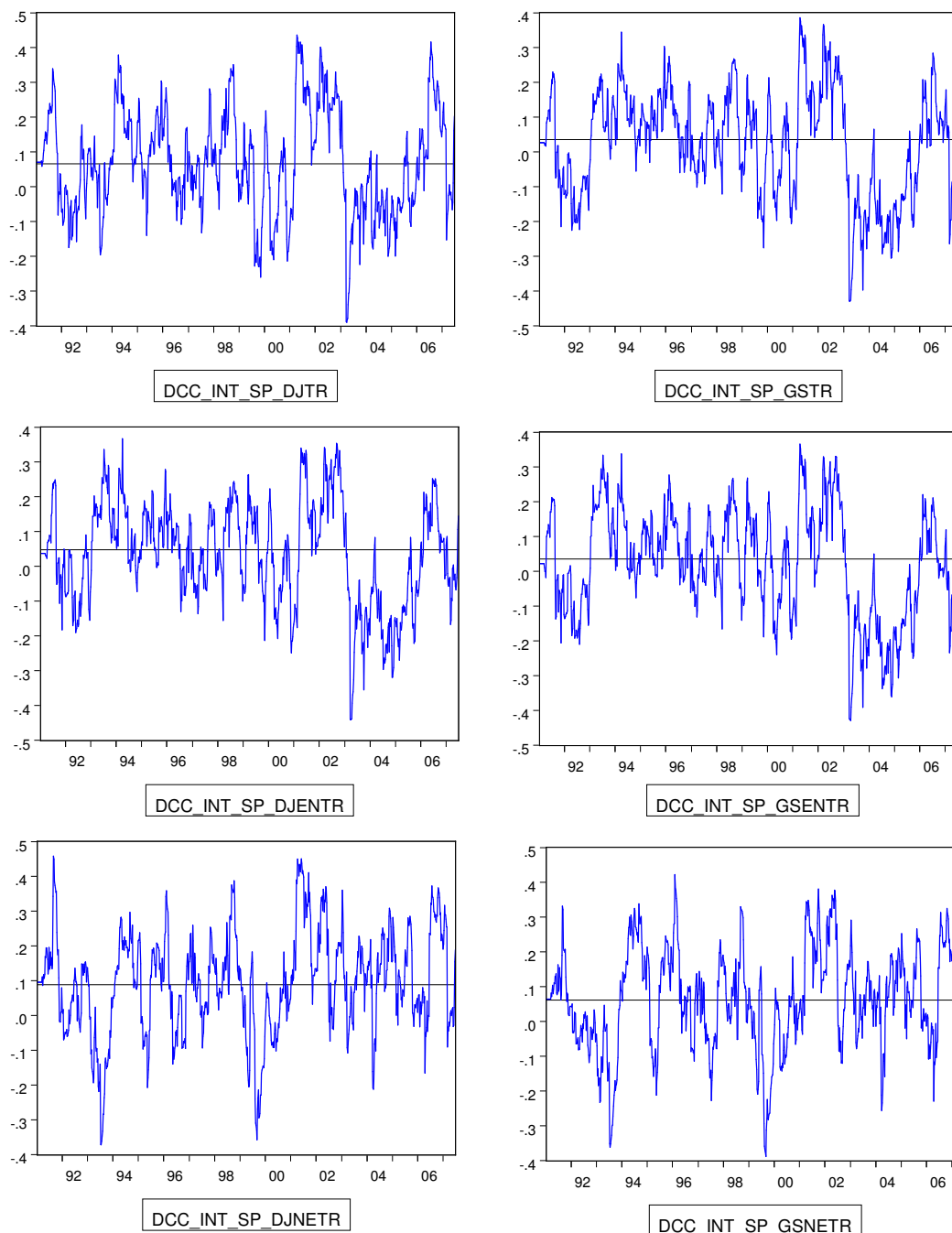
Note: Figure 5 depicts estimates of the time-varying correlation between the unlevered rates of return on the Dow Jones Industrial Average (DJ) and DJ-AIGCI total return (DJTR) indices from January 15, 1991 to July 2, 2007. The Figure provides plots for the following four estimation methods: dynamic conditional correlation with integrated moving average estimation (top left panel) and dynamic conditional correlation by log-likelihood for integrated process (top right); rolling historical correlation (bottom left); and, exponential smoother with 0.94 smoothing parameter (bottom right). The straight line running through each graph is the unconditional correlation from Table 2A.

Figure 6: S&P 500 and DJIA Weekly Equity Returns Correlations, 1991-2007



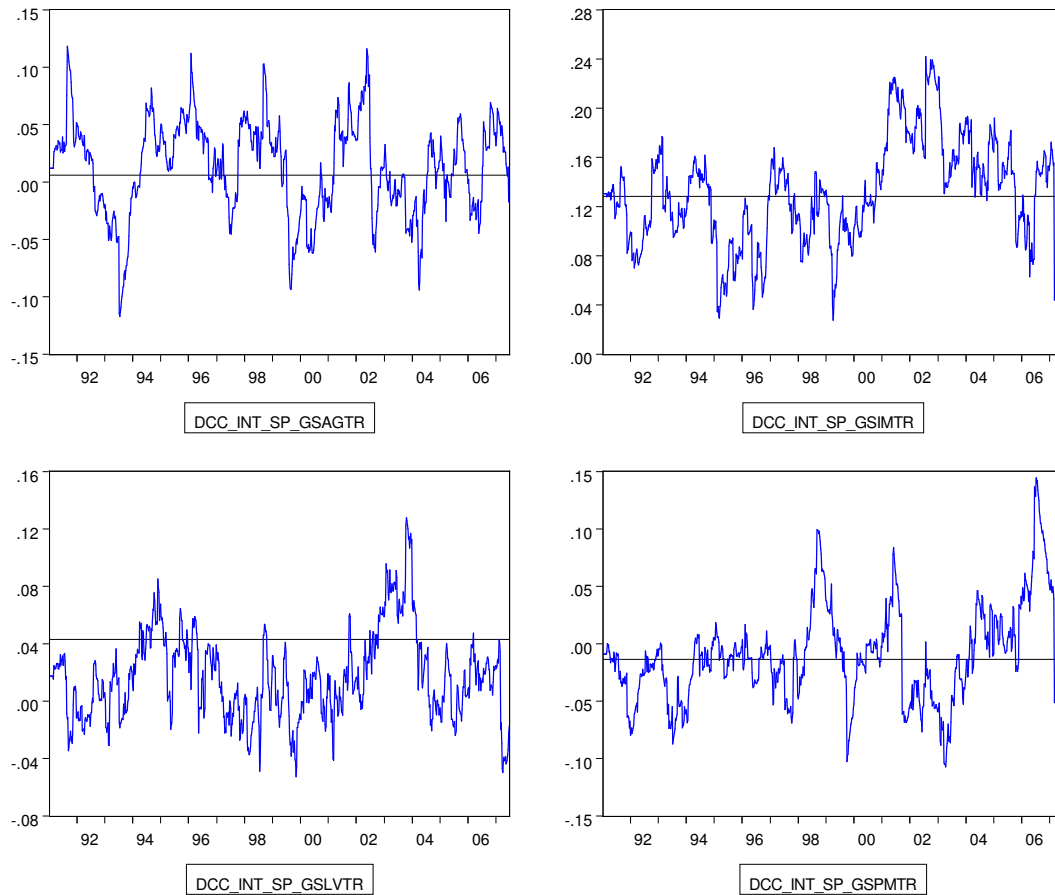
Note: Figure 6 depicts estimates of the time-varying correlation between the unlevered rates of return on the Dow Jones Industrial Average (DJ) and S&P 500 (SP) equity indices from January 15, 1991 to July 2, 2007. The Figure provides plots for the following four estimation methods: dynamic conditional correlation with integrated moving average estimation (top left panel) and dynamic conditional correlation by log-likelihood for integrated process (top right); rolling historical correlation (bottom left); and, exponential smoother with 0.94 smoothing parameter (bottom right). The straight line running through each graph is the unconditional correlation from Table 2A.

Figure 7: S&P 500, Energy, and, Non-Energy Weekly Index Returns Correlations (1991-2007)



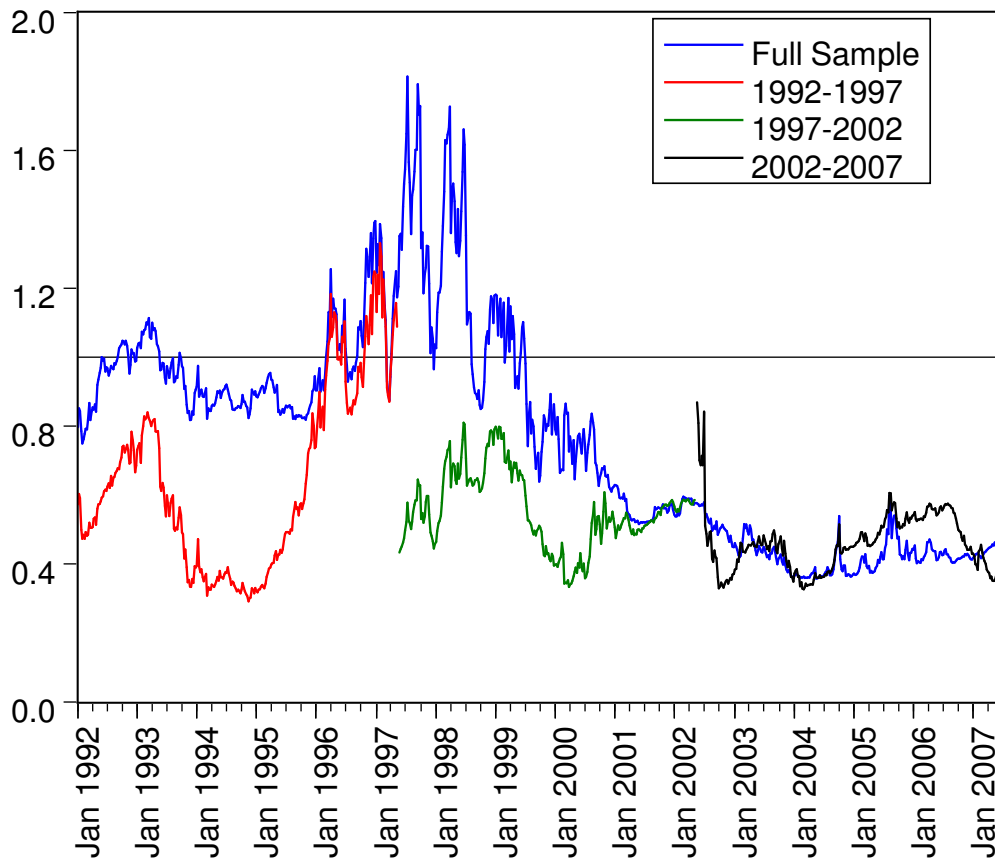
Note: Figure 7 plots the time-varying correlations between the unlevered rates of return on the S&P 500 (SP) equity index and six investable commodity products. Dynamic conditional correlation are estimated by log-likelihood for integrated process (Engle, 2002). The straight lines through the graphs show the unconditional correlations from January 15, 1991 to July 2, 2007. Clockwise from top right: GSCI total return index (GSTR); GSCI energy total return index (GSENTR); GSCI non-energy total return index (GSNETR); DJ-AIG non-energy total return index (DJNETR); DJ-AIG energy total return index (DJENTR) and, DJ-AIG total return index (DJTR).

Figure 8: S&P 500 and GSCI Weekly Sub-Index Returns Correlations, 1991-2007



Note: Figure 8 depicts estimates of the time-varying correlation between the unlevered rates of return on the S&P 500 (SP) equity index and various investable GSCI total return commodity sub-indices. Counter-clockwise from the top left corner: GSCI total return (GSTR) index; GSCI Industrial-Metals total return index (GSIMTR); GSCI Precious-Metals total return index (GSPMTR); GSCI Livestock total return index (GSLVTR); and, GSCI Agriculture total return index (GSAGTR). Dynamic conditional correlation are estimated by by log-likelihood for integrated process (Engle, 2002). The straight line running through each graph shows the corresponding unconditional correlation from January 15, 1991 to July 2, 2007.

Figure 9: Recursively Calculated Trace Test Statistic Scaled by the 5% Critical value, 1992-2007



Note: Figure 9 shows the R-1 form of the trace statistic. The 5% critical value is represented by the solid (horizontal) black line. The dark blue graph shows the estimate calculated recursively using data from the whole sample, i.e., from January 1991 through July 2007. The red, green and black lines plot the estimate for three successive sub-periods: 1992-1997; 1997-2002; 2002-2007. Weekly price data from the year prior to a given estimation period are utilized to start the recursive procedure for that period.