Index Investing and the Financialization of Commodities[*]

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Abstract

This paper examines the financialization process of commodities precipitated by the rapid growth of index investment to the commodities markets since the early 2000s. We find that concurrent with the increasing presence of index investors, commodity prices have been increasingly exposed to market-wide shocks, such as shocks to the world equity index and US dollar exchange rate, and to shocks to other commodities, such as oil. In particular, this trend is more pronounced for commodities in the two popular commodity indices, the GSCI and DJ-AIG indices. As a result of the financialization process, the spillover effects of the recent financial crisis contributed substantially to the large increase in commodity price volatility in 2008. Our study thus highlights the increasingly important interactions between commodities markets and financial markets.

The dramatic rise and fall of crude oil prices in 2008 (as shown in Figure 1) has stimulated increasing public attention and research interest in commodities markets. In particular, there is heated debate in policy circles about whether speculation caused unwarranted increases in the cost of energy and food and induced excessive price volatility. Both the Senate and the House have held hearings about this issue. Recently, the U.S. Commodity Futures Trading Commission (CFTC) said it would consider new measures to curb speculation. The surge in oil prices even prompted UK Prime Minister Gordon Brown and French President Nicolas Sarkozy to write a joint Wall Street Journal editorial in July 2009 to urge joint effort by international governments to supervise the energy markets.

The ongoing debate attributes the recent rise and fall of oil prices either to a simple matter of supply and demand or to excessive speculation by index investors. According to the first view, which is emphasized by many economists, e.g., Krugman (2008), Hamilton (2009), and Kilian

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(2009), oil prices soared before the summer of 2008 because world demand had been rapidly increasing, propelled by booming economies such as China and India. Prices later fell sharply when the world recession caused demand to fade. The second view attributes the large volatility of oil prices to price distortions caused by the large investment flow to commodity indices. According to a CFTC staff report (2008) and Masters (2008), the total value of various commodity index-related instruments purchased by institutional investors increased from an estimated $15 billion in 2003 to at least $200 billion in mid-2008. A recent report by the US Senate Permanent Subcommittee on Investigations (2009) argues that the dramatic index investment flow had distorted the prices of some commodities, such as wheat.

Despite the great public attention on the large increase in commodity price volatility in recent years, the concurrent, and arguably more fundamental, economic transition of the commodities markets, precipitated by the rapid growth of index investment in commodities, has gone unnoticed. Prior to the early 2000s, despite the liquid futures contracts traded on many commodities, commodities behaved very differently from typical financial assets. Commodities had little price co-movement with stocks, and commodities in different sectors had little price co-movement with each other. These aspects of commodity prices were in sharp contrast to the price dynamics of financial assets, which are typically exposed to market-wide shocks and shocks to other assets, through various channels related to risk appetite and the trading of diversified investors, e.g., Campbell and Shiller (1988), Campbell and Cochrane (1999), Kyle and Xiong (2001), and Barberis and Shleifer (2003). The tide changed in the early 2000s, when the collapse of the equity market in 2000 and the widely publicized discovery of a small negative correlation between commodity returns and stock returns led to a belief that commodity futures could be used to reduce portfolio risk. This belief allowed Goldman Sachs and other financial institutions to successfully promote commodity futures as a new asset class for prudent investors. As a result, various instruments based on commodity indices have attracted billions of dollars of investment from institutional investors and wealthy individuals.

Commodities are real assets in that their values are intrinsically connected to physical productions and consumer demands of commodities. This aspect makes them different from typical financial assets, such as stocks and bonds, whose values derive from their future cash flows. On the other hand, the need of commodity producers and consumers to share commodity price risk with a larger set of economic agents also motivates integration of commodities markets with the broad financial markets. The increasing presence of index investors in commodities markets precipitated a fundamental process of financialization amongst the commodities markets, through which commodity prices now become exposed to shocks to financial markets and to other commodities. In this paper, we systematically analyze this financialization process and the resulting spillover effects of the recent financial crisis on commodity price volatility.

We report several interesting results. At the index level, while there was a small negative return correlation between the Goldman Sachs Commodity Index (GSCI), a widely used commodity index, and the Morgan Stanley world equity index prior to the early 2000s, we find the emergence of an increasing trend in the exposure of the GSCI index return to the world equity index return, concurrent with the increasing presence of index investors in the commodities markets in recent years. There is also an intensifying trend in the negative exposure of the GSCI index return to shocks to the US dollar exchange rate in recent years.

For individual commodities in four different non-energy sectors, which include grains, softs, livestock, and metals, we find that in recent years, their prices have become not only increasingly exposed to shocks to the world equity index and US exchange rate, but also to oil shocks. More interestingly, by comparing the differences in the changes in these exposures between commodities in the two most popular commodity indices, the GSCI and DJ-AIG (Dow-Jones AIG Commodity Index) indices, and those off the indices, we find that the changes are consistently stronger for indexed commodities in each of the four non-energy sectors. This difference-in-difference result suggests that the increasing exposures of commodity prices to the market-wide shocks and oil shocks were associated with the increasing presence of index investors, whose investments are concentrated in commodities in the indices.

We also analyze the trading volume of individual commodities and find that the presence of index investors also increased the co-movement of trading volume, in particular, for commodities in the GSCI and DJ-AIG indices. The CFTC's commodity index traders (CIT) report, which is only available since 2006 for twelve agricultural and livestock commodities, allows us to construct a measure of index investment flow in and out of these commodities. We document intricate joint dynamics of this index investment flow with the commodity prices, the world equity index return and the US dollar return.

The large increase of oil price volatility from around 30% to near 60% in 2008 caused serious concerns among the public and regulators. What is the source of this large volatility increase? In contrast to previous episodes of large oil price volatility increases, this one was also accompanied by concurrent rises of volatility in the broad financial markets, a reflection of the world financial crisis, and in other non-energy commodities. The largely increased exposures of commodities to market-wide shocks, together with the turmoil in the broad financial markets, provide a natural cause. We find that spillovers of market-wide shocks, such as those to the world equity index and US dollar exchange rate, and of oil shocks contributed significantly to the volatility increases of oil and other non-energy commodities in 2008. Furthermore, non-energy commodities in the GSCI and DJ-AIG indices had larger volatility increases than those off the indices, and their larger increases are associated with their greater exposures to the market-wide shocks and oil shocks.

Our study adds to the aforementioned debate about the large increases in the commodity price volatility in recent years. We document the effects of the increasing presence of index investors on the exposures of commodity prices to market-wide shocks and oil shocks. We also highlight a specific mechanism---the spillovers of the recent financial crisis---for explaining the large increases in commodity price volatility. The appearance of these spillover effects implies that arguments put forward by one side of the debate based on simple demand and supply of physical commodities are not complete. One the other hand, these spillover effects are not outright price distortions, as argued by the other side of the debate. Instead, they are a byproduct of a fundamental financialization process of the commodities markets. This process holds the promise of more efficient allocation of commodity price risk among a larger set of agents; but it also exposes individual commodities to the spillover effects documented in our study. Our findings thus lay out the necessary ground for a systematic evaluation of the financialization process of the commodities markets in the future. [1]

The emphasis of our study on the exposures of commodity prices to market-wide shocks and oil shocks is distinct from the literature on the returns and risk premia of commodities, e.g., Fama and French (1987), Bessembinder (1992), de Roon, Nijman, and Veld (2000), Gorton, Hayashi, and Rouwenhorst (2007), and Hong and Yogo (2009). Instead, our analysis corroborates with Pindyck and Rotemberg (1990) who find that common macro shocks cannot fully explain the co-movement of commodity prices between 1960 and 1985. In contrast, our analysis emphasizes the increases in co-movement of commodity prices in recent years. Furthermore, we find larger increases in the price co-movement of oil with indexed commodities than with off-index commodities. In this regard, our study is related to Barberis, Shleifer and Wurgler (2005), who find that after a stock is added to S&P 500 index, its co-movement with the index increases significantly.

Our study also complements the large literature on the important effects of commodity prices on economic growth and monetary policies, e.g., Hamilton (1983), Bernanke, Gertler, and Watson (1997), Barsky and Kilian (2002), and Blanchard and Gali (2008). In particular, our findings highlight the increasingly important interactions between commodities markets and financial markets.

The paper is organized as follows. Section I provides some background information about commodities and commodity indices. Section II summarizes several empirical hypotheses for the effects of the rapid growth of index investment on commodities markets. We analyze the

[1] The standard econometric theories imply that it requires a long span of data period to reliably measure the risk premium embedded in the price of an asset. Given that the financialization of commodities only started since the early 2000s, the current data sample is still too short to form a reliable measure of this benefit. On the other hand, one can reliably measure volatility and co-movement of asset prices in a short sample period by using high frequency data, which is the focus of this paper.

integration of commodity index returns in Section III, and spillover effects to individual commodities in Section IV. Section V analyzes trading by commodity index investors. In Section VI, we analyze the contribution of spillover effects to the large increases of commodity price volatility in recent years. Finally, we conclude in Section VII.

I. Commodities and Commodity Indices

Due to the lack of centralized trading for many commodities, spot prices are often not reliable. Thus, for our analysis, we focus on commodities with active futures contracts traded in U.S. There are 28 such commodities available in recent years. We obtain daily futures prices and open interest of these commodities from Pinnacle Data Corp. Table 1 lists and classifies these commodities in five sectors: energy, grains, softs, livestock, and metals.[2]

The energy sector contains 4 commodities: WTI (West Texas Intermediate grade) crude oil, heating oil, gasoline, and natural gas.[3] Crude oil is the most important component in this sector as heating oil and gasoline are refined oil products, whose prices move closely with crude oil. The grain sector contains 9 commodities: corn, Chicago wheat, Kansas wheat, Minneapolis wheat, soybeans, soybean oil, soybean meal, rough rice, and oat. These grains are substitutes for each other as food for humans and animals.[4] The soft sector is a mix of tropics that are grown primarily in tropical and subtropical regions. There are 6 commodities in this sector: coffee, cotton, sugar, cocoa, lumber and orange juice. We follow the common practice to classify them in one sector although the links between the softs are not as close as commodities in other sectors. There are four commodities in the livestock sector: feeder cattle, lean hogs, live cattle and pork

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[2] See Geman (2005) for a comprehensive description of these commodity sectors and distribution of the global supply and demand of each of the commodities.

[3] The New York Mercantile Exchange (NYMEX) offers futures contracts on each of them with expirations in every month of a year. The WTI crude oil contracts specify a type of light and sweet oil (with 38-40° API and 0.3% sulfur) to be delivered at Cushing, Oklahoma. These contracts are heavily traded and their prices are widely used as benchmarks for determining the prices of crude oil of different grades and at different locations. The Brent crude oil contracts specify a similar grade of oil to be delivered at Shetland Islands, UK. Their prices move closely with those of the WTI contracts. The demand and supply fluctuations in the local markets of North America and Europe could also cause some variations between the prices of Brent and WTI contracts. We do not include the Brent contracts in our sample to avoid potential complications from asynchronous daily closing prices of different commodities between the US and London markets.

[4] Soybeans are crushed to produce meal and oil. The three forms constitute the so-called "soybean complex", each of which underlies futures contracts traded on Chicago Mercantile Exchange (CME). Corn is mostly used as animal feed, competing with wheat and soybean meal. In the recent years, corn is also used in the U.S. for producing ethanol and other alternative fuels. Wheat is traded on three exchanges: the CME, the Kansas City Board of Trade (KCBOT), and the Minneapolis Grain Exchange (MGE). Chicago wheat is a soft winter wheat, grown primarily in the central states. It is a low-grade wheat mostly used as livestock feed or as flour for cheap bread. Kansas wheat is a hard, red, winter wheat, grown primarily in the southern states, and is used mainly for human food. Minneapolis wheat is the highest-grade wheat, planted in the northern states. Rice is the second largest crop in planting acreage across the world after wheat. It is primarily used for human consumption. While oats are suitable for human consumption as oatmeal and rolled oats, its primary use is as livestock feed.

bellies. These commodities are primarily used for human consumption. The metals sector contains 5 commodities, gold, silver, copper, platinum and palladium.[5] They are used both as investments and as inputs for industrial production.

An increasingly popular investment strategy in the recent years has been to invest in a basket of commodities following a certain commodity index. A commodity index functions like an equity index, such as the S&P 500, in that its value is derived from the total value of a specified basket of commodities. Each commodity in the basket is assigned a specified weight. To avoid the cost of holding physical commodities, commodity indices typically build on the values of futures contracts, which are typically nearby contracts with delivery time longer than one month.[6] When a first-month contract matures and the second-month contract becomes the first-month contract, a commodity index specifies the so-called "roll," i.e., replacing the current contract in the index with a following contract. In this way, commodity indices provide returns comparable to passive long positions in listed commodity futures contracts. By far the largest two indices by market share are the S&P Goldman Sachs Commodity Index (GSCI) and the Dow-Jones AIG Commodity Index (DJ-AIG). There is also a proliferation of other smaller indices operated by other institutions, such as the Rogers International and Deutsche Bank Liquid Commodity Indices. These indices differ in terms of index composition, commodity selection criteria, rolling mechanism, rebalancing strategy, and weighting scheme.[7]

Table 1 provides the weights of the GSCI and DJ-AIG indices in the 28 US traded commodities. Both indices incorporate a wide range of commodity futures, although not all of them. There are some commodities in neither index: Minneapolis wheat, soybean meal, rough rice, and oats in the grain sector, lumber and orange juice in the soft sector, pork bellies in the livestock sector, and platinum and palladium in the metal sector. These two indices use different selection and weighting schemes: GSCI is weighted by each commodity's world production, while DJ-AIG relies on the relative amount of trading activity of a particular commodity. As a result, commodities in these indices tend to be large in terms of world production and liquid in terms of trading in the futures markets. The composition of these indices is stable and has stayed the same since 2004. Furthermore, the joint set of GSCI and DJ-AIG also covers almost all of the commodities in the other smaller indices.

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[5] We exclude several popular metals that are only traded in London, such as aluminum, lead, nickel, zinc, and tin , to avoid potential complications from asynchronous daily closing prices of different commodities between the US and London markets.

[6] As shown in Gorton and Rouwenhorst (2006) and Hong and Yogo (2009), commodity futures contracts often become illiquid in the delivery month. This is because many traders are reluctant to deliver or accept delivery of the physical commodities

[7] See AIA Research Report (2008) for a detailed account of construction methods of various commodity indices.

The energy sector carries a much greater weight than the other sectors in the GSCI and DJ-AIG indices. The four energy commodities listed in Table 1 add up to 58% of the GSCI and 39.6% of the DJ-AIG. WTI crude oil alone accounts for 40.6% of the GSCI. Since the commodities in the energy sector move closely with each other, we will use crude oil as a focal point in our later analysis to study the spillovers of oil shocks to non-energy commodities.

There are three types of financial instruments that enable investors to gain exposure to the value of a commodity index: commodity index swaps, exchange traded funds, and exchange traded notes.[8] A commodity index swap is, in essence, a financial instrument that pays a return based on the value of a specified index. A swap dealer, such as a bank or broker-dealer, typically offers a qualified investor the opportunity to purchase, for a fixed price, a swap whose value is linked, on any given date, to the value of the specified commodity index on that date. After selling a swap contract, the swap dealer will typically hedge its own exposure to the swap contract by purchasing the corresponding futures contracts in the commodity index. In the past few years, financial institutions have devised another type of instrument, known as exchange traded funds (ETFs), to mirror the performance of specified commodity indices. Unlike commodity index swaps, which are bilateral transactions between investors and swap dealers, ETFs are traded in exchanges like stocks. An ETF is typically structured so that the value of the ETF shares should reflect the value of the specified commodity index. A third commodity-based instrument involves exchange traded notes (ETNs). ETNs are designed and sold by financial institutions to permit retail investors to purchase shares of a debt security whose price is linked to that of a commodity index.

II. Empirical Hypotheses

Prior to the early 2000s, commodities behaved very different from typical financial assets, despite the liquid futures contracts traded on many commodities. The prices of commodities did not co-move much with stock prices. In fact, there is a widely publicized finding in the investment communities by Greer (2000), Gorton and Rouwenhorst (2006) and Erb and Harvey (2006) that commodity indices had a slight negative return correlation with stock indices prior to the early 2000s. Furthermore, the commodities in different sectors did not co-move much with each other. These aspects of commodity prices were in sharp contrast to the price dynamics of financial assets, which are typically exposed to market-wide shocks and shocks to other assets, through various channels related to risk appetite and trading by investors. In this sense, the commodities markets were largely segmented from the broad financial markets. The segmentation of commodities was, at least partially, caused by the "prudent investor" rule of many institutional investors. Because holding physical commodities involves large storage costs

[8] The recent report by US Senate Permanent Subcommittee on Investigations (2009) provides a detailed description of these instruments.

and investing in unhedged futures contracts on commodities is usually perceived as speculative, institutions had stayed away from commodities. As such, the commodities futures were mostly traded by producers, consumers and a set of traditional speculators specializing in specific commodities.

The tide changed in early 2000s, when the collapse of the equity market in 2000 and the widely publicized discovery of the negative correlation between commodity returns and stock returns led to a belief that commodity futures could be used to reduce portfolio risk. This belief allowed Goldman Sachs and other indexers to successfully promote commodity futures as a new asset class for prudent investors. As a result, commodities have attracted billions of dollars of investment from financial institutions, insurance companies, pension funds, foundations, hedge funds, and wealthy individuals. Figure 2 depicts the rapid growth in the open interest (i.e., the total number of contracts outstanding with maturities less than one year) of various commodity futures after 2004. The recent CFTC staff report (2008) and Masters (2008) also suggest that index investment in commodities quickly rose after 2004. In this paper, we examine the changes precipitated by the rapid growth of index investment in the commodities markets. Although we will use the year 2004 as a break point in our analysis, we later show that our main findings are not sensitive to the choice of this particular year.

With the increasing presence of index investors, we expect commodities to behave more like a financial asset, which is exposed to market-wide shocks and shocks to other assets through several channels. First, shocks to the market-wide risk premium affect all assets in the financial markets, regardless of their cash flow, e.g., Campbell and Shiller (1988) and Campbell and Cochrane (1999). In other words, the price of an asset is not only determined by its own future cash flow, but also by a discount rate that is subject to fluctuations of the risk appetite of the aggregate financial markets. Since this risk premium channel affects all assets in the financial markets, it should also affect commodities, both in and off the commodity indices, as they become integrated with the broader financial markets.

Second, the price of an asset is exposed to shocks that affect other assets held by its marginal investor, e.g., Kyle and Xiong (2001). As the marginal investor rebalances his portfolio in response to shocks to one asset, the shocks are spilled over to other assets in the portfolio. The exact nature of such spillover effects depends on the marginal investor's portfolio composition and rebalancing strategies. Since commodity index investors usually invest a large fraction of their portfolios in stocks, commodity prices are exposed to shocks to the stock markets through the portfolio rebalancing of the index investors between stocks and commodities. Furthermore, the rapid growth in commodity index investing is a global phenomenon and a significant fraction of the investment flow comes from outside U.S. Since commodity indices are all constructed in US dollars, international index investors are exposed to shocks to the US exchange rate. As a result, commodity prices are also exposed to shocks to the US dollar exchange rate. As these spillover effects operate through index investors' portfolio rebalancing, they directly affect commodities in the commodity indices, rather than those off indices.

Third, an asset in a certain asset class is exposed to spillovers of shocks to other assets in the same class, e.g., Barberis and Shleifer (2003). Since index investors focus on strategic allocation of their capital to the commodity class versus other asset classes, such as stock and bond, they are not particularly sensitive to the prices of individual commodities. Instead, they tend to move in and out of commodities in a chosen index at the same time, based on its performance relative to other asset classes. The index investors' strategic allocation thus exposes the price of an individual commodity to shocks to other commodities, such as oil, whose performance has a significant impact on the commodity indices. This spillover effect has a direct impact on the commodities in the commodity indices, rather than those off indices.

An implicit assumption in our discussion above is that the other participants of the commodities markets, such as the traditional speculators and commercial users, only have a limited capacity to absorb the price impact of index investors' trades. As a result, the increasing presence of commodity index investors could affect commodity prices.

It is also useful to note that while index investors typically trade futures contracts, their impact on the futures prices would eventually trickle down to the spot prices through speculators' carry trades between the futures and spot markets. Since the carry trades are particularly effective when the maturities of the futures contracts are short, the spot prices are closely tied to the prices of nearby futures. For this reason, we will use the futures prices of nearby contracts with delivery time longer than one month throughout our analysis.[9]

Furthermore, while the aforementioned second and third channels operate through commodity index investors' trades in indexed commodities, the potential substitution in consumers' demands between different commodities could further transmit the impact of index investors to off-index commodities.[10] For example, if the prices of soybean meal fall far below corn prices, consumers will substitute soybean meal for corn to feed their animals, or vice versa. But, this substitution effect is likely to be imperfect, and at relatively longer horizons than the horizons of financial trading, such as the daily frequency used in our study. Thus, we expect the price impact of index investors to be stronger on indexed commodities than on off-index commodities.

[9] See McDonald (2006) for extensive discussion on convergence of spot and futures prices.

[10] See Casassus, Liu and Tang (2009) for a study of multi-commodity systems with production, substitution and complementary relationships.

Based on the economic channels discussed above, we summarize several hypotheses for our empirical analysis of the impact of the rapid growth of index investment on the commodities markets. The focus of our analysis is to identify the impact jointly through all of the channels, rather than to isolate the effect from each of the channels.

The first hypothesis is related to the commodity index returns.

- **Hypothesis 1**: After 2004, commodity index returns are more exposed to shocks to the world equity index and US dollar exchange rate.

The increasing presence of index investors exposes individual commodities to market-wide shocks and to shocks to other commodities. These spillover effects are especially stronger for indexed commodities, as summarized in the next hypothesis.

- **Hypothesis 2**: After 2004, the commodities in the GSCI and DJ-AIG indices become more exposed to market-wide shocks, such as those to the world equity index and US dollar exchange rate, and to shocks to other commodities, such as oil shocks, than those off the indices.

Furthermore, the trading by index investors makes the trading volumes of individual commodities to co-move together.

- **Hypothesis 3**: After 2004, the correlation between the trading volumes of individual commodities increases, and the correlation increase is greater for indexed commodities than those off the indices.

Note that since the commodities in the GSCI and DJ-AIG indices tend to be large in terms of world production and liquid in terms of trading in the futures markets, these selection criteria tend to bias against Hypotheses 2 and 3. Thus, any supportive evidence of these hypotheses is unlikely to be driven by selection biases of these indices.

Finally, the evidence summarized by Hamilton (2009) suggests that the demand and supply of physical commodities have small elasticity to commodity prices. As a result, even if the rapid growth of index investment has affected commodity prices, we do not necessarily expect dramatic changes in production and consumption of commodities. For this reason, we focus our analysis on fluctuation of commodity prices, but not inventories of individual commodities.

III. Integration of Commodity Index Returns

We examine Hypothesis 1 by analyzing the exposures of the return of the GSCI excess return index to a list of variables related to market-wide shocks.[11] The list includes the returns of the

[11] Throughout this paper, we use "excess return" indexes (including the return indexes we construct in later sections) instead of "total return" indexes. The difference between them is the interest earned on the collaterals for futures

Morgan Stanley world equity index ($R_{MSW,t}$), the JP Morgan Treasury bond index ($R_{JPM,t}$), the US dollar index ($R_{USD,t}$), and the US CPI change ($R_{CPI,t}$). The US dollar index tracks the dollar exchange rate with six component currencies (euro, Japanese yen, British pound, Canadian dollar, Swedish krona and Swiss franc) in their respective percentage weights in the index. We download these index returns from Datastream, a widely used data source. The data period goes from 1/4/1988 to 3/2/2009, the longest period during which all these variables are available. The world equity, Treasury bond, and US dollar index returns are available at the daily frequency, while the US CPI change is only at the monthly frequency.

We first use the following specification for regressions of the daily GSCI return ($R_{GSCI,t}$):

$$
\begin{aligned}
R_{GSCI,t} = {} & a_0 + a_{04}I_{y=04} + a_{05}I_{y=05} + a_{06}I_{y=06} + a_{07}I_{y=07} + a_{08}I_{y\geq 08} \\
& +\left(b_0 + b_{04}I_{y=04} + b_{05}I_{y=05} + b_{06}I_{y=06} + b_{07}I_{y=07} + b_{08}I_{y\geq 08}\right)R_{MSW,t} \\
& +\left(c_0 + c_{04}I_{y=04} + c_{05}I_{y=05} + c_{06}I_{y=06} + c_{07}I_{y=07} + c_{08}I_{y\geq 08}\right)R_{JPM,t} \\
& +\left(d_0 + d_{04}I_{y=04} + d_{05}I_{y=05} + d_{06}I_{y=06} + d_{07}I_{y=07} + d_{08}I_{y\geq 08}\right)R_{USD,t} + \epsilon_t
\end{aligned}
\tag{1}
$$

where $I_{y=04}$ is a year dummy, i.e., it equals to 1 if the observation is in year 2004 and 0 otherwise. In this specification, we include a set of year dummies to isolate the exposures of the GSCI return to each of the independent variables in each of the years after 2004. For example, coefficient b_0 measures the exposure of the GSCI return to the world equity index return before 2004, and coefficients b_{04}, b_{05}, b_{06}, b_{07}, and b_{08} measure the changes in the exposures relative to the pre-2004 level in years 2004, 2005, 2006, 2007, and 2008 (which also includes the early part of 2009), respectively.

Panel A of Table 2 reports the results from regressing the GSCI return on the world equity, Treasury bond, and US dollar index returns separately and jointly. The panel shows that the GSCI return is negatively correlated to the world equity index return before 2004. The estimate of coefficient b_0 is marginally significant with a t-stat of -1.62 in the separate regression and a t-stat of -1.91 in the joint regression. This result is consistent with the finding of Gorton and Rouwenhorst (2006) and Erb and Harvey (2006) that there was a slight negative correlation between commodity and equity indices before 2004. The panel also shows that the estimates of coefficients b_{06}, b_{07}, and b_{08} are significantly positive in both separate and joint regressions, suggesting that the exposure of the GSCI return to the world equity index return is significantly increased in each of years 2006, 2007 and 2008.[12] Furthermore, there appears to be an increasing

contracts. We ignore this interest component because it does not affect commodities' exposures to market-wide shocks and co-movement between commodities.

[12] Buyuksahin, Haigh and Robe (2009) also find an increase in the return correlation between the GSCI and S&P 500 indices, although the increase was concentrated in 2008. Our analysis differs from theirs in two important

trend in the estimates of coefficients b_{04}, b_{05}, b_{06}, b_{07}, and b_{08}. This trend suggests that the exposure of the GSCI return to the world equity index return is only gradually increased, rather than by a one-time jump during a particular year. This gradual trend is consistent with the gradual arrival of index investment flow to the commodities markets. It also shows that the choice of year 2004 as the break point in our analysis is inconsequential.

While there is a significant negative exposure of the GSCI return to the Treasury bond return before 2004, which is consistent with the finding of Gorton and Rouwenhorst (2006) and Erb and Harvey (2006), the change in this exposure is insignificant in each of the years after 2004. This suggests that commodities have always been exposed to interest rate fluctuations and this exposure has not been significantly affected by the growth of index investing.

Finally, the panel shows that the GSCI return is negatively exposed to the US dollar return before 2004, although the estimate of coefficient d_0 is insignificant. This negative exposure is consistent with the presence of international investors in the commodities markets. When dollar appreciates, commodities become cheaper in dollars because the reduced purchase power of international investors. This negative exposure becomes stronger after 2004. The change is significant in all years after 2004, except 2005. There also appears to be an increasing trend in the intensity of this exposure, although the trend is not perfectly monotonic. This increasing trend could be explained by the increasing presence of international investors in the commodities markets.

Motivated by the results shown in Panel A, we simplify the multiple year dummies used in regression specification (1) by using a linear trend to fit the exposure of the GSCI return to each of the independent variables:

$$R_{GSCI,t} = a_0 + a_1 I_{t\geq 04} + [b_0 + b_1 I_{t\geq 04}(t-2004)]R_{MSW,t} + [c_0 + c_1 I_{t\geq 04}(t-2004)]R_{JPM,t} + [d_0 + d_1 I_{t\geq 04}(t-2004)]R_{USD,t} + \epsilon_t \qquad (2)$$

Coefficients b_1, c_1, and d_1 measure the slopes of these trends.

Panel B of Table 1 reports the regression results based on this simplified specification. Consistent with Panel A, Panel B shows that the estimates of coefficients b_1 and d_1 are significant, confirming increasing trends in the exposures of the GSCI return to shocks to the world equity index and US exchange rate. Furthermore, the R-squared of various regressions in

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dimensions. First, we use the Morgan Stanley world equity index rather than the S&P 500 index. Because the rapid growth of commodity index investment is a global phenomenon and a significant fraction of the investment flow comes from outside U.S., the world equity index is a more appropriate proxy for market-wide shocks to the equity markets. Second, we analyze daily prices rather than weekly prices focused by Buyuksahin, Haigh and Robe (2009). As is well known in econometrics, co-movement and volatility are more precisely measured in higher frequencies.

Panel B is close to the corresponding ones in Panel A, suggesting that the linear trend specification performs reasonably well in approximating the year-dummy based specification.

We also repeat the regression analysis specified in (2) using monthly data and include the US CPI change in the analysis.[13] The results reported in Table 2 are similar to those using daily data, and the regression R-squared from using monthly data is larger than from using daily data. The table also shows that the GSCI return has an insignificant exposure to the CPI change before 2004, but there is a significant increasing trend in the exposure thereafter. What drives the increasing exposure of the GSCI return to the CPI change? We attribute it to index investors' inflation fears. When index investors anticipate inflation to rise, they are likely to invest more in commodities, which in turn cause commodity prices to rise. Through this mechanism, the increasing presence of index investors would cause commodity prices to move more closely with the CPI index.

Figure 3 plots the GSCI commodity index, the Morgan Stanley world equity return index, and the US dollar exchange rate index to provide a visual presentation of the links between them. The plot confirms several features. First, there was little co-movement between the GSCI and world equity indices before 2004. Second, the two indices co-move more after 2004, especially in 2008, when both indices had large drops during the world financial crisis.[14] Third, the GSCI index and the US dollar exchange rate have clear negative co-movement after 2004.

Overall, our analysis in this section shows that the exposures of the GSCI return to shocks to the world equity index and US dollar exchange rate significantly increased after 2004. Furthermore, these increases occur in gradual trends, rather than one-time jumps. These findings are consistent with Hypothesis 1.[15]

IV. Spillovers to Individual Commodities

How are individual commodities affected by the increasing presence of index investors? In this section, we examine Hypothesis 2. We first plot the one-year rolling return correlation between oil and several non-energy commodities, which provides an aggregate measure of the

[13] Regression specification (1) is less appropriate for monthly data because it requires estimating 5 parameters for each year after 2004 based on 12 monthly observations.

[14] A closer look at the figure also indicates two short periods between July 2006 and January 2007 and between October 2007 and March 2008, in which the GSCI and world equity indices moved in different directions. Anecdotal evidence attributes the price divergence in these episodes to institutional investors' portfolio shifts between stocks and commodities, which reflects a more subtle spillover effect from stocks to commodities than posited in Section II. Despite this subtle effect, Table 2 shows that the exposure of the GSCI return to the world equity return is significantly positive in each of the years after 2004.

[15] These changes are consistent with what happens in the stock markets of emerging economies after they are liberalized to foreign investors, e.g., Bekaert and Harvey (2000).

spillover effects of market-wide shocks and oil shocks to non-energy commodities. We then formally examine the exposures of all individual non-energy commodities to these shocks.

A. Rolling Return Correlation

For each commodity, we follow Gorton and Rouwenhorst (2006) and Erb and Harvey (2006) to construct a return index from rolling the first-month futures contract. More specifically, we construct a hypothetical investment position in the first-month contract of the commodity on a fully collateralized basis. We hold the contract to the 7th calendar day of its maturity month before rolling into the next contract. The excess return of this hypothetical investment on a non-rolling day represents the excess futures return to the initial capital (as we can still earn interest on the capital):

$$R_{i,t} = \ln(F_{i,t}) - \ln(F_{i,t-1})$$

where $F_{i,t}$ is the futures price of the first-month contract. On a rolling day, the return not only incorporates the futures price change, but also the price ratio between the first-month contract and the next contract. This second component is also called the "roll return".

We first take a cursory look at the one-year rolling return correlation between oil and a selected commodity from each of the four non-energy sectors: soybeans from the grain sector, cotton from the soft sector, live cattle from the livestock sector, and copper from the metal sector. These commodities share few direct supply-and-demand links with oil, with the probable exception of copper (as both copper and oil are important industrial inputs).

We normalize the daily excess return from investing in a commodity in each 1-year rolling window by its average return and return volatility:

$$R_{i,t}^{n} = [R_{i,t} - mean(R_i)]/std(R_i).$$

We then regress the normalized return $R_{i,t}^{n}$ of the commodity onto the normalized oil return $R_{oil,t}^{n}$:

$$R_{i,t}^{n} = \alpha + \rho R_{oil,t}^{n} + \varepsilon_{i,t}.$$

The estimated coefficient ρ is the return correlation between the two commodities.

Figure 4 plots the one-year rolling return correlation of oil with soybean, cotton, live cattle, and copper, from 1986 to 2009, together with the 95% confidence interval. Panel A shows that before 2004, the return correlation between soybean and oil moves around zero in a narrow range between -0.1 and 0.2, and is mostly insignificant from zero. Between 2004 and late 2008, the correlation steadily climbs up from 0.1 to near 0.6, which is significantly different from zero. Similarly, Panels B, C, and D show that oil had a small return correlation with cotton, live cattle, and copper before 2004 that has gradually risen to 0.5, 0.4, and 0.6, respectively, in recent years.[16] Overall, Figure 4 shows that the return correlation of oil with a broad set of non-energy commodities has shot up significantly since 2004.

B. Difference-in-Difference Analysis

The dramatic increase in the return correlation between oil and other non-energy commodities could be driven by spillovers of market-wide shocks or oil shocks to other commodities. To formally examine these different channels, we use regressions to measure the exposures of individual non-energy commodities to these shocks. To identify the roles played by the rapid growth of index investment in driving these exposures, we use a difference-in-difference approach to analyze the differences in the changes of these exposures after 2004 between indexed and off-index commodities in the same sector.

We pool together all the commodities in each of the four non-energy sectors listed in Table 1 from 1/2/1998 to 3/2/2009. We choose this sample period so that there are six years before 1/1/2004 and a little more than five years afterward. We normalize the daily return of each commodity by its average return and return volatility in the sample period. We use the following specification for panel regressions of all the normalized returns $R_{i,t}^n$ in a sector on the Morgan Stanley world equity index return $R_{MSW,t}$, the JP Morgan Treasury bond index return $R_{JPM,t}$, the US dollar index return $R_{USD,t}$, and the normalized oil return $R_{oil,t}^n$:

$$\begin{aligned} R_{i,t}^n = \alpha &+ [\gamma_0 + \gamma_1(t-2004)I_{t\geq 2004} + \gamma_2 I_{index} + \gamma_3(t-2004)I_{t\geq 2004}I_{index}]R_{MSW,t} \\ &+[\theta_0 + \theta_1(t-2004)I_{t\geq 2004} + \theta_2 I_{index} + \theta_3(t-2004)I_{t\geq 2004}I_{index}]R_{JPM,t} \\ &+[\eta_0 + \eta_1(t-2004)I_{t\geq 2004} + \eta_2 I_{index} + \eta_3(t-2004)I_{t\geq 2004}I_{index}]R_{USD,t} \\ &+[\beta_0 + \beta_1(t-2004)I_{t\geq 2004} + \beta_2 I_{index} + \beta_3(t-2004)I_{t\geq 2004}I_{index}]R_{oil,t}^n + \varepsilon_{i,t} \end{aligned} \tag{3}$$

This regression specification separates the exposures of a commodity to the four independent variables, and further decomposes the exposure to each of the variables into four components. Figure 5 provides a graphical account of this decomposition. For example, in the case of the exposure to the oil shock, the first component β_0 measures the baseline exposure of an off-index commodity before 2004. The second component $\beta_1(t-2004)I_{t\geq 2004}$ captures an increasing trend in the exposure of an off-index commodity after 2004, as motivated by our previous analysis of the GSCI index return. The third component $\beta_2 I_{index}$, where I_{index} is a dummy for whether the commodity is in at least one of the GSCI and DJ-AIG indices, measures additional exposure from being in the commodity indices before 2004. The fourth component $\beta_3(t-2004)I_{t\geq 2004}I_{index}$ measures the additional increasing trend after 2004 of the exposure of

[16] We also adopt the procedure proposed by Forbes and Rigobon (2002) to adjust for possible biases caused by time-varying volatility in measuring spillover effects. The adjustment does not create any significant change to the return correlation plots.

an indexed commodity. This last component captures the difference in the changes after 2004 between the exposures of indexed and off-index commodities in the sector to the oil shock. We also decompose each commodity's exposure to each of the returns of the world equity index, the Treasury bond index, and the US dollar index in the same way.

For each of the four non-energy sectors, we first regress the commodity returns on each of the four independent variables separately, and then jointly. Table 3 reports the regression results in four panels, one for each sector.

Panel A provides several interesting results for the grain sector. The first regression shows that after 2004 there is a significant increasing trend (γ_1) in the exposure of all commodities in this sector to the world equity index return, consistent with our earlier finding for the GSCI index return. The significant and positive estimate for coefficient γ_3 indicates that the increasing trend is significantly stronger for commodities in the GSCI and DJ-AIG indices than those off the indices. This pattern is consistent with Hypothesis 2, and suggests a stronger spillover effect of the world equity return shock to the indexed commodities.

The third regression illustrates a similar pattern in the exposure of commodities in this sector to the US dollar return. After 2004, there is a significant trend (η_1) that intensifies the negative exposure of all commodities in this sector. Moreover, it is significantly stronger for the indexed commodities (η_3), suggesting a stronger spillover effect of the US dollar exchange rate shock to the indexed commodities.

Likewise, the fourth regression shows that there is a significant increasing trend (β_1) in the exposure of all commodities in the sector to the oil return, and this trend is significantly stronger for the indexed commodities (β_3). Since the oil return is also exposed to the market-wide shocks, this observed pattern could be a reflection of the commodities' exposures to the market-wide shocks. To address this concern, we analyze an alternative regression. We first regress the oil return on the returns of the world equity index, the Treasury bond index, and the US dollar index according to regression specification (2), and then use the residual oil return to represent the oil shock. The result is reported in the fifth regression. While the estimates of coefficients β_1 and β_3 have a slight drop, both are still significant. This result thus suggests that oil shocks are themselves spilled over to commodities in the grain sector, and that this spillover effect is stronger for indexed commodities.

Finally, we pool all the independent variables together in a single regression, the sixth regression. While there are some reductions in the estimates of the aforementioned key coefficients relative to the corresponding estimates in the stand-alone regressions, they nevertheless remain significant (or at least marginally significant).

Panels B, C, and D report the regression results for the other three non-energy sectors, the soft, livestock, and metal sectors. Note that the number of commodities in each of these sectors (6, 4, and 5, respectively) is smaller than that in the grain sector (9). The smaller number of cross-sectional observations has probably caused the t-stats for some of the coefficients to become less significant. Nevertheless, the general results in these sectors are similar to those reported for the grain sector.[17]

Overall, we find consistent patterns across the four non-energy sectors that after 2004, there are increasing trends in the individual commodities' exposures to shocks to the world equity index, the US dollar index, and oil.[18] Furthermore, these trends are all stronger for commodities in the GSCI and DJ-AIG indices than those off the indices. These patterns are consistent with Hypothesis 2 and point to spillover effects brought on by the increasing presence of index investors to individual commodities.

V. Trading of Index Investors

In this section, we directly examine the trading of commodity index investors using data from two different sources. First, we examine the correlation between the trading volumes of oil and other non-energy commodities. We find an increasing trend in the correlation after 2004 and the trend is stronger for indexed commodities than off-index commodities. We then construct a measure of commodity index investment flow based on the Commodity Index Traders (CIT) report released by the CFTC for 12 agricultural and livestock commodities after 2006. This flow measure allows us to analyze the joint dynamics of the index flow with commodity prices and other market variables.

A. Co-movement of Trading Volumes

As index investors trade in and out of commodities in a chosen index at the same time, the correlation between the trading volumes of different commodities provides a useful channel to gauge the presence of index investors in the commodities markets. As the GSCI and DJ-AIG indices are both constructed from rolling nearby futures contracts, we use the daily percentage changes of the sum of the open interest of the first- and second-month contracts of a commodity to proxy the trading of index investors in this commodity:

$$VO_{i,t} = \frac{OI_{i,t} - OI_{i,t-1}}{OI_{i,t-1}}$$

[17] The only exception is that the estimate of coefficient γ_3 in the metal sector becomes negative, but nevertheless the t-stat is insignificant.

[18] The panels in Table 3 also show that there is not a consistent trend in the commodities' exposure to the Treasury bond return. In unreported analysis, we have also analyzed their exposure to the US CPI change, which is only available in monthly observations. Because of the smaller data sample, we do not find any significant pattern.

where $OI_{i,t}$ is the sum of the open interest of the first- and second-month contracts.[19]

We examine the correlation between the trading volumes of oil and commodities in each of the four non-energy sectors using the following panel regression:

$$VO_{i,t} = \alpha + [\beta_0 + \beta_1(t - 2004)I_{t\geq 2004} + \beta_2 I_{index} + \beta_3(t - 2004)I_{t\geq 2004}I_{index}]VO_{oil,t} + \varepsilon_{i,t} \quad (4)$$

This regression specification is the same as the one in regression (3) and decomposes the link between two trading volumes in four parts. The second part represents a baseline trend in the link after 2004, and the last part represents the difference in the trend between indexed and off-index commodities.

Table 4 reports the regression results for each of the four non-energy sectors. Although there is no consistent pattern in the estimates for coefficient β_1 across the four sectors, the estimates for coefficient β_3 are consistently positive across all four sectors and are statistically significant for three of them. Taken together, these estimates suggest that while there is not a clear increasing trend in the co-movement between the trading volumes of oil and non-energy commodities off the GSCI and DJ-AIG indices, there is a significant increasing trend between oil and those commodities in the indices. This result is consistent with Hypothesis 3.

B. Index Investment Flow

The Commodity Index Traders (CIT) report, released by the U.S. Commodity Futures Trading Commission (CFTC) on each Friday, allows us to construct a measure of index investment flow to a set of commodities after 2006. The report shows positions of index traders, which include swap dealers, and pension and other investment funds which trade commodity indices, for 12 agricultural commodities since 1/3/2006.[20] These include corn, soybeans, Chicago wheat, Kansas wheat, and soybean oil from the grain sector, coffee, cotton, sugar, and cocoa from the soft sector, and feeder cattle, lean hogs, and live cattle from the livestock sector. This list coincides with the joint set of GSCI and DJ-AIG indices in these three sectors. The CIT report does not cover any commodity in the energy and metal sectors.

The CIT report classifies the reportable market participants into three groups: commercial traders, index traders, and non-commercial traders. The CFTC identifies an individual reportable trader as commercial if the trader uses futures contracts in that particular commodity for hedging. The non-commercial traders include all reportable traders who are neither commercial nor index

[19] We include both first- and second-month contracts to avoid counting the trading caused by index investors' rolling of first-month contracts into second-month contracts in the rolling periods.

[20] The CIT report supplements the standard Commitments of Traders (COT) report, which is also released by the CFTC on the breakdown of every Tuesday's positions on all exchange-traded futures and options on US-based exchanges. The COT report only classifies reportable traders to two categories, commercial and non-commercial.

traders. The CIT report provides the aggregate long and short positions of each of the three groups in a particular commodity.[21]

Table 5 provides some summary information about the weekly CIT report from 1/3/2006 to 3/3/2009. Panel A reports the average position size of each group of traders in each of the commodities. The panel shows that index traders' long positions contribute to a substantial fraction of the open interest of each of the commodities, with an average of 28.1% across all commodities and, at the high end, 43.3% of lean hogs and 41.3% of Chicago wheat. Furthermore, index traders' short positions are minimal, with an average of 1.4% of the open interest across all commodities.

We conduct a principal component analysis of the weekly net long positions of index traders in the 12 commodities. Panel B of Table 5 reports the variance explained by the 6 leading principal components. The first leading component explains 50.8%, and the second explains 27.5%. Together, these two explain over 78%, suggesting that the index traders' trading across the 12 commodities is highly correlated.[22]

We can construct the investment flow by index traders in and out of the 12 commodities in each week by summing up the dollar value of index traders' net position change in each of the commodities:

$$IF_t = \sum_{i=1}^{12}(NL_{i,t} - NL_{i,t-1})P_{i,t-1} \qquad (4)$$

where $NL_{i,t}$ represents the net long position of index traders in commodity i in week t and $P_{i,t-1}$ is the price of the commodity in week t-1. In this calculation, we use the prices of first-month futures contracts, and assume that all the position changes occur during the previous week. Then, we add up the index flow from the first week of 2006, the beginning of the CIT report data, to any week before 3/3/2009 to obtain the accumulated index flow to that week.

Figure 6 plots the accumulated index flow together with the GSCI Agriculture & Livestock Excess Return Index. This index follows the performance of the same three sectors---grains, softs, and livestock---as those covered by the CIT report. The figure shows that since the beginning of 2006, these three sectors had a large net inflow, which accumulated to near 20 billion dollars in early 2008. Then, there was a stream of outflow, which led to an accumulated index flow of negative 5 billion dollars by March 2009. The figure also shows that the fluctuation of the GSCI Agriculture & Livestock Excess Return Index was strikingly synchronized with the index flow.

[21] The CIT report also presents the non-commercial traders' aggregate spreading positions, i.e., the equal long and short futures position on the same commodity but with different maturities.

[22] While it is hard to identify the exact sources of these two components, they could be related to the trading in the two popular indices, GSCI and DJ-AIG.

To further our understanding of the joint dynamics of the index flow and the commodity prices, we conduct a vector auto-regressive (VAR) analysis of the index flow IF_t, the GSCI Agriculture & Livestock index return $R_{GSCI-A\&L,t}$, the world equity index return $R_{MSW,t}$, the US dollar index return $R_{USD,t}$, and the oil return $R_{Oil,t}$. We define these variables together in a vector

$$v_t \equiv \begin{pmatrix} IF_t \\ R_{GSCI-A\&L,t} \\ R_{MSW,t} \\ R_{USD,t} \\ R_{Oil,t} \end{pmatrix}.$$

We then estimate the following VAR regression:

$$v_t = \sum_{i=1}^{L} \varphi_{t-i} v_{t-i} + \epsilon_t \qquad (5)$$

where L is the number of lags and φ_{t-i} is a 5×5 coefficient matrix for the i-th lag. The Akaike Information Criterion (AIC) and likelihood ratio test indicate that the optimal number of lags is 1.[23]

Table 6 reports the regression coefficients and the corresponding t-stats. While the sample period of this analysis is only a little longer than 3 years, the table shows a surprising result that the one-week lagged index flow has significant predictive power for all the variables. First, the lagged index flow has positive predictive power for the index flow itself with a high t-stat of 6.56. This predictive power is consistent with the findings in the finance literature that investment flow tends to be persistent. Second, the lagged index flow also positively predicts the return of the GSCI Agriculture & Livestock Excess Return Index with a t-stat of 3.70. This predictive power is likely driven by the price impact of persistent index flow. Finally, the lagged index flow also positively predicts the returns of the world equity index and oil with t-stats of 3.80 and 3.84, respectively, and negatively predicts the return of US dollar with a t-stat of 2.74. These predictive powers of the index flow over the broad set of financial returns suggest that the index flow is inherently associated with the trading behavior of investors in the broad financial markets. This is an indication that trading by commodity index investors has closely integrated the commodities markets to the broad financial markets.

Figure 7 plots the impulse responses of each variable in the VAR analysis to the shocks to itself and other variables. The impulse response plots further highlight the predictive powers of the index flow for itself and the other variables for over two weeks.

VI. Volatility of Commodities

[23] The likelihood ratio test shows that there is no significant difference in 90% confidence interval when using 1 lag or 2 lags in the VAR analysis.

The dramatic increase in oil price volatility has generated serious concerns among the public and regulators. Figure 8 plots the annualized daily return volatility of oil, the GSCI non-energy excess return index, and the Morgan Stanley world equity index, estimated from one-year rolling windows. The figure shows that in 2008, oil return volatility shot up from around 30% to near 60%, close to the volatility level during the Gulf War in early 1990s. In contrast to the situation in early 1990s, the sudden rise in oil price volatility in 2008 was also accompanied by concurrent rises in volatility of the non-energy commodities and the world equity index, a reflection of the world financial crisis in 2008. Given our early analysis on the increasing exposures of commodities to shocks to the broad financial markets and to other commodities, the rises in volatility of oil and other non-energy commodities in 2008 could be driven by spillover effects of the world financial crisis.

To analyze the relevance of this argument, we filter out the market-wide shocks from the oil return and the market-wide shocks and oil shocks from the GSCI non-energy index return. More specifically, we regress the daily oil return on $R_{MSW,t}$, $R_{JPM,t}$, $R_{USD,t}$, and $R_{CPI,t}$ using the following specification:

$$R_{oil,t} = a_0 + a_1 I_{t\geq 04} + [b_0 + b_1 I_{t\geq 04}(t-2004)]R_{MSW,t} + [c_0 + c_1 I_{t\geq 04}(t-2004)]R_{JPM,t} + [d_0 + d_1 I_{t\geq 04}(t-2004)]R_{USD,t} + [e_0 + e_1 I_{t\geq 04}(t-2004)]R_{CPI,t} + \epsilon_t \qquad (6)$$

We have used a similar specification to analyze the GSCI index return. Since we only have monthly observations on the CPI, we treat $R_{CPI,t}$ as constant during a month. Panel B of Figure 8 plots the one-year rolling volatility of the residual oil return, together with that of the raw return. The plot shows that while the two volatilities were close to each other before 2008, the volatility of the residual oil return is substantially lower than that of the raw return in 2008. When the raw return volatility peaked at near 60% level, the residual return volatility was below 50%. This contrast suggests that a significant part of the dramatic increase of oil volatility in 2008 can be attributed to spillovers of market-wide shocks.

We use a similar regression to filter out market-wide shocks from the GSCI non-energy index return, but add the oil return as an additional variable into the regression to filter out oil shocks. Panel C of Figure 8 plots the volatilities of the residual GSCI non-energy index return after filtering out the market-wide shocks and after filtering out both the market-wide shocks and oil shocks, together with the raw return volatility. The plot also shows that the spillovers of the market-wide shocks and oil shocks had both contributed to a significant part of the volatility of the GSCI non-energy index return in 2008. When the raw return volatility peaked at 28%, the volatility of the residual return after filtering out the market-wide shocks was at 23%, its volatility after filtering out the market-wide and oil shocks was below 20%.

To further identify the role played by the rapid growing index investment in driving the volatility spillovers, we analyze the difference between the daily-return volatility increases of indexed and off-index commodities in the non-energy sectors between 1/2/1998 and 3/2/2009. We first normalize the daily returns of each commodity by its return volatility before 2004 and its whole sample mean. After the normalization, the return series of all commodities have the same volatility before 2004. We then analyze the changes in the volatility after 2004 by regressing the pooled squared normalized returns onto a set of year dummies for each year after 2004 and their interaction terms with an index dummy of whether a given commodity is in at least one of the GSCI and DJ-AIG indices:

$$\begin{aligned}\left(R_{i,t}^{n}\right)^{2} = a_0 + a_1 I_{index} + b_{2004} I_{year=2004} + b_{2005} I_{year=2005} + b_{2006} I_{year=2006} \\ + b_{2007} I_{year=2007} + b_{2008} I_{year\geq 2008} + c_{2004} I_{index} I_{year=2004} \\ + c_{2005} I_{index} I_{year=2005} + c_{2006} I_{index} I_{year=2006} \\ + c_{2007} I_{index} I_{year=2007} + c_{2008} I_{index} I_{year\geq 2008} + \varepsilon_{i,t} \qquad (7)\end{aligned}$$

The squared return is a widely used proxy for return volatility. The coefficients b_{2004}, b_{2005}, b_{2006}, b_{2007}, b_{2008} measure the baseline volatility changes of off-index commodities in each of the years after 2004, while the coefficients c_{2004}, c_{2005}, c_{2006}, c_{2007}, c_{2008} measure the additional volatility increases of the indexed commodities relative to the off-index commodities in each of the years. Table 7 reports the regression results. It shows that the estimates for coefficients b_{2004} and b_{2008} are positive and significant, indicating a significant baseline volatility increase in years 2004 and 2008 across the commodities markets. Interestingly, the estimates for coefficients c_{2004}, c_{2006}, and c_{2008} are all positive and significant, indicating that in years 2004, 2006 and 2008, the indexed commodities exhibited larger volatility increases than those off-index commodities. This result is consistent with the argument that the large increase of commodity price volatility in 2008 was related to the presence of index investors.

To further assess the channels for index investors to drive the volatility of non-energy commodities, we filter out the market-wide shocks, such as shocks to the world equity index, the Treasury bond index, the US dollar index, and the CPI change, and the oil shocks using the same regression specification given in (6). Depending on whether we include the oil return in the regression, we obtain two sets of residual returns, one after filtering out only the market-wide shocks and the other after filtering out both the market-wide and oil shocks.

We then repeat the difference-in-difference analysis of regression (7) using the two sets of residual returns. The results are also reported in Table 7. After only filtering out the market-wide shocks from the non-energy commodity returns, the estimates for coefficients c_{2004}, c_{2006}, and

c_{2008} are substantially reduced, although c_{2006}, and c_{2008} are still positive and significant. The large reduction in these estimates suggests that the spillover effects of the market-wide shocks played a significant role in the greater volatility increases of the indexed commodities relative to the off-index commodities in 2008. After further filtering out oil shocks, the estimates of coefficients c_{2004}, c_{2006}, and c_{2008} are further reduced, and the estimate of c_{2008} now becomes insignificant. These reductions indicate that the spillover effects of oil shocks also played an important role in the greater volatility increases of indexed commodities in 2008.

Overall, our analysis in this section shows that spillovers of market-wide shocks contributed significantly to the volatility increases of oil and other non-energy commodities in 2008, and the spillovers of oil shocks also contributed significantly to the volatility increases of non-energy commodities. Furthermore, we find that non-energy commodities in the GSCI and DJ-AIG indices had significantly larger volatility increases than off-index commodities in 2008 and the larger increases were primarily related to the greater exposures of indexed commodities to market-wide and oil shocks.

VII. Conclusion

This paper examines the financialization process of commodities precipitated by the rapid growth of index investment to the commodities markets since early 2000s. We find that concurrent with the growth of index investment, commodity prices have been increasingly exposed to market-wide shocks, such as shocks to the world equity index and US dollar exchange rate, and to shocks to other commodities, such as oil. In particular, this trend is more pronounced for commodities in the two popular commodity indices, the GSCI and DJ-AIG indices. As a result of the financialization process, the spillover effects of the recent financial crisis contributed to a substantial part of the large increase of commodity price volatility in 2008. Our study thus highlights the increasingly important interactions between commodities markets and financial markets.

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Figure 1: Commodity Prices

This figure plots the price appreciations of five commodities, oil, soybeans, cotton, live cattle, and copper, since January 1991. We normalize the price of each commodity in January 1991 to be 100.

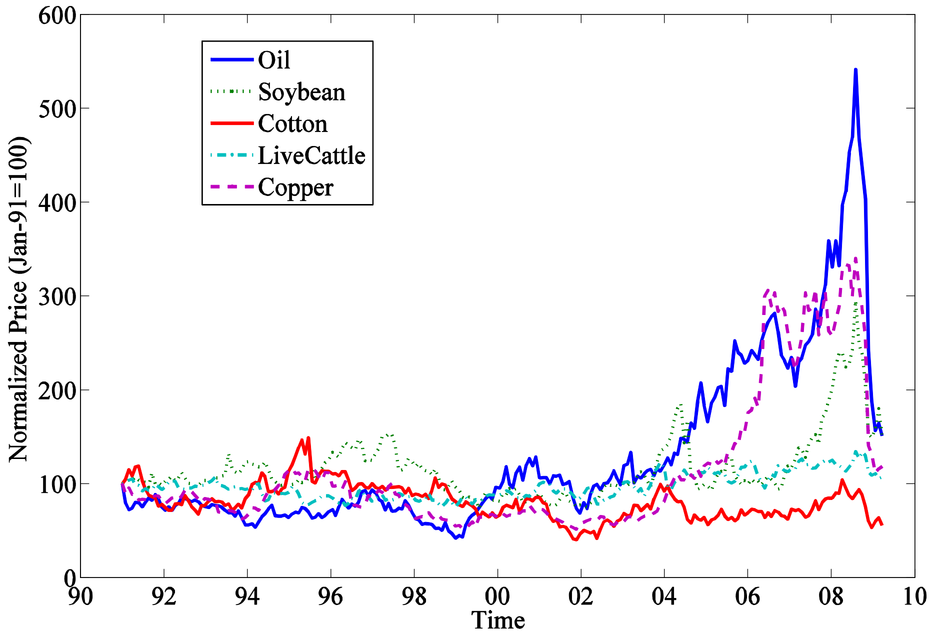


Figure 2: Open Interest of Commodity Futures Contracts

This figure plots the total open interest of futures contracts with maturities less than one year of five commodities, oil, soybeans, cotton, live cattle, and copper, since January 1991. We normalize the open interest of each commodity in January 1991 to be 100.

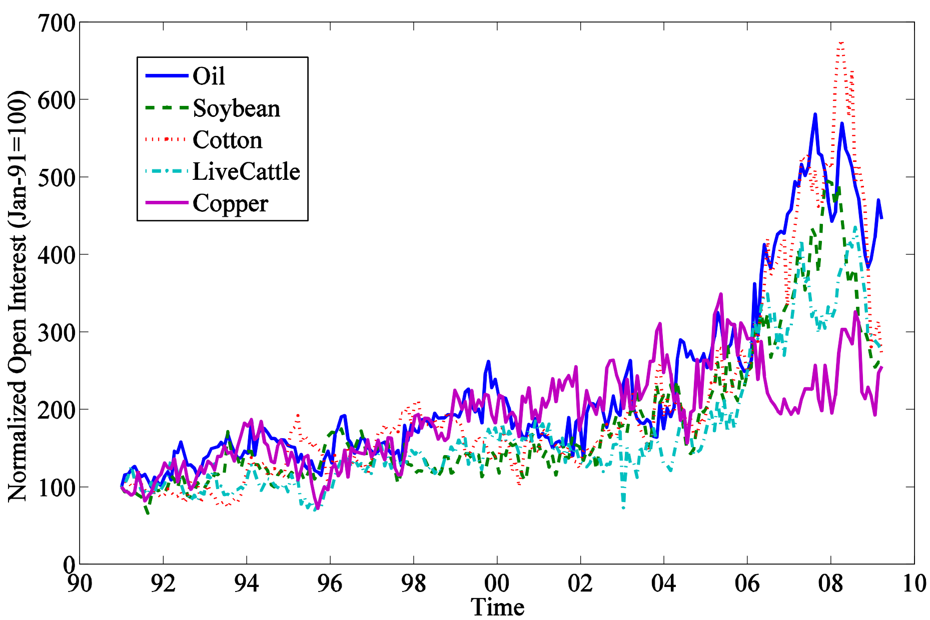


Figure 3: The GSCI, World Equity, and US Dollar Indices

This figure plots the GSCI excess return index, the Morgan Stanley world equity return index, and the US dollar return index, since January 1988. We normalize the level of each index in January 1988 to be 100.

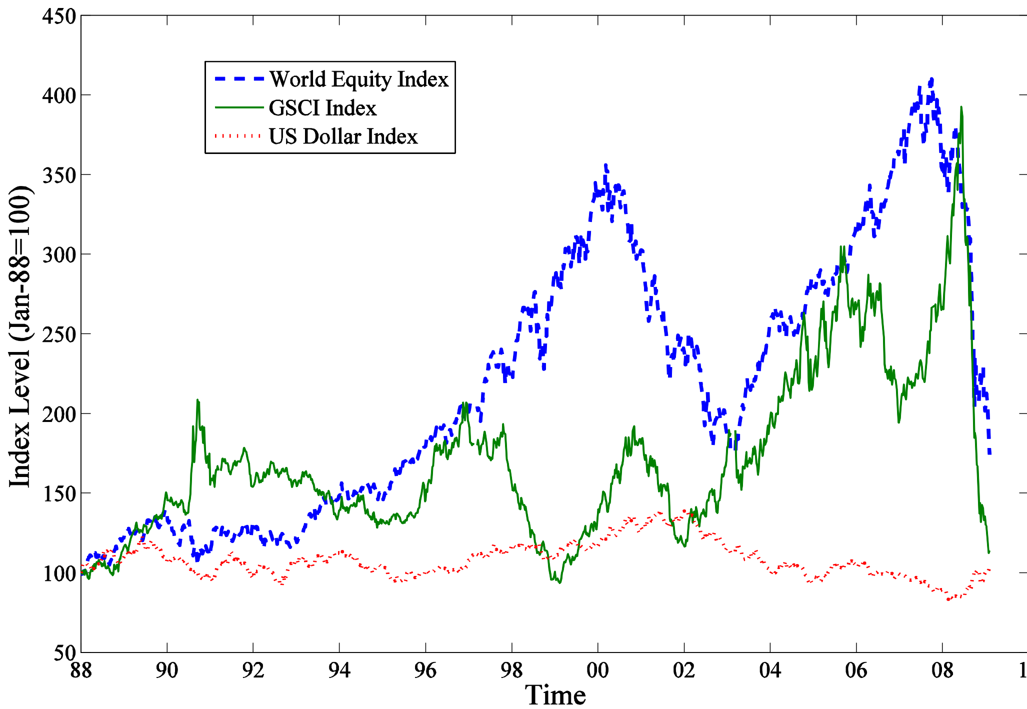


Figure 4: Rolling Return Correlation of Oil with Cotton, Corn, Live Cattle, and Copper

This figure plots the one-year rolling return correlation of oil with soybean, cotton, live cattle, and copper, from 1986 to 2009, together with the 95% confidence interval, in Panels A, B, C, and D, respectively.

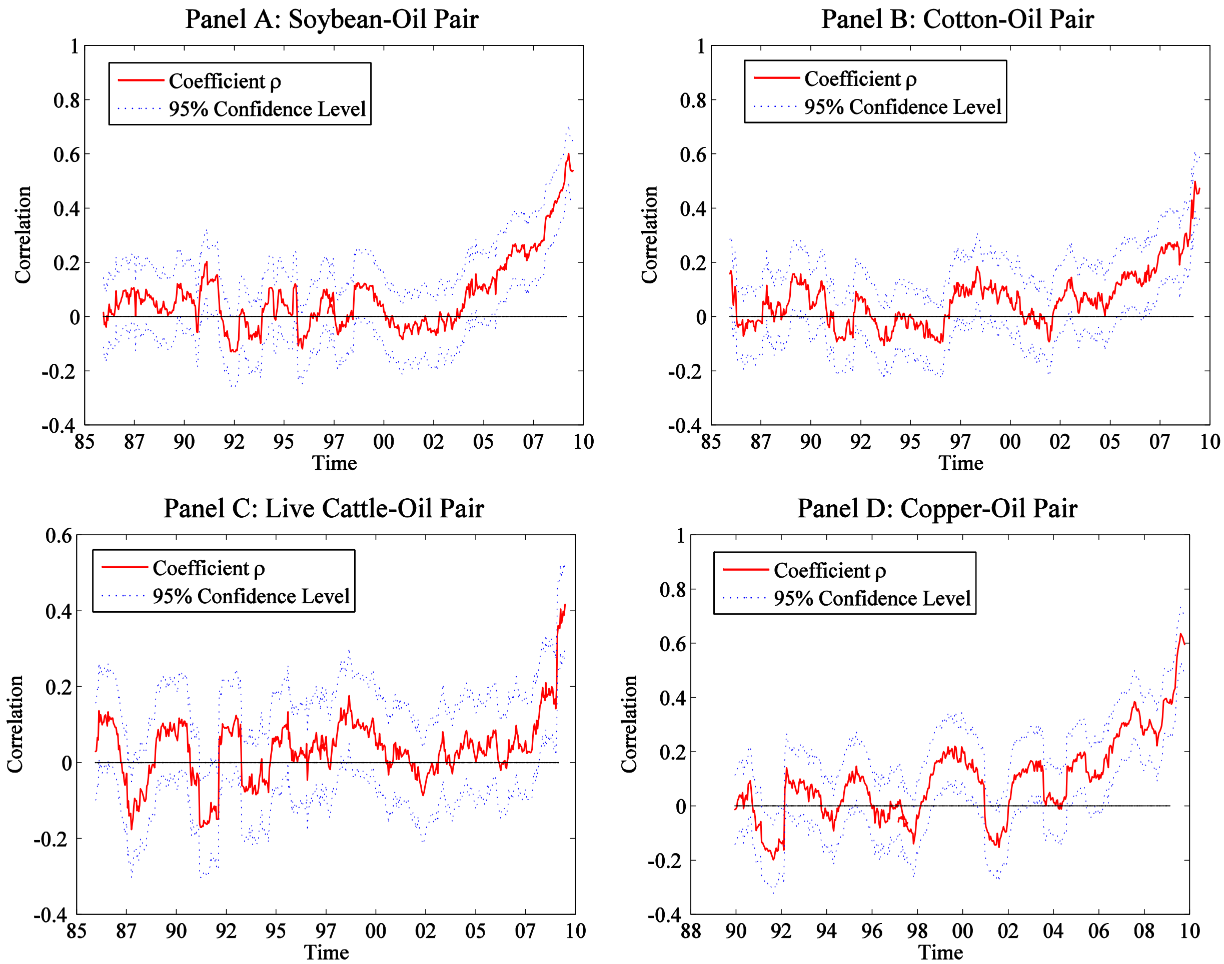


Figure 5: The Difference-in-Difference Specification

This figure plots the difference-in-difference specification for individual commodities' exposure to any independent variable in regression (3). For example, the exposure to oil return is

$$\beta_0 + \beta_1(t - 2004)I_{t\geq 2004} + \beta_2 I_{index} + \beta_3(t - 2004)I_{t\geq 2004}I_{index}$$

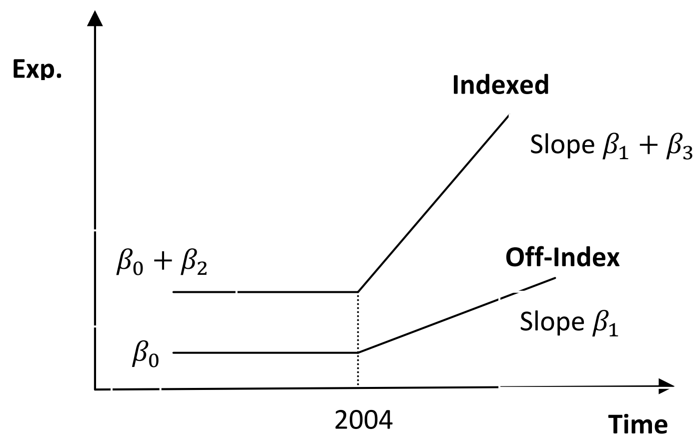


Figure 6: Accumulated Index Flow and GSCI Agriculture & Livestock Excess Return Index

This figure plots the accumulated index flow to the 12 agricultural and livestock commodities covered by the CFTC's CIT report. The weekly flow to each of the commodities is computed according to (4), and the accumulated flow to the commodity is computed from adding up the weekly flow from the first week of 2006 to any given week. By adding up the accumulated flow to the 12 commodities, we obtain the accumulated flow plotted in the figure.

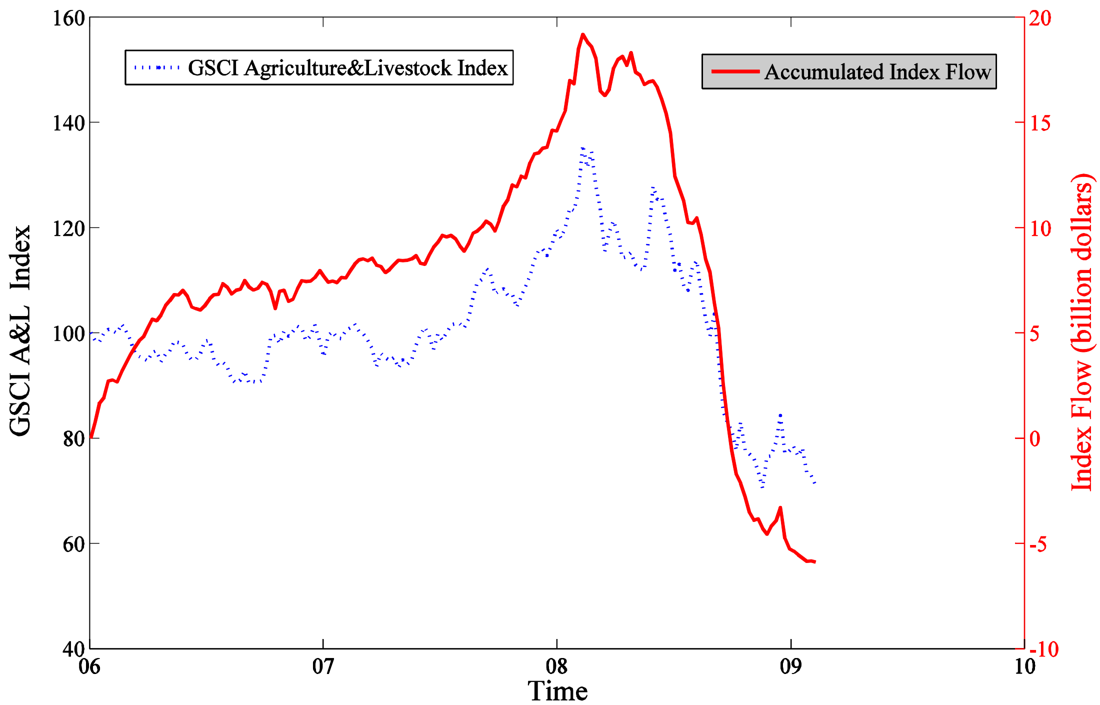


Figure 7: Impulse Responses from the VAR Analysis

This figure reports the impulse responses from the VAR analysis reported in Table 6.

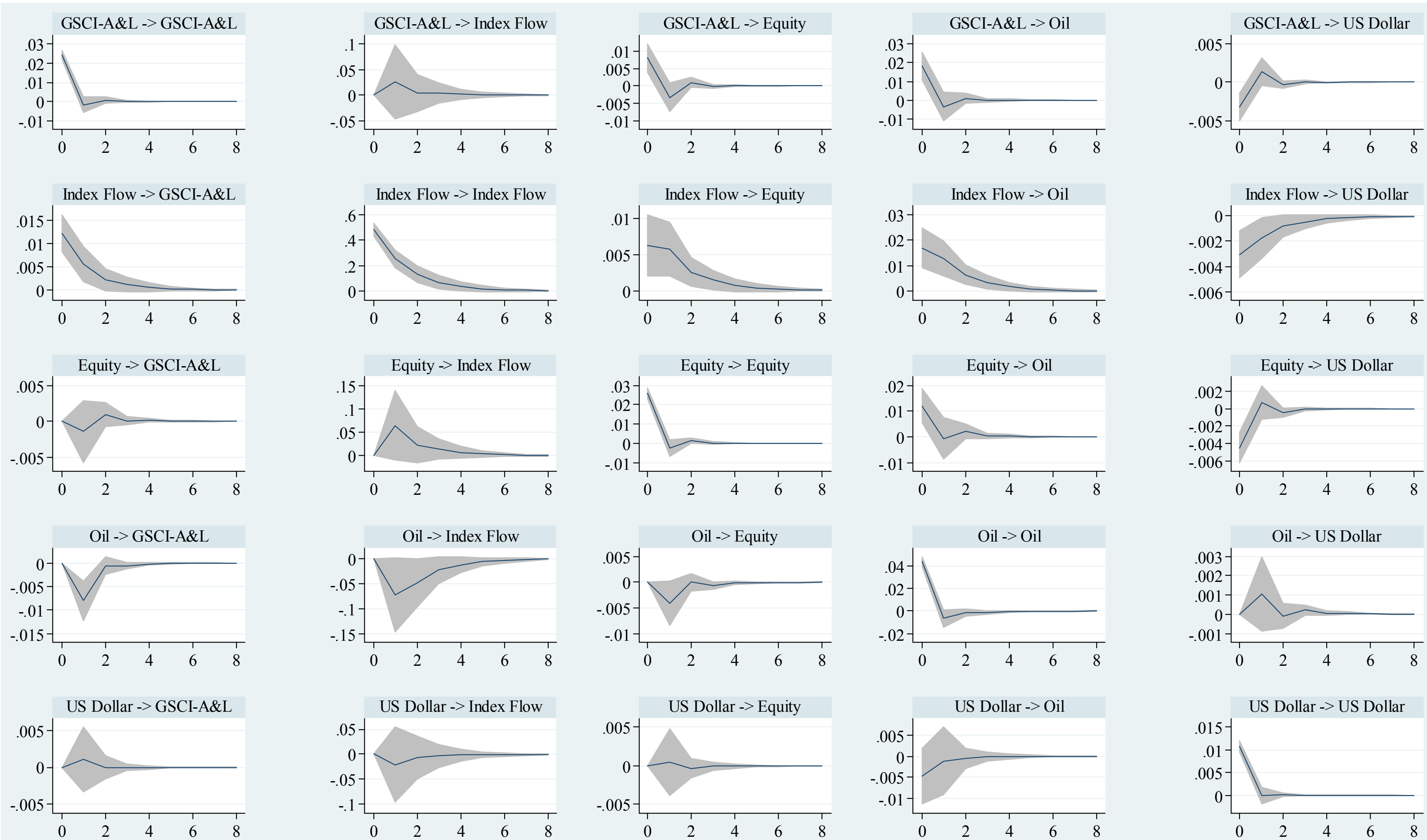


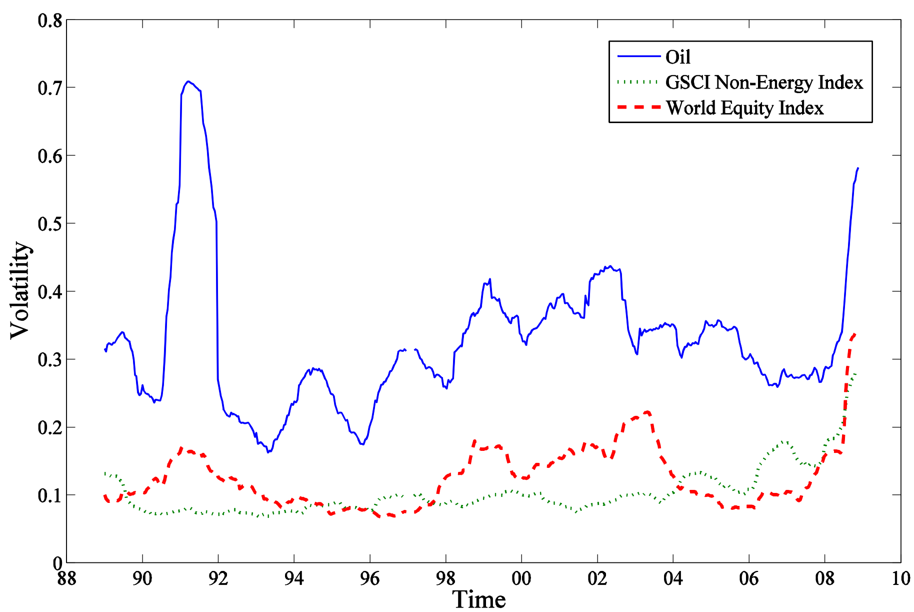
Figure 8: Volatility of Commodities

Panel A plots the one-year rolling volatility of daily returns of oil, the GSCI non-energy excess return index, and the Morgan Stanley world equity index. Panel B plots the one-year rolling volatility of raw oil return, together with that of the residual oil return after filtering out the market-wide shocks according to the following regression:

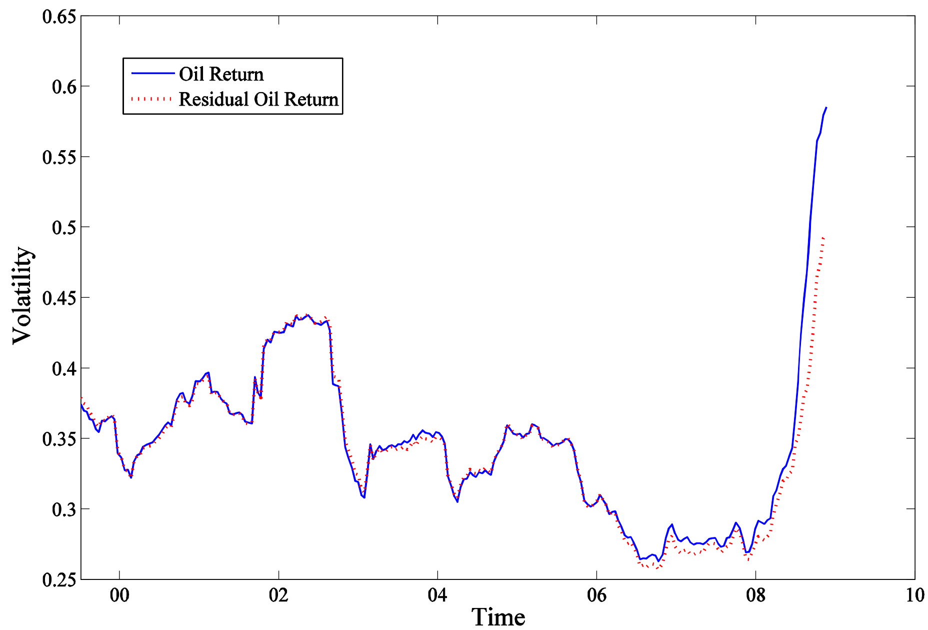
$$R_{oil,t} = a_0 + a_1 I_{t\geq 04} + [b_0 + b_1 I_{t\geq 04}(t-2004)]R_{MSW,t} + [c_0 + c_1 I_{t\geq 04}(t-2004)]R_{JPM,t}$$
$$+[d_0 + d_1 I_{t\geq 04}(t-2004)]R_{USD,t} + [e_0 + e_1 I_{t\geq 04}(t-2004)]R_{CPI,t} + \epsilon_t$$

Panel C plots the one-year rolling volatility of raw GSCI non-energy index return, together with that of two sets of residual returns, one after filtering out the market-wide shocks and the other after filtering out the market-wide and oil shocks. We use the same regression specification as above for filtering out these shocks.

Panel A: Volatility of Oil, GSCI Non-Energy Index and Morgan Stanley World Equity Index



Panel B: Composition of Oil Volatility



Panel C: Composition of Volatility of GSCI Non-Energy Index

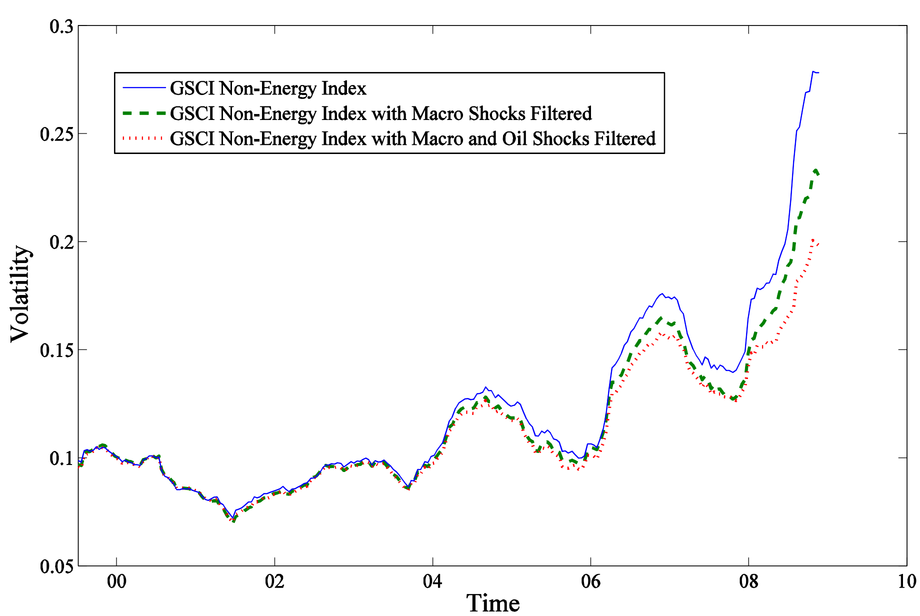


Table 1: Commodity Futures Traded in US and Weights in the GSCI and DJ-AIG Indices

This table lists all of the commodity futures contracts traded in U.S. The weights of these commodities in the GSCI and DJ-AIG contracts are taken from 2008.[24]

Commodities	GSCI	DJ-AIG	Exchange	Contracts
Energy (4 Commodities)				
WTI Crude Oil	40.6%	15.0%	NYMEX	Every month
Heating Oil	5.3%	4.5%	NYMEX	Every month
RBOB Gasoline	4.5%	4.1%	NYMEX	Every month
Natural Gas	7.6%	16.0%	NYMEX	Every month
Grains (9 commodities)				
Corn	3.6%	6.9%	CME Group	Mar, May , Jul, Sep & Dec
Soybeans	0.9%	7.4%	CME Group	Jan, Mar, May , Jul, Aug, Sep, Nov
Chicago Wheat	3.0%	3.4%	CME Group	Mar, May , Jul, Sep, Dec
Kansas Wheat	0.7%	0	KCBT[25]	Mar, May, Jul, Sep, Dec
Soybean Oil	0	2.9%	CME Group	Jan, Mar, May, Jul, Aug, Sep, Oct, Dec
Minneapolis Wheat	0	0	MGE[26]	Mar, May, Jul, Sep, Dec
Soybean Meal	0	0	CME Group	Jan, Mar, May, Jul, Aug, Sep, Oct, Dec
Rough Rice	0	0	CME Group	Jan, Mar, May, Jul, Sep, Nov
Oats	0	0	CME Group	Mar, May, July, Sep, Dec
Softs (6 Commodities)				
Coffee	0.5%	2.7%	ICE	Mar, May, Jul, Sep, Dec
Cotton	0.7%	2.2%	ICE	Mar, May, Jul, Oct, Dec
Sugar	2.1%	2.8%	ICE	Mar, May, Jul, Oct
Cocoa	0.2%	0	ICE	Mar , May, Jul, Sep, Dec
Lumber	0	0	CME Group	Jan, Mar, May, Jul, Sep, Nov
Orange Juice	0	0	ICE	Jan, Mar, May, Jul, Sep, Nov
Livestock (4 Commodities)				
Feeder Cattle	0.3%	0.0%	CME Group	Jan, Mar, Apr, May, Aug, Sep, Oct, Nov
Lean Hogs[27]	0.8%	2.5%	CME Group	Feb, Apr, May, Jul, Aug, Oct, Dec
Live Cattle	1.6%	4.1%	CME Group	Feb, Apr, Jun, Aug, Oct, Dec
Pork Bellies	0	0	CME Group	Feb, Mar, May, Jul, Aug
Metals (5 Commodities)				
Gold[28]	1.5%	6.1%	NYMEX	Feb, Apr, Jun, Aug, Oct, Dec
Silver	0.2%	2.4%	NYMEX	Jan, Mar, May, Jul, Sep, Dec
Copper[29]	2.6%	6.7%	NYMEX	Mar, May, Jul, Sep, Dec
Platinum	0	0	NYMEX	Jan, Apr, Jul, and Oct
Palladium	0	0	NYMEX	Mar, Jun, Sep, and Dec

[24] The GSCI and DJ-AIG indices also include commodities traded in London, which are not included in our analysis.

[25] Kansas City Board of Trade.

[26] Minneapolis Grain Exchange.

[27] A June contract has been added to the Lean Hog Futures series since 2002. As this new contract has a low open interest, we omit this contract in our analysis.

[28] For gold, silver, platinum, and palladium, contracts include the current month and the next two consecutive months, plus those contracts listed in the table. However, because the open interest of those short-maturity contracts (with maturities less than 3 months) is typically small, we omit these contracts in our analysis.

[29] The GSCI Index uses the copper contracts traded on LME, while the DJ-AIG Index uses those from NYMEX. We follow the convention of the DJ-AIG index and choose Mar, May, Jul, Sep and Dec for copper contracts in our analysis.

Table 2: Regressions of the Daily GSCI Return on Aggregate Variables

This table reports regression results of the daily return of the GSCI excess return index on the returns of the Morgan Stanley world equity index ($R_{MSW,t}$), the JP Morgan Treasury bond index ($R_{JPM,t}$), and the US dollar index ($R_{USD,t}$), separately and jointly. The data sample goes from 1/4/1988 to 3/2/2009. The t-statistics are adjusted for heteroskedasticity and serial correlation using the Newey-West method with five lags.

Panel A: Specifications Based on Yearly Dummies

This panel uses the following regression specification based on a set of year dummies in the exposures of the GSCI return to each of the independent variables:

$$R_{GSCI,t} = a_0 + a_{04}I_{y=04} + a_{05}I_{y=05} + a_{06}I_{y=06} + a_{07}I_{y=07} + a_{08}I_{y\geq 08}$$

$$+\left(b_0 + b_{04}I_{y=04} + b_{05}I_{y=05} + b_{06}I_{y=06} + b_{07}I_{y=07} + b_{08}I_{y\geq 08}\right)R_{MSW,t}$$

$$+(c_0 + c_{04}I_{y=04} + c_{05}I_{y=05} + c_{06}I_{y=06} + c_{07}I_{y=07} + c_{08}I_{y\geq 08})R_{JPM,t}$$

$$+\left(d_0 + d_{04}I_{y=04} + d_{05}I_{y=05} + d_{06}I_{y=06} + d_{07}I_{y=07} + d_{08}I_{y\geq 08}\right)R_{USD,t} + \epsilon_t$$

		Regression (1)		**Regression (2)**		**Regression (3)**		**Regression (4)**	
		estimate	t-stat	estimate	t-stat	estimate	t-stat	estimate	t-stat
	a_0	0.01	0.81	0.01	0.79	0.01	0.73	0.01	0.85
	a_{04}	0.03	0.41	0.04	0.49	0.02	0.29	0.02	0.30
	a_{05}	0.04	0.58	0.05	0.66	0.06	0.86	0.06	0.81
	a_{06}	-0.15	-2.10	-0.07	-1.19	-0.09	-1.62	-0.11	-1.92
	a_{07}	0.11	1.49	0.06	1.02	0.03	0.61	0.03	0.52
	a_{08}	-0.10	-1.05	-0.24	-2.15	-0.18	-1.83	-0.10	-1.16
Exposure to equity index	b_0	-0.05	-1.62					-0.06	-1.91
	b_{04}	0.10	0.79					-0.01	-0.09
	b_{05}	0.20	1.67					0.13	0.93
	b_{06}	0.32	2.63					0.29	2.87
	b_{07}	0.25	3.32					0.18	2.69
	b_{08}	0.49	9.02					0.39	5.82
Exposure to bond index	c_0			-0.07	-3.46			-0.07	-3.62
	c_{04}			0.16	2.42			0.05	0.66
	c_{05}			0.12	1.12			0.09	0.85
	c_{06}			0.14	1.77			-0.02	-0.28
	c_{07}			0.00	0.06			-0.03	-0.36
	c_{08}			-0.17	-1.65			-0.08	-1.03
Exposure to dollar index	d_0					-0.01	-0.52	-0.02	-0.98
	d_{04}					-0.18	-2.86	-0.19	-2.32
	d_{05}					-0.16	-1.75	-0.14	-1.31
	d_{06}					-0.28	-3.87	-0.24	-3.12
	d_{07}					-0.39	-3.53	-0.38	-3.10
	d_{08}					-0.56	-4.92	-0.33	-2.84
	R^2	6.1%		1.4%		4.4%		8.4%	

Panel B: Specifications Based on Linear Trends

This panel uses the following regression specification based on a set of linear trends in the exposures of the GSCI return to each of the independent variables:

$$R_{GSCI,t} = a_0 + a_1 I_{t\geq 04} + [b_0 + b_1 I_{t\geq 04}(t-2004)]R_{MSW,t} + [c_0 + c_1 I_{t\geq 04}(t-2004)]R_{JPM,t}$$
$$+[d_0 + d_1 I_{t\geq 04}(t-2004)]R_{USD,t} + \epsilon_t$$

		Regression (1)		**Regression (2)**		**Regression (3)**		**Regression (4)**	
		estimate	t-stat	estimate	t-stat	estimate	t-stat	estimate	t-stat
	a_0	0.01	0.79	0.01	0.77	0.01	0.73	0.01	0.84
	a_1	-0.02	-0.43	-0.05	-1.15	-0.04	-0.99	-0.02	-0.64
Exposure to equity index	b_0	-0.06	-1.87					-0.06	-1.96
	b_1	0.10	9.37					0.08	6.12
Exposure to bond index	c_0			-0.05	-2.69			-0.06	-3.19
	c_1			-0.03	-1.47			-0.01	-0.96
Exposure to dollar index	d_0					-0.02	-0.96	-0.03	-1.86
	d_1					-0.11	-5.34	-0.07	-3.23
	R^2	6.1%		0.8%		4.0%		7.8%	

Table 2: Regressions of the Monthly GSCI Return on Aggregate Variables

This table reports regression results of the monthly return of the GSCI excess return index on the returns of the Morgan Stanley world equity index ($R_{MSW,t}$), the JP Morgan Treasury bond index ($R_{JPM,t}$), the US dollar index ($R_{USD,t}$), and the CPI change $R_{CPI,t}$, separately and jointly. The data sample goes from 1/4/1988 to 3/2/2009. The t-statistics are adjusted for heteroskedasticity and serial correlation using the Newey-West method with five lags. We use the following regression specification based on a set of linear trends in the exposures of the GSCI return to each of the independent variables:

$$R_{GSCI,t} = a_0 + a_1 I_{t\geq 04} + [b_0 + b_1 I_{t\geq 04}(t-2004)]R_{MSW,t} + [c_0 + c_1 I_{t\geq 04}(t-2004)]R_{JPM,t}$$
$$+[d_0 + d_1 I_{t\geq 04}(t-2004)]R_{USD,t} + [e_0 + e_1 I_{t\geq 04}(t-2004)]R_{CPI,t} + \epsilon_t$$

		Regression (1)		**Regression (2)**		**Regression (3)**		**Regression (4)**		**Regression (5)**	
		estimate	t-stat	estimate	t-stat	estimate	t-stat	estimate	t-stat	estimate	t-stat
	a_0	0.05	0.70	0.05	0.78	0.04	0.65	0.05	0.64	0.06	0.85
	a_1	-0.07	-0.35	-0.21	-0.76	-0.16	-0.78	-0.12	-0.61	-0.09	-0.66
Exposure to equity index	b_0	-0.10	-0.94							-0.11	-1.08
	b_1	0.13	3.91							0.08	2.84
Exposure to bond index	c_0			-0.18	-3.11					-0.20	-3.18
	c_1			0.04	1.02					0.01	0.30
Exposure to dollar index	d_0					-0.05	-0.72			-0.11	-1.42
	d_1					-0.16	-4.36			-0.14	-2.96
Exposure to CPI	e_0							-0.09	-0.91	-0.11	-1.17
	e_1							0.11	4.08	0.10	2.98
	R^2	8.6%		3.2%		11.0%		8.3%		24.5%	

Table 3: Regression Analysis of Non-energy Commodities

For each of the four non-energy sector, we pool together the normalized daily returns of all individual commodities in the sector between 1/2/1998 and 3/2/2009. We regress the pooled returns on the Morgan Stanley world equity index return $R_{MSW,t}$, the JP Morgan Treasury bond index return $R_{JPM,t}$, the US dollar index return $R_{USD,t}$, and the normalized oil return $R^n_{oil,t}$, with the exposure to each independent variable decomposed into four components:

$$R^n_{i,t} = \alpha + [\gamma_0 + \gamma_1(t-2004)I_{t\geq 2004} + \gamma_2 I_{index} + \gamma_3(t-2004)I_{t\geq 2004}I_{index}]R_{MSW,t}$$

$$+[\theta_0 + \theta_1(t-2004)I_{t\geq 2004} + \theta_2 I_{index} + \theta_3(t-2004)I_{t\geq 2004}I_{index}]R_{JPM,t}$$

$$+[\eta_0 + \eta_1(t-2004)I_{t\geq 2004} + \eta_2 I_{index} + \eta_3(t-2004)I_{t\geq 2004}I_{index}]R_{USD,t}$$

$$+[\beta_0 + \beta_1(t-2004)I_{t\geq 2004} + \beta_2 I_{index} + \beta_3(t-2004)I_{t\geq 2004}I_{index}]R^n_{oil,t} + \varepsilon_{i,t}$$

The t-statistics are adjusted for heteroskedasticity and serial correlation using the Newey-West method with five lags.

Panel A: The Grain Sector

		Regression (1)		**Regression (2)**		**Regression (3)**		**Regression (4) Raw Oil**		**Regression (5) Residual Oil**		**Regression (6)**	
		est	t-stat	est	t-stat	est	t-stat	est	t-stat	est	t-stat	est	t-stat
	α	0.00	0.67	0.00	-0.02	0.00	0.30	0.01	1.00	0.00	0.27	0.01	0.89
Exposure to equity index	γ_0	0.03	2.16									0.03	2.04
	γ_1	0.04	7.86									0.02	4.28
	γ_2	0.00	-0.02									0.00	0.03
	γ_3	0.02	3.02									0.01	1.91
Exposure to bond index	θ_0			-0.01	-0.86							-0.02	-1.89
	θ_1			-0.02	-2.71							-0.01	-1.76
	θ_2			0.00	0.13							0.00	-0.13
	θ_3			-0.01	-1.18							-0.01	-0.85
Exposure to dollar index	η_0					-0.04	-3.63					-0.05	-4.42
	η_1					-0.05	-7.71					-0.03	-5.16
	η_2					0.00	-0.06					0.00	-0.20
	η_3					-0.02	-2.52					-0.02	-1.84
Exposure to oil	β_0							0.04	3.08	0.03	3.13	0.04	3.17
	β_1							0.06	10.01	0.05	6.79	0.05	7.10
	β_2							0.00	0.22	0.00	0.25	0.00	0.27
	β_3							0.04	4.06	0.03	3.17	0.03	3.37
	R^2	3.1%		0.4%		2.8%		6.2%		3.0%		7.6%	

Panel B: The Soft Sector

		Regression (1)		**Regression (2)**		**Regression (3)**		**Regression (4) Raw Oil**		**Regression (5) Residual Oil**		**Regression (6)**	
		est	t-stat	est	t-stat	est	t-stat	est	t-stat	est	t-stat	est	t-stat
	α	0.00	0.34	0.00	-0.01	0.00	0.17	0.00	0.48	0.00	0.11	0.00	0.43
Exposure to equity index	γ_0	0.10	5.39									0.09	5.17
	γ_1	0.01	1.36									0.01	0.88
	γ_2	-0.06	-2.79									-0.06	-2.71
	γ_3	0.03	4.02									0.02	2.42
Exposure to bond index	θ_0			-0.03	-1.72							-0.01	-0.76
	θ_1			0.00	-0.22							0.00	0.14
	θ_2			0.02	0.86							-0.01	-0.50
	θ_3			-0.01	-1.29							-0.01	-0.79
Exposure to dollar index	η_0					0.03	1.58					0.02	1.11
	η_1					-0.03	-3.66					-0.01	-1.52
	η_2					-0.07	-3.37					-0.07	-3.45
	η_3					-0.02	-1.83					-0.01	-1.44
Exposure to oil	β_0							0.01	0.38	0.01	0.60	0.01	0.59
	β_1							0.03	4.16	0.02	2.25	0.02	2.34
	β_2							0.02	0.92	0.02	0.81	0.02	0.85
	β_3							0.03	2.73	0.02	1.74	0.02	1.78
	R^2	2.0%		0.2%		1.4%		2.2%		0.8%		3.4%	

Panel C: The Livestock Sector

		Regression (1)		**Regression (2)**		**Regression (3)**		**Regression (4) Raw Oil**		**Regression (5) Residual Oil**		**Regression (6)**	
		est	t-stat	est	t-stat	est	t-stat	est	t-stat	est	t-stat	est	t-stat
	α	0.00	0.21	0.00	0.00	0.00	0.09	0.00	0.26	0.00	0.06	0.00	0.31
Exposure to equity index	γ_0	-0.01	-0.35									-0.02	-0.64
	γ_1	0.02	2.18									0.02	1.98
	γ_2	0.06	1.74									0.05	1.61
	γ_3	0.01	0.86									0.01	0.70
Exposure to bond index	θ_0			-0.04	-1.39							-0.04	-1.46
	θ_1			0.00	0.23							0.01	0.68
	θ_2			-0.03	-0.97							-0.02	-0.68
	θ_3			0.00	0.33							0.01	0.61
Exposure to dollar index	η_0					0.01	0.33					0.00	-0.06
	η_1					-0.01	-1.16					0.00	-0.16
	η_2					0.02	0.54					0.01	0.28
	η_3					-0.02	-1.65					-0.01	-0.63
Exposure to oil	β_0							0.03	0.88	0.02	0.87	0.02	0.88
	β_1							0.01	0.81	0.00	0.03	0.00	0.02
	β_2							-0.01	-0.18	0.00	-0.04	0.00	-0.06
	β_3							0.04	3.17	0.03	2.34	0.03	2.42
	R^2	1.1%		0.3%		0.3%		1.2%		0.5%		1.9%	

Panel D: The Metal Sector

		Regression (1)		**Regression (2)**		**Regression (3)**		**Regression (4) Raw Oil**		**Regression (5) Residual Oil**		**Regression (6)**	
		est	t-stat	est	t-stat	est	t-stat	est	t-stat	est	t-stat	est	t-stat
	α	0.00	0.45	0.00	-0.01	0.00	0.20	0.01	0.68	0.00	0.18	0.00	0.53
Exposure to equity index	γ_0	0.05	2.65									0.05	2.65
	γ_1	0.05	5.30									0.03	3.81
	γ_2	0.05	1.96									0.05	2.42
	γ_3	-0.01	-0.60									-0.02	-1.92
Exposure to bond index	θ_0			0.00	-0.09							-0.03	-1.91
	θ_1			0.00	-0.42							0.01	1.06
	θ_2			0.04	1.56							0.03	1.34
	θ_3			-0.01	-0.57							-0.01	-1.12
Exposure to dollar index	η_0					-0.15	-7.83					-0.16	-8.58
	η_1					-0.04	-3.53					-0.01	-1.00
	η_2					-0.07	-2.87					-0.06	-2.63
	η_3					-0.02	-1.42					-0.03	-2.11
Exposure to oil	β_0							0.06	3.31	0.05	2.95	0.05	3.02
	β_1							0.06	5.85	0.04	4.28	0.04	4.30
	β_2							0.05	2.22	0.04	1.98	0.04	1.99
	β_3							0.02	1.35	0.02	1.61	0.02	1.74
	R^2	3.9%		0.1%		7.8%		6.7%		3.3%		12.8%	

Table 4: Regression Analysis of Trading Volume of Commodities

For each commodity, we use the percentage change of the daily open interest of its first- and second-month contracts to proxy the daily trading volume by index investors:

$$VO_{i,t} = \frac{OI_{i,t} - OI_{i,t-1}}{OI_{i,t-1}}$$

where $OI_{i,t}$ is the sum of open interest of the first- and second-month contracts. For each of the four non-energy sector, we pool together the daily trading volume of all individual commodities in the sector between 1/2/1998 and 3/2/2009. For each of the sector, we run the following panel regression:

$$VO_{i,t} = \alpha + [\beta_0 + \beta_1(t - 2004)I_{t\geq 2004} + \beta_2 I_{index} + \beta_3(t - 2004)I_{t\geq 2004}I_{index}]VO_{oil,t} + \varepsilon_{i,t}$$

The regression result for each sector is reported in a separate column. The t-statistics are adjusted for heteroskedasticity and serial correlation using the Newey-West method with five lags.

	Grains		**Softs**		**Livestock**		**Metals**	
	estimate	t-stat	estimate	t-stat	estimate	t-stat	estimate	t-stat
α	0.00	-0.06	0.00	-0.02	0.00	-0.06	0.00	-0.01
β_0	0.02	1.56	0.06	2.99	-0.04	-1.96	0.04	2.27
β_1	0.01	2.31	0.00	0.42	0.00	0.22	-0.01	-1.31
β_2	0.09	4.53	0.17	6.11	0.19	7.32	-0.07	-3.19
β_3	0.03	2.99	0.02	1.27	0.06	4.21	0.03	2.55
R^2	2.0%		4.6%		4.4%		0.1%	

Table 5: The Commodity Index Traders Report

Each Friday, the CFTC release the Commodity Index Traders (CIT) report for a breakdown of the prior Tuesday's positions for 12 agricultural commodities. The sample period covers from 1/2/2006 to 3/3/2009. In Panel A, we calculate the position of each reported category in each commodity relative to the total open interest, and then calculate the mean across the whole sample period. In Panel B, we conduct principal component analysis of the net long position of index traders in the 12 commodities and report the variance explained by the 6 leading components.

Panel A: Average Position Size of Each Category of Traders

	Index Traders		**Non-commercial Traders**			**Commercial Traders**	
	Long	Short	Long	Short	Spread	Long	Short
Chicago Wheat	41.3%	3.2%	10.7%	13.7%	28.3%	12.2%	41.8%
Kansas Wheat	21.2%	0.6%	23.9%	6.9%	13.8%	23.5%	55.6%
Corn	22.8%	1.3%	12.6%	5.4%	29.7%	23.6%	46.6%
Soybean	25.3%	1.3%	13.6%	8.0%	28.6%	20.4%	44.4%
Soybean Oil	23.6%	1.0%	15.3%	7.2%	22.4%	28.9%	62.5%
Cotton	31.0%	1.1%	13.1%	11.9%	27.8%	19.8%	53.9%
Lean Hogs	43.3%	0.9%	12.3%	14.4%	24.2%	8.8%	42.7%
Live Cattle	39.5%	0.7%	16.0%	11.7%	23.2%	12.3%	43.6%
Feeder Cattle	24.8%	1.1%	23.7%	16.3%	18.0%	16.0%	20.6%
Cocoa	12.4%	0.9%	28.1%	13.7%	10.8%	40.9%	70.1%
Sugar	27.8%	4.0%	11.7%	7.1%	21.9%	28.6%	59.6%
Coffee	24.3%	0.7%	17.3%	12.9%	29.2%	22.7%	52.8%
Average	28.1%	1.4%	16.5%	10.8%	23.2%	21.5%	49.5%

Panel B: Principal Component Analysis of the Net Long Position of Index Traders in the 12 Commodities

Component	**Variance Explained**
1	50.8%
2	27.5%
3	7.7%
4	4.2%
5	3.3%
6	2.4%

Table 6: VAR Analysis of Index Flow and Other Variables

This table reports the result from the vector auto-regressive (VAR) analysis of the index flow IF_t, the GSCI Agriculture & Livestock index return $R_{GSCI-A\&L,t}$, the world equity index return $R_{MSW,t}$, the US dollar index return $R_{USD,t}$, and the oil return $R_{Oil,t}$. The weekly data sample covers from 1/3/2006 to 3/3/2009. The AIC and likelihood ratio tests indicate that the optimal number of lags is 1. The regression coefficients are reported below together with the t-stats and the R-squared for each of the variables.

		IF_t		$R_{GSCI-A\&L,t}$		$R_{MSW,t}$		$R_{USD,t}$		$R_{Oil,t}$	
		estimate	t-stat	estimate	t-stat	estimate	t-stat	estimate	t-stat	estimate	t-stat
Lagged Variables	constant	-0.02	-0.58	0.00	-1.03	0.00	-1.75	0.00	0.03	-0.01	-1.36
	IF_{t-1}	0.51	6.56	0.02	3.70	0.02	3.80	-0.01	-2.74	0.03	3.84
	$R_{GSCI-A\&L,t-1}$	1.03	0.62	0.06	0.65	-0.05	-0.48	0.03	0.73	-0.05	-0.29
	$R_{MSW,t-1}$	2.80	1.71	0.03	0.37	-0.05	-0.57	0.02	0.37	0.02	0.11
	$R_{USD,t-1}$	-2.64	-0.74	0.02	0.08	0.00	0.00	0.00	-0.01	-0.17	-0.45
	$R_{Oil,t}$	-1.65	-1.89	-0.18	-3.72	-0.09	-1.85	0.02	1.07	-0.15	-1.60
	R^2	31.1%		13.1%		9.4%		4.9%		9.8%	

Table 7: Regression Analysis of Volatility of Non-energy Commodities

We analyze the volatility of the daily returns of all commodities in the grain, soft, livestock, and metal sectors between 1/2/1998 and 3/2/2009. We normalize the returns of each commodity by its volatility before 2004 and its whole sample mean. We filter out the market-wide and oil shocks from the return of each commodity using the following specification:

$$R_{oil,t} = a_0 + a_1 I_{t\geq 04} + [b_0 + b_1 I_{t\geq 04}(t-2004)]R_{MSW,t} + [c_0 + c_1 I_{t\geq 04}(t-2004)]R_{JPM,t}$$
$$+[d_0 + d_1 I_{t\geq 04}(t-2004)]R_{USD,t} + [e_0 + e_1 I_{t\geq 04}(t-2004)]R_{CPI,t}$$
$$+[f_0 + f_1 I_{t\geq 04}(t-2004)]R_{CPI,t} + \epsilon_t$$

Then, we regress the raw returns, the residual returns after filtering out the market-wide shocks, including those to the world equity index, the Treasury bond index, the US dollar index, and the CPI change, and the residual returns after filtering out the market-wide and oil shocks onto a set of index and year dummies:

$$(R_{i,t}^n)^2 = a_0 + a_1 I_{index} + b_{2004} I_{year=2004} + b_{2005} I_{year=2005} + b_{2006} I_{year=2006} + b_{2007} I_{year=2007}$$
$$+ b_{2008} I_{year\geq 2008} + c_{2004} I_{index} I_{year=2004} + c_{2005} I_{index} I_{year=2005}$$
$$+ c_{2006} I_{index} I_{year=2006} + c_{2007} I_{index} I_{year=2007} + c_{2008} I_{index} I_{year\geq 2008} + \varepsilon_{i,t}$$

		Raw Returns		**Residual Returns without Market-wide Shocks**		**Residual Returns without Market-wide and Oil Shocks**	
		estimate	t-stat	estimate	t-stat	estimate	t-stat
	a_0	1	42.96	1	42.93	1	42.91
	a_1	0	-0.01	0	0	0	0
Baseline Effects	b_{2004}	0.27	3.64	0.22	3.02	0.22	3.03
	b_{2005}	-0.08	-1.41	-0.1	-1.79	-0.11	-1.92
	b_{2006}	-0.01	-0.18	-0.07	-1.08	-0.09	-1.36
	b_{2007}	-0.06	-1.02	-0.11	-1.73	-0.12	-1.91
	b_{2008}	1.43	11.23	1.19	10.19	1.07	9.63
Diff-in-Diff Effects	c_{2004}	0.34	3.38	0.26	2.7	0.25	2.59
	c_{2005}	0.09	1.21	0.07	0.94	0.06	0.79
	c_{2006}	0.52	4.43	0.45	4.35	0.38	3.94
	c_{2007}	0.25	3.06	0.18	2.28	0.14	1.82
	c_{2008}	0.68	3.63	0.42	2.55	0.25	1.68
	R^2	3.4%		2.5%		2.0%	