FINANCIALIZATION OF THE COMMODITIES FUTURES MARKETS AND ITS EFFECTS ON PRICES

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A Dissertation Presented
by

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ABSTRACT

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After declining for almost three decades, the food price index of the Food and Agricultural Organization (FAO) rose by 90 percent between January 2002 and June 2008. Besides the magnitude, the rise in prices was remarkable for its breadth, affecting a broad range of commodities including agricultural (wheat, corn, soybeans, cocoa, coffee), energy (crude oil, gasoline), and metals (copper, aluminum). According to the US Department of Agriculture, this price spike was responsible for increasing the number of malnourished people by 80 million. These dramatic developments in prices coincided with a rapid inflow of investment into the commodities futures market -- the number of open contracts between 2001 and June 2008 increased by more than six-fold, from around 6 million to 37 million. The new investment was primarily driven by portfolio diversification motives of a new class of traders who were neither producers nor direct consumers of the underlying commodities.

This dissertation examines the potential causal links between this financialization of the commodities futures market and the 2008 global spike in food prices and other commodities. The dissertation consists of three major chapters. The second chapter analyses the relationship between spot and futures markets for a range of commodities. The third and fourth chapters seek to understand the role of

financialization in causing the 2008 price developments. Chapter 3 explores commodity markets individually, studying the correlation between the inflow of liquidity and price changes. Chapter 4 studies the issue at a more macro level by investigating if the inflow of investment can explain the increase in comovement of prices between unrelated commodities.

My results show that i) for many commodities, prices are determined in the futures markets, and ii) financialization of the futures market was an important factor in causing the 2008 price rises for a range of commodities. These results underscore the increasingly important role of financial motive, financial markets, and financial instruments in the operation of the commodities market. The findings are especially relevant with respect to debates as to the relative efficiency of financial markets and the need to regulate them.

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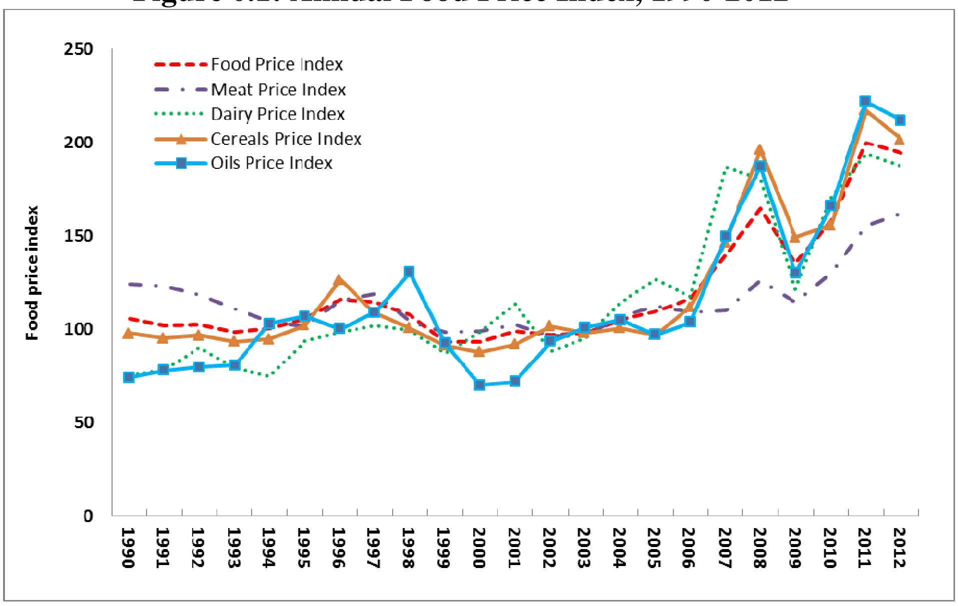
CHAPTER 1
INTRODUCTION

1.1 Background

For almost three decades, commodity prices[1] witnessed a steady decline – between 1975 and 2000 world food prices declined by 53 percent. This has led economists,[2] to theorize about declining long run commodity prices. In 2001 this trend was reversed – between January 2002 and June 2008, the food price index of the Food and Agricultural Organization (FAO) rose by 90 percent. After peaking in June 2008, prices dropped precipitously only to reach new heights in February 2011 (see Figure 1.1) Besides the magnitude, the 2008-2011 commodity price developments were remarkable for the breadth of commodities affected – prices of a wide range of commodities including agricultural (wheat, corn, soybeans, cocoa, coffee), energy (crude oil, gasoline), and metals (copper, aluminum), all rose and fell together during this period.

Figure 0.1: Annual Food Price Index, 1990-2012



Source: FAO

[1] Throughout this dissertation, I will refer to spot prices simply as prices to differentiate it from futures prices.

[2] For example Prebisch (1950) and Singer (1950) argued that the terms of trade of primary commodities will witness a secular long-term decline against manufactured commodities.

Various factors have been attributed to this sharp rise and fall of commodity prices. As these price developments were seen in a broad range of unrelated commodities, economists have questioned commodity-specific demand and supply shocks (such as drought and use of corn and oil-seeds for producing biofuels) and emphasized factors that affect many commodity markets simultaneously (Gilbert 2010b, Frankel and Rose 2009). These include increased demand from emerging markets (Krugman 2008, Hamilton 2009), devaluation of the US dollar (Akram 2008), low interest rate (Calvo 2008, Frankel 2006), and financialization of the commodities futures market (Mayer 2009; Robles, Torero, and Braun 2009; Gilbert 2010b; Singleton 2011; Hong and Yogo 2012; Mou 2011).

In this dissertation, I study if financialization of the commodities futures market can explain recent developments in commodity prices. The dissertation consists of three inter-related parts:

i) In this chapter, I define financialization of the commodities futures market and explore the theoretical channels through which financialization may lead to price bubbles.

ii) In Chapter 2, I seek to understand the relationship between spot and futures markets, and their relative importance for price determination. This is a critical link in understanding how developments in the futures markets affect spot prices.

iii) Finally, in the next two chapters, I examine if financialization can explain the recent rise in magnitude and comovement of commodity prices. In Chapter 3, I analyze commodity markets individually to understand the correlation between the inflow of money into the markets and price developments. In Chapter 4, I take a broader approach and examine commodity markets altogether, to explore if financialization can explain common movements in commodity prices.

1.2 Financialization of the Commodities Futures Markets

Commodities futures contracts have existed in the US since 1865 in the Chicago Board of Trade (CBOT), providing a means for producers and consumers of agricultural goods to hedge (spot) price risks. A commodity futures contract is an agreement to buy (or sell) a specified quantity of a commodity at a future date at a price agreed upon when entering the contract. Unlike traditional securities such as stocks and bonds, commodity futures do not raise resources for the underlying firm and so are not claims on a company. They are derivative securities that represent bets on the expected future spot price of the underlying commodity.

Traditionally, commodities were not considered good assets, as commodity prices were highly volatile and declining in the long-run. Commodity futures contracts have short maturities (3 months or so), which made investing in commodity futures a time consuming and expensive endeavor. This all changed in early 2000s. The Commodity Futures Modernization Act (CFMA) of 2000 effectively placed over-the-counter (OTC)[3] derivatives outside of the jurisdiction of the Commodity Futures Trading Commission (CFTC). Commodity futures were then marketed by the financial industry and several academic economists (some of whom were funded by the financial industry)[4] as an "asset class." Gorton and Rouwenhorst (2004) showed that the risk premium and returns of a weighted index of commodities are comparable to that of S&P500; while returns are uncorrelated with stocks and bonds, but correlated with inflation. Commodities were thus seen an effective way to diversify

[3] Contracts traded bilaterally over the counter and not listed on any exchanges

[4] Gorton and Rouwenhorst (2006) was funded by AIG Financial Products, which used to partially own and manage the DJ-UBS commodity index, formerly known as the DJ-AIG commodity index

investment and hedge against inflation (Greer 2000, Gorton and Rouwenhorst 2004, Erb and Harvey 2006, Chong and Miffre 2008).

After the collapse of the equity market in early-2000s; investors were looking for safe assets as investments. Consequently, investment in commodity derivatives market, through both exchanges and OTC increased rapidly. As trading in the futures market are restricted to members and investing in commodity futures entails timely "rolling" of contracts[5] which requires considerable time and trading expertise, a majority of investors gain exposure to commodities through managed funds that agree to mimic a popular commodity index benchmark such as the Standard & Poor's Goldman Sachs Commodity Investment Index (S&P-GSCI) and Dow Jones–UBS (DJ-UBS) commodity index.[6] The index fund manager then either enters the commodities future market directly or sets up an over-the-counter (OTC) swap contract with a swap dealer. The swap dealer will then enter the futures market and take corresponding long positions to hedge the swap. Investors also enter into OTC agreements with swap dealers directly. Swap dealers are mostly affiliated with banks or other large financial institutions. Market participants use swap agreements instead of exchanges as they offer the ability to customize contracts to match particular hedging needs, which might not be available through standardized futures contracts.[7] Large institutional investors like pension funds and university endowments have been especially active in this kind of passive investment strategies. According to United States Commodity Futures Trading Commission (CFTC), the total value of various commodity-index-related instruments increased from $15 billion in 2003 to $200

[5] Commodity futures unlike stock and bonds have short maturities so they need to be periodically replaced or "rolled" by newer contracts to maintain the investment.
[6] S&P-GSCI holds over 63 percent of the market while DJ holds over 32 percent of the market. More details on S&P-GSCI are provided in Appendix 1.1.
[7] An example of a common OTC swap is an investor and a Wall Street Bank enter into a contract such that the investor agrees to pay 3-month US Treasury-bill rate plus a management fee to a Wall Street Bank, and the Wall Street Bank agrees to pay returns mimicking the S&P-GSCI.

billion in mid-2008. Institutional investors accounted for over 42% of the total notional value (CFTC 2008).

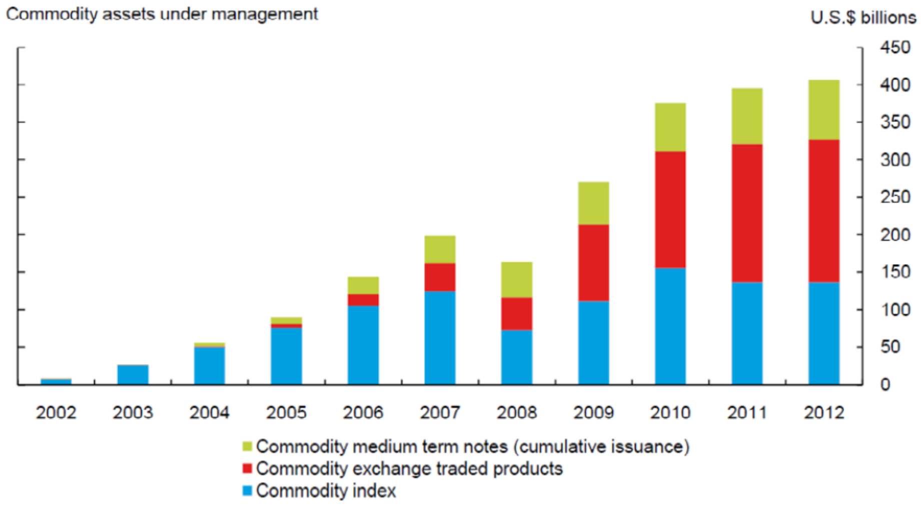
Besides commodity indices, in recent years Exchange Traded Funds (ETFs) and Exchange Traded Notes (ETNs) have gained popularity. Exchange traded funds (ETFs) are like mutual fund shares that trade on a stock exchange and are structured in such a way that the price of the shares reflects the value of the index upon which it is based. The first commodity-based ETF was gold ETF, introduced in 2003. Commodity-based exchange traded notes (ETNs) are debt securities whose price is linked to an underlying index. On the maturity date of the note, the issuer of the note promises to pay the holder of each share of the note the value of a specified commodity index minus a management fee. Investments through ETFs and ETNs are usually more active and short-term. The ETF and ETN managers then hedge their positions directly in the futures market or through OTC swap agreements. I will refer to all investments that buy futures contracts of baskets of commodities as commodity index investment.

How big is commodity-based index investment?

Unfortunately, it is quite difficult to measure the exact amount of funds invested in commodity derivatives via these new financial instruments. The current CFTC data classifies data by entity and not by trading activity. Some entities, for example swap dealers, are used by both commercial traders who seek to hedge price risks and others who are in the market to gain price exposure. This makes it difficult to estimate the exact inflow of “speculative” funds in the market. In addition, swap dealers internally net long and short positions so the positions they take in the commodity exchange may only be a fraction of the total portfolio they are responsible for (discussed in more detail in Chapter 3).

According to the Bank of International Settlements (BIS), the number of outstanding contracts or open interest in US exchange-traded commodity derivatives market increased from around 6 million in 2001 to 37 million in June 2008, and more than 50 million in 2011. Barclays Capital has estimated the size of both US and non-US assets invested in commodity index investment which is presented in Figure 1.2 below. Until 2004, about 50 billion was invested in commodity index products; by 2007 it had reached more than 200 billion, and more than 400 billion in 2012. A majority of commodity index investment until 2008 occurred through commodity index swaps. In recent years exchange traded products such as ETFs and ETNs have gained importance.

Figure 0.2: US and non-US Assets in Commodity Index Products



Source: Lane (2012) based on Barclays Capital

Characteristics of commodity index traders

Besides this quantitative change, the inflow of index traders has changed the futures market qualitatively. Historically two types of traders have existed in the commodities futures market – "bonafide" physical hedgers and "traditional" speculators. Hedgers are producers and consumers of commodities like corn and wheat farmers, cereal and airline companies. They have commercial interest in the underlying commodities and are in the futures market to hedge against spot price risks due to weather variability and other demand-supply shocks. Speculators are traders who do not have any commercial interest in the physical commodities, and they are in the market to profit from changes in the price of futures. Commodity index traders, the new financial actors in the commodities futures market, who have invested huge sums of money into the commodities market, also have no interest in the production, distribution, or consumption of the underlying commodities they are trading. Unlike traditional speculators, index traders' decisions however are not based on individual commodity prices, but instead on prices of a broad range of commodities and other portfolio considerations.

Although they are few commodity index traders (CITs), compared to hedgers (commercial traders) and traditional speculators (non-commercial traders), there still control a large share of the market (Table 1.2). This is because, average position sizes of CITs are much larger compared to other traders (Table 1.3). Table 1.1 below shows the number of reporting traders in each category. In CBOT wheat, there are only 25 CITs compared to 93 non-commercial traders and 65 commercial in the long-side of the market. Similar trends hold in all of the commodities analyzed.

Table 0.1: Number of Reporting Traders in Each Trader Category (2006-09)

		NC			**C**		**CIT**	
	All	Long	Short	Spread	Long	Short	Long	Short
wheat(CBOT)	363	93	121	141	65	96	25	13
Corn	731	185	139	235	257	316	25	13
soybeans	453	136	108	168	109	151	25	11
Sugar	224	67	48	70	69	72	23	11
Coffee	373	132	83	106	98	108	24	5
live cattle	335	80	73	88	82	139	24	5

Compared to commercial traders and non-commercial traders, CITs have very large average positions, and are mostly in the long-side of the market. Table 1.2 shows that CIT average long positions are close to 10 times larger than the average long position of non-commercial traders. Table 1.3 shows that CIT traders control between 24-42 percent of the long side of the market, while their short positions are comparatively negligible. We also observe that commercial traders are mostly in the short side of the market, although they also have substantial long positions, while non-commercial traders have strong presence on both sides of the market.

Table 0.2: Average Position Size of Traders (2006-09)

	NC		C		CIT	
	Long	Short	Long	Short	Long	Short
wheat (CBOT)	535	562	895	2018	7775	1246
Corn	1077	646	1473	2348	15259	1844
soybeans	579	346	1028	1707	5889	848
Sugar	1643	1086	3909	7852	11600	4380
coffee	227	236	393	877	1875	288
live cattle	581	486	434	878	4529	428

NC: non-commercial traders, C: Commercial traders, CIT: Commodity Index Traders

Table 0.3: Percent of Long and Short Positions held by Traders (2006-09)

	NC		C		CIT	
	Long	Short	Long	Short	Long	Short
wheat(CBOT)	38.56	42.90	12.00	40.66	41.82	3.74
Corn	41.85	35.37	23.27	45.45	23.78	1.72
soybeans	42.73	36.55	19.86	44.54	25.77	1.69
Sugar	34.33	28.80	28.45	59.18	27.67	5.04
Coffee	45.48	40.26	22.38	54.32	25.58	0.79
live cattle	39.36	35.77	12.96	43.44	38.62	0.68

NC: non-commercial traders, C: Commercial traders, CIT: Commodity Index Traders

Some argue that since index trader positions are passive, long–only, and their trading decisions are not affected by short-term price changes or motivations, they should not be considered speculators (Stoll and Whaley 2010). It is true that index traders are different than traditional speculators as their trading strategies are transparent and mostly predictable, and they are usually not in the market to benefit from short-term price fluctuations. However, as showed by the sudden drop in index investment after the fall in prices in mid-2008, index trading is not completely insulated from short-term price developments. In addition, second and third generation[8] index trading strategies and ETFs and ETNs are more active and short

[8] Second and third generation commodity indices called “enhanced”, “dynamic”, or “active” indices

term oriented. In any case, index traders are neither hedgers nor speculators in the traditional sense;[9] therefore the classification is not accurate.

This aspect of the financialization of the commodities market has been discussed widely in both academic circles and in popular media. However, there are other aspects of financialization that has not received as much attention. First, the involvement of "bona fide" hedgers in "speculative" activities -- for example big grain trading companies like Cargill, Bunge, Drefyus, and ADM that are involved in the production and distribution of food crops, have in recent years established financial services divisions to manage third-party assets. For example Cargill established Black River Asset Management, a hedge fund (Irwin and Sanders 2010, Murphy et al. 2012). As these traders do not report the details about the individual business segments, it is difficult to determine what part of their activity is "bona fide" hedging and what part is speculation, which further complicates the already difficult process of measuring the amount of funds invested through these new investment vehicles. In addition, other speculative traders with varied strategies have also joined the market to benefit from the upward price trends such as traders who front run commodity indices (Mou 2011).[10]

(such as the S&P GSCI dynamic roll index) change strategies and market exposure based on state of the particular market and seek positive roll returns when the market is in both contango or backwardation. Compared to first generation indices, these trading strategies are not as predictable and transparent.

[9] The economic definition of speculation is buying or storing a commodity not for current consumption but for future use (Kilian and Murphy 2010). In the commodities futures market, the traditional definition of speculation is somewhat different and is based on who is buying the commodity and for what purpose. Traders who have exposure to the physical commodity and seek to hedge their exposure in the futures market is termed (commercial) hedgers. While those who are in the futures market without exposure to the physical commodity are called speculators. A hedger in the commodities futures market might well be a speculator in the economic sense. For example an airline company that buys crude oil futures to hedge against future oil price fluctuations is a hedger by the commodity market's definition, but a speculator by the economic definition. In this prospectus, I will use the traditional commodity market definition of hedgers and speculators as it is the more relevant definition.

[10] The process of financialization has taken over not just the commodities futures market but agriculture production itself. There is growing involvement of financial companies such as asset management companies, private equity firms, and institutional investors like pension funds in agricultural production, processing, and distribution (Murphy et al 2012). Although important, I will

There is no denying that the commodities futures market underwent a structural transformation in the last decade. The market witnessed a vast inflow of money, along with the emergence of new classes of traders, trading strategies, and financial instruments. I will refer to this quantitative and qualitative transformation of the commodities futures market as *financialization,* such that instead of commodity-specific demand and supply being the drivers, financial motive, financial markets, and financial actors take a more prominent role in the operation of the market (UNCTAD 2011).

The term *financialization* has been used in the broader economics literature loosely to describe a range of related developments that show the dominance of finance in the US economy since the 1970s.[11] The rise of finance in the commodities market, vis-à-vis the entry of financial traders, who do not have a stake in the underlying commodities, fits nicely into this broad framework of financialization. In the next section, I will explore relevant theoretical models that may explain how this process of financialization may lead to price bubbles in the commodities market.

1.3 Financialization and price bubbles, the theoretical links

Efficient market hypothesis (EMH), the cornerstone of mainstream theory, argues that asset prices accurately reflect all available information and the market instantaneously responds to any new information reflecting them in the price. EMH is based on the assumption that market participants are rational and use information on the fundamentals of demand and supply to base their actions independently of each other. Under the EMH analysis, the difference in trader motivation and trading strategy does not matter as all traders take positions based on the fundamentals of

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not discuss this aspect of financialization and focus on commodities futures markets in the dissertation.

[11]Krippner (2005), Crotty (2005), and Stockhammer (2004) use financialization of the US economy to refer to the steady rise in financial investment and financial income of non-financial corporations. Orhangazi (2008) provides a good survey of the various usages and definitions of financialization.

each specific commodity and bring the market to the equilibrium price. According to this view, the increasing role of finance in the economy is not a problem and should not affect the efficiency of the market in any way. Friedman (1953) further argues that speculators have a stabilizing effect on prices as they buy when prices are low and sell when prices are high, so they reduce volatility. It is often argued, especially in the case of commodities futures markets, that speculators bring much needed liquidity to balance the hedging needs of market participants, thus helping price discovery and making markets more efficient. There is no question that market liquidity is important to ensure that traders can quickly buy or sell commodity futures, and thus fulfill their hedging needs. However, the question is if there is some level of liquidity beyond which the benefits outweigh the costs, much in the same way that development of financial markets after a certain point may be a drag on economic growth (Cecchetti and Kharroubi 2012).

Many criticisms have been levied against this benign view of financial markets, the most critical attack is perhaps by Keynes (1936). Keynes's most important contribution to understanding financial markets is bringing the presence of uncertainty into the forefront of economic theory. Market participants do not know what the future holds, and they have to make economic decisions based on social and psychological "conventions". Behavioral economists like Shiller (2005) and Shleifer (2000) have also highlighted the role of asymmetric information in their works and the presence of ill-informed noise traders. During times of boom, over-confidence and "irrational exuberance" takes over pushing prices up and up. The conventions or "anchors" on which trading decision are based on are fragile and are subject to unexpected and "violent changes" which leads to fluctuations of the financial markets well beyond what market fundamentals can explain.

A more critical point raised by Keynes is that if markets are frequently moved away from fundamentals, even traders who have some knowledge of demand-supply conditions will find it more profitable (at least in the short run) to follow the trend than take positions based on fundamentals. Keynes argued that similar to a 'beauty-pageant', trades in the financial markets are carried out not based on fundamentals, but trying to "anticipate what average opinion thinks average opinion will be." This is in stark contrast to the mainstream view, where traders who do not follow fundamentals are punished rather than rewarded.

Especially relevant to our analysis is the notion of capital market inflation developed by Toporowski (2002). Toporowski argues that prices in the securities markets are determined by financial inflows, rather than the other way around. "Excess inflow" [12] of funds into the market pushes prices up and leads to capital market inflation. Like Keynes, he also argues that during the process of capital market inflation, "best returns are gained by adding to that inflation, even if prudence dictates that a contrarian tactic, selling while the boom is still active, is necessary to secure those returns" (Toporowski 2002, p. 6) Furthermore, Toporowski emphasizes the rise of pension funds and financial derivatives as the most distinctive feature of this era of finance, and he highlights their role in creating this excess inflow of liquidity that flood the capital market.

There are also commodity-market specific theoretical models that show that relaxing the assumption of perfect information can lead to speculative bubbles. In a commodities market model with heterogeneous information, Stein (1987) shows that the introduction of speculators can lead to destabilization of prices. The model has

[12] Toporowski (2002) divides net inflow into securities market into two parts: the book value of the company and excess inflow. He argues that the excess net inflow is the one that inflates or deflates the actual value of securities.

two types of traders in the commodity futures market: spot and secondary traders. Spot traders can be considered bona-fide hedgers who have a stake in the underlying commodity; whereas secondary traders are speculators who have some knowledge about the fundamentals of the underlying commodity, but their knowledge is not perfect. Stein shows that in such a market, the informed spot traders will not be able to correct the “mistakes” of the ill-informed secondary traders and prices will not reflect supply-demand fundamentals. From Stein’s model, we can observe that if commodity futures markets operate in an environment characterized by uncertainty and presence of noise traders, it won’t be surprising to find that speculative bubbles appear. This will be especially true if a large portion of the market trades based not on fundamental supply-demand of individual commodities, but based on other portfolio considerations.

Similarly, Basak and Pavlova (2012) use a multi-good extension of a standard asset-pricing framework with institutional investors along with traditional futures markets participants. The institutional investor objective function captures the notion that index investors are evaluated based on their performance against the index. Basak and Pavlova find that the presence of institutional investors leads to prices of all commodities go up. The price increase is higher for commodities that belong to the commodity index than for commodities that are not in the index as supply and demand shocks specific to a commodity will spillover other commodities in the index.

One of the biggest critiques of the speculative bubble argument is that since financial markets are only involved in financial transactions in the futures markets (a majority of contracts do not end up in physical delivery), they cannot impact spot prices. Lack of inventory build-up is presented as evidence for the argument that rises in energy and food prices are not due to speculation (Krugman 2008, Irwin and

Sanders 2010). The no-inventory argument makes several assumptions about commodities futures market. First, even if we take the argument at face-value, the global inventory data for commodities, including oil, are known to be very poor, so it is difficult to estimate the real build-up of inventories (IMF 2008). Second, speculation by producers may lead inventories to be left underground, this will not be reflected in the (above ground) inventory data. Third, there is actually some evidence of stockpiling of industrial metals – according to media reports, Goldman Sachs owns a network of aluminum warehouses, and in 2009 Morgan Stanley hired more tankers than Chevron, and JP Morgan hired a supertanker to store heating oil off the coast of Malta.[13]

Furthermore, the relation between inventory and prices is not very stable. Hamilton (2009) shows that speculation could result in a surge in the real price of oil without any additional oil inventory accumulation, if the short-run price elasticity of gasoline demand is zero. Similarly, Kilian and Murphy (2010) show that different oil shocks often offset changes in oil inventories, but reinforce changes in prices in the same direction. This implies that the price-inventory relationship is not a good indicator for speculation (Pirrong 2008).

More importantly, the no-inventory argument makes the assumption that speculators operate in a different market from physical hedgers-- that the bets they make in the futures market have no effect on "real" prices. However, this is not true. Speculators trade in the same futures market as physical hedgers, and therefore bets made by speculators can have an impact on spot prices. This is especially true in

[13] http://www.businessweek.com/magazine/content/10_31/b4189050970461.htm#p4 and http://www.huffingtonpost.com/2011/06/20/goldman-sachs-reportedly-manipulating-commodities_n_880379.html?ncid=edlinkusaolp00000008

recent years, where speculators have in fact outnumbered physical hedgers in the futures markets.

Finally, and most importantly, the no-inventory argument is based on the assumption that futures prices are determined by spot prices – that is futures prices should be equal to current spot price and the cost of storing the commodity until the delivery date. If futures prices are higher than given by this equality, we should see inventory build-up. However, most papers that study the relationship between spot and futures prices show that futures prices are actually more important for price determination. Furthermore, futures prices act as a benchmark not only for *future* spot prices but also *current* spot prices. This implies that besides affecting future spot prices through the inventory link, changes in the futures markets can have a *direct* impact on current spot prices (Silvapulle and Moosa 1999, UNCTAD 2009a). A more detailed exploration of the relationship between spot and futures prices is provided in section 2 of this prospectus.

The argument is not that there are no demand- or supply-side pressures, but that the futures markets have exaggerated these pressures such that prices can no longer be explained by these shocks alone. To be sure, speculative traders operated in the commodities futures market before 2000s, but their numbers were limited. With the influx of this new type of traders whose motivations and strategies are different from that of traditional hedgers and speculators, it will not be surprising to find that the commodities futures market has fundamentally changed. As money flows into the market, as with any other commodity, the rise in demand will bid prices up. Toporowski (2005) calls this rise in prices in the context of capital market *capital market inflation*. For example the mechanical rolling from an expiring futures contract to another by a huge index fund might lead to upward price pressures due to the sheer size of the demand as there may not be enough arbitragers to absorb the impact of these traders.

Moreover, in an environment of uncertainty, other traders might interpret the large inflow of index funds into the long side of the commodity market as a reflection of valuable private information about commodity fundamentals. This is especially true if index traders control a large part of the market.

Similarly, if commodity futures are traded not based on demand-supply of each commodity but traded as a group based on the performance of stocks and bonds then i) prices of a broad range of commodities will move together and ii) commodity and financial markets will become increasingly inter-related, with shocks from financial markets getting transmitted to the commodities market. There is evidence that in recent years correlation between prices of unrelated commodities have increased. Similarly, the correlation between commodity prices and stocks (S&P 500) have also gone up substantially (Tang and Xiong 2010; Buyuksahin, Haigh and Robe 2010; Silvennoinen and Thorp 2010; Hong and Yogo 2009; Buyuksahin and Robe 2011).

1.4 Motivation

My motivation for this research is two-fold. First, as international commodity prices rose, they were quickly transmitted to domestic markets, however when international prices fell in mid-2008, they continued at their higher levels. (Ghosh 2010) This has had serious consequences on food security and development. It reversed measured achievements in poverty reduction and slowed down the global progress in reducing hunger (FAO 2012). This is especially true for Africa, where the number of undernourished actually increased between 2007 and 2008. The 2008 price developments was responsible for increasing the number of malnourished people by

80 million (USDA 2009), and even leading to food riots in many parts of the world.[14] Most of the countries that were affected by the 2008 food crisis were poor, food-importing countries that neither had the budgetary means nor the option to restrict exports and shield their population from high prices. At the household level, the poorest of the population were the major victims, because they spend a higher proportion of their income on food and are unable to smooth consumption (Robles, Torero and Cuesta 2010; FAO 2011).[15]

There are other dimensions of the impact of food prices that are related to existing inequalities of the society. A majority of negatively impacted were women-headed households who had limited access to land and other resources. Impact also depended on access to land; a case in point is the substantially different impact on rural welfare in Vietnam and Bangladesh. Rice is the stable food in both countries which is mainly grown by small farmers. Vietnam has a fairly egalitarian distribution of land, whereas land distribution in Bangladesh is highly unequal and most farmers have only limited access to land. In Vietnam even poor households benefitted from rising prices, whereas in Bangladesh the impact was negative and large, especially for the poorest households (Zezza et al. 2008).

Second, this research is being carried out in an environment where both the United States and the European Union are debating if more stringent rules should be implemented to regulate financial markets. After the 2008 collapse of the housing bubble and the subsequent meltdown of the US and global economy, there is a general acceptance that stricter regulations are needed to rein in Wall Street interests. The US

[14] For example Lagi, Bertrand and Bar-Yam (2011) show that violent protests in North Africa and the Middle East in 2008 and 2011 coincided with large peaks in global food prices.

[15] Some have argued that higher food prices may be beneficial in the long run to households that are net sellers of food. (Rodrik 2007, Headey 2014) Much work needs to be done to understand the impact of higher commodity prices on poverty in the long run, especially if higher prices are transferred to small farmers or are captured by middle men.

Senate Permanent Subcommittee on Investigations has released several reports that examine the role of speculation in the commodities market including oil, wheat, and natural gas. In July 2010, the US passed the Dodd-Frank Wall Street Reform and Consumer Protection Act, the most comprehensive measure since the Glass-Steagall Act implemented in the 1930s. One of the purposes of the Dodd-Frank Act is to regulate the derivatives markets and opaque financial instruments like credit default swaps whose risks were neither understood by the "financial engineers" that developed them nor the regulators. The Act leaves a majority of the implementation details to the regulatory agencies such as the Securities and Exchange Commission (SEC) and the CFTC. The regulatory agencies, including CFTC, have been debating and hammering out the definitions, while also including exemptions that may undermine the Act. From a policy stand point, economic analysis such as this will be important to determine the effects of financialization and the policy initiatives required to ensure markets are transparent and are guided by fundamentals, instead of being taken over by financial motives and interests.

Appendix 1
Appendix 0.1: Standard and Poor- Goldman Sachs Commodity Index

Commodity indices attempt to replicate the returns to holding long positions in agricultural, metal, energy, and/or livestock investment. There are quite a few commodities indices these days that differ in terms of index composition, commodity selection criteria, rolling mechanism, and weighting scheme. The S&P-GSCI and the DJ-UBS Commodity Index are the two most popular commodity indices. The S&PGSCI holds approximately 63 percent market share and the DJ-USB holds 32 percent of the market share.

Goldman Sachs was launched in 1991, although Goldman Sachs has calculated historic index starting from 1970 (based on methodology of 1991). Futures contracts on the Goldman Sachs Futures Price Index (GSFPI) began trading on the CME in July 1992. S&P acquired the index in February 2007.

The S&P-GSCI comprises of important physical commodities that are traded in liquid futures markets. Currently the GSCI include six energy commodities, five industrial metals, eight agricultural commodities, three livestock products, and two precious metals. The weight of each commodity is determined by average world production quantity in the last five years. The S&P GSCI is dominated by the energy sectors accounting for over 75 percent of its weight.

The S&P-GSCI uses nearby futures, and when these contracts are near to expiration they are "rolled over" and replaced by second nearby futures. Because rolling of positions might be difficult to implement in a single day, the rolling takes place over a period of several days. The "Goldman Roll" takes place within five days starting from the 5^{th} business day and ending on the 9^{th} business day. Each day of the roll period, 20 percent of contracts are replaced by second-nearby futures contracts.

Table 1A: S&P GSCI components weights

Trading facility	Commodity	Ticker	2010	2011	Delivery Months used (2007)
Agriculture			17.4		
CBT	Chicago Wheat	W	3.8	3.00	Mar, May, Jul, Sep, Dec
KBT	Kansas City Wheat	KW	0.8	0.69	Mar, May, Jul, Sep, Dec
CBT	Corn	C	4.3	3.37	Mar, May, Jul, Sep, Dec
CBT	Soybeans	S	2.7	2.36	Jan, Mar, May, Jul, Nov
ICE-US	Coffee	KC	1.0	0.76	Mar, May, Jul, Sep, Dec
ICE-US	Sugar #11	SB	2.8	2.25	Mar, May, Jul, Oct
ICE-US	Cocoa	CC	0.3	0.39	Mar, May, Jul, Sep, Dec
ICE-US	Cotton #2	CT	1.8	1.24	Mar, May, Jul, Dec
Livestock			4.3		
CME	Lean Hogs	LH	1.4	1.59	Feb, Mar, Jun, Jul, Aug, Oct, Dec
CME	Live Cattle	LC	2.5	2.59	Feb, Apr, Jun, Aug, Oct, Dec
CME	Feeder Cattle	FC	0.4	0.44	Jan, Mar, Apr, May, Aug, Sep, Oct, Nov
Energy			66.5		
NYM/ICE	Crude Oil	CL	34.6	34.71	All
NYM	Heating Oil	HO	4.5	4.66	All
NYM	RBOB Gasoline	RB	4.3	4.67	All
ICE-UK	Brent Crude Oil	LCO	14.3	15.22	All
ICE-UK	Gasoil	LGO	5.5	6.30	All
NYM/ICE	Natural Gas	NG	3.2	4.20	All
Industrial Metals			8.3		
LME	Aluminum	MAL	2.4	2.70	All
LME	Copper	MCU	4.0	3.66	All
LME	Lead	MPB	0.5	0.51	All
LME	Nickel	MNI	0.8	0.82	All
LME	Zinc	MZN	0.6	0.72	All
Precious Metals			3.4		
CMX	Gold	GC	2.9	2.80	Feb, Apr, Jun, Aug, Dec
CMX	Silver	SI	0.5	0.36	Mar, May, Jul, Sep, Dec

Source: S&P GSCI Index Methodology, Standard and Poor (March 2011)
http://www2.goldmansachs.com/what-we-do/securities/products-and-business-groups/products/gsci/index.html

CHAPTER 2
PRICE DETERMINATION IN THE COMMODITIES MARKETS: RELATIONSHIP BETWEEN SPOT AND FUTURES PRICES

2.1 Introduction

In this chapter, I investigate the relationship between futures and spot markets, in particular their relative importance for price determination. Understanding how prices are formed and what the role of futures market is in the process, is key to understanding how developments in futures markets, including financialization, may affect spot prices. The theoretical literature suggests an inter-temporal relationship between spot and futures prices, but it does not discern their comparative importance for price determination. Low transaction costs and high liquidity levels in the futures market may be the channels through which the dominant causal influence runs from the futures to the spot market in setting commodities prices. Results of previous empirical studies also vary according to the commodities and time period analyzed; although futures markets seem to be important, especially for energy commodities.

An important limitation of the existing literature is that most of the empirical analyses do not take into account the possibility of structural breaks in the data, even though a visual inspection shows potential breaks. This may cause a number of problems -- first conventional unit-root tests lack the power to reject the false null hypothesis of unit-root in the presence of structural breaks. Second, structural break may lead to changes in the cointegration vector and affect the power of the cointegration test.

In this chapter, I seek to understand the long-run relations between commodity spot and futures prices, in particular the nature of lead-lag dynamics between the two markets that may explain the process of price determination. In the empirical analysis, I allow for structural breaks into account that have been mostly ignored in the previous literature. The empirical analysis covers a 20 year period (1991-2012) for a wide range of commodities including agriculture, energy, livestock, and metals that have not been covered in previous studies.

The results show a long-run relation between spot and futures prices for almost all of the commodities, with futures markets leading price determination in most cases. These results suggest that market participants perceive futures prices as containing valuable information regarding supply-demand fundamentals, and look to the futures market to form expectations regarding spot prices. This has two major implications for the discussion of market efficiency and the role of financialization in the 2008 commodity price spike. First, lack of inventory build-up has been used as evidence of no speculation in the commodities market in 2008 (Krugman 2008, Irwin and Sanders 2010). Given the central role of futures prices in forming spot market expectations, my research suggests that lack of inventory build-up is not sufficient to discount financialization as a cause of the 2008 price spike. Second, previous studies have argued that if prices are "discovered" in the futures market, then it is a validation of the efficient market hypothesis (EMH). I argue in this chapter that commodity markets can be (in)efficient no matter where prices are determined, the spot or the futures market. However, given the critical role of futures markets in price determination, my research suggests that if futures market experience speculative bubbles, it will most likely be transmitted to the spot market. These results lend support to the call for strict regulation in the commodity futures markets.

The rest of the chapter is organized as follows: Section 2.2 provides a brief background on financialization, and reviews the theoretical and empirical literature to examine if there are any reasons to believe that either the spot market or the futures market is more important for price determination. Section 2.3 provides an overview of the data and the empirical strategy. In Section 2.4, I summarize the results of the empirical exercise, and conclude in Section 2.5.

2.2 Literature Review

Theoretical Underpinnings

The starting point in thinking about the relationship between spot and futures prices is based on the notion that if both markets reflect underlying demand-supply conditions, then the two prices should move together and converge at the delivery date. A futures contract traded at a given price reflects current expectations of the (spot) price of the commodity at the future delivery date. As new information about the commodity emerges, futures price should adjust to reflect this new information such that when we finally reach the delivery date, we expect the price of the futures contract to be equal to the spot price.

In reality, we do not know what market participants' expected future spot price is, not to mention there is no reason for expectation to be identical across market participants and across time. So what determines the inter-temporal relation between spot and futures prices? There are two main theories that explain the relation between spot and futures prices based on risk premium and storage costs.

Keynes (1930) was one of the first to contribute towards the theoretical literature on the relationship between commodity spot and futures prices. He argued that to protect themselves from price-fluctuations, commodity producers will be willing to pay a risk premium to speculators to take the long-side[16] of the market. During normal conditions (no excess inventory), producers will sell the futures

[16] buy futures contract

contract at a lower price than the *expected* future spot price. "Backwardation" is the term used to describe this relation between futures contracts and future spot prices. Keynes theory of "normal backwardation" only holds if producers are more risk-averse than consumers, or if short hedgers outnumber the long hedgers. In a market, where a majority of hedgers are consumers (for example airlines in the crude oil market or cereal companies in the grains market), the situation may be reversed. Hedgers will be in the long side of the market and they will be willing to pay a risk premium to speculators to take the short side of the market, and the market will be in contango[17] (Cootner 1960).[18]

Working (1948) criticized Keynes's argument that commodities futures market exist for the sole purpose of transferring risk from hedgers to speculators, and put forth the idea that inter-temporal price relationships are determined by the cost of carrying or storing stock of commodities between two time periods. If market participants need a certain commodity in the future, they can either buy the commodity now in the spot market and store it or buy the commodity in the futures market (take a long position) for delivery in time-period t. If they buy the commodity at the spot market, they have to incur storage costs and opportunity costs. Having stocks also provides the ability to use the commodity when needed without any supply disruptions; this benefit is termed *the convenience yield* (Kaldor 1939). The futures price is thus given by:

$$F_0^t = S_0 + I + W - C \qquad 0.1$$

where,

F_0^t = current price of futures contract deliverable at time t,
S_0 = current spot price
W = cost of storing inventory through time 0 to t

[17] futures contract will be sold at a higher prices than the expected future spot price
[18] see Carter 1999, Gray and Rutledge 1971 for a detailed literature review on the theory of normal backwardation

C = convenience yield

The theory of storage indirectly suggests that the relationship between spot and futures prices, which are ultimately based on expectations, work through the inventory channel. If market participants expect (spot) prices in the future to be higher than can be accounted by storage costs, i.e. $S_0^e > S_0 + I + W - C$ then there is an incentive to hold-off the commodity from the market and store it for future sale or consumption. This speculative inventory build-up decreases the amount of commodity available for consumption now and increase the amount of commodity available in the future. The change will be reflected through an increase in the current spot price and decrease in future spot price, until the equation is maintained.

Based on this analysis, lack of inventory build-up is presented as evidence for the argument that the rise in commodity prices in 2008 was not due to speculation (Krugman 2008, Irwin and Sanders 2010). There are two important weaknesses with this argument that are directly related to the relationship between spot and futures prices. First, the supply-demand response to an expected price increase in the future may or may not lead to an increase in inventory. Expectation of higher prices in the future, may lead commodity producers and suppliers to hold-off commodities from the market and save it for future sale, thus leading to an increase in current price and inventory. However, this expectation of future price increases may also lead consumers to demand more of the commodity now to save for future consumption. The producers/suppliers will be willing to sell more commodities at this new higher price, leading to no inventory changes but higher prices due to speculative consumption. In fact, the price-inventory relationship is not a good indicator for speculation (Pirrong 2008). It depends on a range of factors including the elasticity of the demand and supply curves. Hamilton (2009) shows that speculation could result in a surge in the real price of crude oil without any additional oil inventory accumulation, if the short-run price elasticity of gasoline demand is zero. Similarly, Kilian and Murphy (2010) show that different oil shocks often offset changes in oil inventories, but reinforce changes in prices in the same direction.

The second and more crucial part of the contention is that the inventory argument is based on the assumption that futures prices are determined by spot prices – that futures price will be equal to current spot price plus the cost of storing the commodity until the future delivery date. However, futures prices may actually affect spot prices directly through expectations. In a market characterized by uncertainty and asymmetric information, the futures market may be seen as embodying market information which may not be incorporated into spot markets. There are in fact several reasons why information may be expected to first be available in futures markets. First, there are no centralized commodity spot markets around the world where market participants can gauge information regarding supply and demand fundamentals. Also, unlike futures markets, where developments in prices are reported immediately, prices are not transparent in spot markets. Futures markets are also more liquid, do not require delivery of the commodity, and can be implemented immediately with little up-front cash, so they have lower transaction costs and generally react to new information more quickly than spot markets (Silvapulle and Moosa 1999). This lead-lag relationship between spot and futures markets is the basis for the so called "price discovery" function of the futures market. In fact there is a widespread view that futures prices (in particular for crude oil) are better predictors of future spot prices than econometric forecasts. This is the reason why institutions like the United States Department of Agriculture, International Monetary Fund, and European Central Bank use NYMEX oil futures prices as a proxy for market expectation of spot price of crude oil (Alquist, Kilian and Vigfusson 2012). Whether or not futures prices actually contain valuable information about future prices is subject to debate; but the important point is that if they are perceived to contain information, they will affect spot markets directly (Silvapulle and Moosa 1999, UNCTAD 2009).

In this sub-section, I have explored the theoretical relationship between spot and futures prices based on risk premium, storage costs, and convenience yield. However, neither the Theory of Normal Backwardation nor the Theory of Storage provide any theoretical reason to expect any one market to be more important that the other. The theoretical literature review suggests that this is an empirical question. Low transaction costs, high liquidity, transparent prices, and fast implementation may be the channels through which the dominant causal influence runs from the futures to the spot market in setting commodities prices.

Empirical Literature

Many empirical studies have been carried out to understand the role of spot and futures markets in price determination. Unfortunately, there is no clear answer; results vary according to commodities and time period analyzed. For energy commodities, a majority of the studies find that prices are determined in the futures market and transmitted to the spot market. For metals and agricultural commodities, results are mixed. This is not surprising, as commodities are a very heterogeneous group, and there is no reason to expect agriculture, energy, livestock commodities to all behave in a similar fashion. Differences in commodity price behavior may reflect differences in the structure of the market, nature of the commodity (storable non-storable), hedging needs of market participants, and liquidity in the futures market.

Another important point is that many empirical papers that study the relationship between spot and futures prices do so in the context of the EMH. The lead-lag dynamics between futures and spot prices is assumed to indicate where new information regarding commodity fundamentals is first reflected. If prices are "discovered" in the futures market, it is often seen as a validation of the EMH. The argument is that if futures prices contain all relevant information, then futures prices should be an unbiased predictor of future spot price. However, this is true only if we believe that financial markets, commodity futures markets in this case, are efficient and reflect demand-supply fundamentals. In fact the term "price discovery" itself presupposes efficiency; it assumes that there is some equilibrium price given by demand and supply fundamentals that the market will "discover".

But if futures market is under the influence of speculative traders, and spot market participants (under uncertainty) look to the futures prices for market information, then it would be a mistake to view spot prices following futures prices as a fulfillment of the EMH. On the contrary, it only means that spot prices can be influenced by speculative dynamics in the futures market. Commodity markets can be (in)efficient no matter where prices are determined, the spot or the futures market. Spot markets following futures market does not imply markets are efficient, nor does it reflect the existence of speculation.[19]

Garbade and Silber (1983) were one of the first to empirically study the relationship between spot and futures prices. They use a variant of Granger causality test to analyze the lag-lead dynamics between futures and spot prices. For wheat, corn, orange juice, and gold they find that new information is first incorporated in the futures prices then transferred to the spot market. For oats, copper, and silver price determination is split between futures and spot markets. Garbade and Silber's paper

[19] In the full dissertation presentation I will explore if futures prices for various commodities can be explained by speculation.

inspired a wave of research on the relationship between spot and futures prices. A majority of the literature find that futures markets are more influential than spot markets for price determination (Bopp and Sitzer 1987; Schwartz and Szakmary 1994; Crowder and Hamed 1993; Walls 1995; Silvapulle and Moosa 1999; Brorsen, Bailey and Richardson 1984; Oellermann, Brorsen, and Ferris 1989; Schroeder and Goodwin 1991; Crain and Lee 1996). Although there are also some papers like Quan (1992) and Mohan and Love (2004) that show the dominant role of spot market in price determination.

Following the rapid rise in commodity prices in 2008, interest in the price determination mechanism of commodities reemerged. A number of studies have been carried out. Kaufmann and Ullman (2009) study 10 major spot and futures markets for crude oil to investigate where price innovations first appear and how they spread. Their results suggest that some innovations first appear in Dubai-Fateh and spread to other spot and futures markets, while other innovations first appear in West Texas Intermediate (WTI) and spread to other exchange and contracts. Alquist and Kilian (2010) compare if futures prices of crude oil are a good predictor of future spot prices, and conclude that futures prices are not significantly better than other forecasting techniques. Chinn and Coibion (2013) show that for energy markets, futures prices seem to be an unbiased predictor of spot prices while in the case of precious metals, base metals and agriculture commodities results are not as strong. Hernandez and Torero (2010) examine spot and futures prices of four agricultural commodities: hard and soft wheat, corn, and soybeans. Results indicate that for corn and hard wheat, prices are generally determined in the futures markets, while for soybeans and soft wheat the results are not that strong.[20]

[20] A summary of the empirical literature is provided in table format in Appendix 2.1

A major weakness of previous studies is that they do not accommodate for structural breaks in the data, even though visual inspection shows potential breaks. This may cause a number of problems; first conventional unit-root test lack the power to reject the false null hypothesis of unit-root in the presence of structural breaks. Second, structural break may lead to changes in the cointegration vector and affect the power of the cointegration test.[21] I have identified 2 empirical studies that have refined the cointegration methodology, and have sought to include structural breaks in the model. Maslyuk and Smyth (2009) explore cointegrating relationships between futures and spot prices of the same and different grades of crude oil using Gregory-Hansen residual based cointegration allowing for one structural break. Results show that spot and futures prices of different grades of crude oil are cointegrated with a structural break in 2003. An important limitation of this study is that the time period analyzed in Maslyuk and Smyth (2009) excludes the 2008 price bubble, our period of interest. Another limitation is that they only allow for one structural break, when there is no reason to believe only one break exists. Similarly, Baldi, Peri, and Vandone (2011) study the cointegration relationship between spot and futures prices of corn and soybeans. They use Kejriwal and Perron's (2010) method to test for multiple structural breaks in the cointegration vector. For corn they find three breaks (January 2005, December 2006, and October 2008), and for soybeans they find two breaks (February 2007 and August 2008). Baldi, Peri, and Vandone then carry out Toda and Yamamoto (1995) causality tests for each sub-period, and find that the direction of causality between spot and futures prices change with the sub-periods analyzed.

The empirical strategy in this chapter will closely follow Maslyuk and Smyth (2009) and Baldi, Peri and Vandone (2011). I will take up to 2 structural breaks into

[21] See Perron (2005) for more details.

account in the cointegration framework using the adjusted Johansen's cointegration method. I will also extend the analysis to 19 different commodities ranging from agriculture, energy, livestock, and metals, for a 20 year period including the 2008 price spike.

2.3 Data and Empirical Strategy

I use weekly futures and spot prices of 19 commodities from Pinnacle Data[22] and Bloomberg,[23] for a 20 year period (1991-2012). These include 11 agriculture commodities (CBOT[24] corn, wheat, soybeans, soybean oil, soybean meal, oats; KCBOT[25] wheat; ICE[26] cocoa, coffee, cotton, sugar), 2 livestock (CME[27] feeder cattle and lean hogs), 4 energy commodities (NYMEX[28] crude oil, heating oil, gasoline, and natural gas), and 2 metals (LME[29] copper and aluminum). Besides soybean meal, soybean oil, and oats all other commodities are part of the S&P-GSCI.[30] I extract end-of-day futures prices from nearby futures[31] contract and take the weekly mean. For more details on the data and sources refer to Appendix 2.3.

The empirical analysis consists of three major steps. The first step determines the stationarity properties of the individual price series. I carry out both conventional unit root tests and those that take structural breaks into account. After establishing that most of the prices series are integrated of order 1, I carry out cointegration tests that take structural breaks into account, to understand the long-run relations between

[22] https://www.pinnacledata.com/
[23] Data for copper and aluminum are from Bloomberg. All other data are from Pinnacle Data
[24] CBOT: Chicago Board of Trade
[25] KCBOT: Kansas City Board of Trade
[26] ICE: Intercontinental Exchange
[27] CME: Chicago Mercantile Exchange
[28] NYMEX: New York Mercantile Exchange
[29] LME: London Metals Exchange
[30] Other commodities that are part of the S&P-GSCI but not included in this paper are: 3 industrial metals (lead, nickel, zinc), 2 precious metals (gold and silver), and two energy commodities (crude oil-Brent, and gasoil).
[31] Nearby futures contact is the contract with the closest settlement date, and it is by far the most heavily traded contract, so it is considered most important for price determination.

spot and futures prices. Finally, I use vector error correction model (VECM) and Toda-Yamamoto (1995) causality tests to understand the lead-lag dynamics between spot and futures prices. These steps are discussed below in more detail.

Structural breaks have been mostly ignored in the previous literature, although a visual inspection points to possible breaks. In the presence of structural breaks, traditional Dickey-Fuller-type unit-root tests lack the power to reject the (false) null hypothesis of unit-root (Perron 1989). [32] To correct for this problem, I use Clemente-Montanes-Reyes (1998) unit root test, which is an extension of the Perron and Vogelsang (1992) test for 2 unknown structural breaks. The test assumes the following equation for innovative outlier model (IO)[33]:

$$y_t = \mu + \rho y_{t-1} + \delta_1 DTB_{1t} + \delta_2 DTB_{2t} + d_1 DU_{1t} + d_2 DU_{2t} + \Sigma_{i=1}^{k} c_j \Delta y_{t-i} + e_t \qquad 0.\text{Error! Bookmark not defined.}2$$

DTB_{it} is a pulse variable which is equal to 1 if t = $TB_i + 1$ (i=1, 2), 0 otherwise. DU_{it} =1 if t > TB_i (i =1, 2) and 0 otherwise. TB_1 and TB_2 are the break dates. The null hypothesis is that the series has a unit root with structural break(s) against the alternative hypothesis that they are stationary with break(s):

$$H_0: y_t = y_{t-1} + \delta_1 DTB_{1t} + \delta_2 DTB_{2t} + u_t$$

$$H_A: y_t = y_{t-1} + d_1 DU_{1t} + d_2 DTB_{2t} + e_t$$

The test is carried out for each possible break date, choosing the date with strongest evidence against the null hypothesis of unit root, i.e. where the t-stat from the augmented Dickey-Fuller test is at the minimum. If Clemente-Montanes-Reyes unit root test suggests less than two breaks in the series, results from Perron–Vogelsang unit root tests with 1 break are considered. If there is no evidence of structural breaks

[32] See Perron (2005) for an exhaustive literature review on unit root tests and structural breaks.

[33] The test allows for both Additive outlier model: change to the trend function occurs instantaneously; and Innovative outlier model: change to the new trend function is gradual.

in the data, results of traditional Dickey-Fuller tests with the null hypothesis of unit root, are considered. I also carry out the KPSS[34] test with the null hypothesis of stationarity, as a robustness check.

Results of unit-root tests show that almost all the series are I(1), accounting for 2 structural breaks. Faced with non-stationary series, the next step is to test for cointegrating relationships between individual spot and futures prices. However, as the price series consist of structural breaks, we need to take these breaks into account when we carry out test for cointegration, because structural breaks may lead to changes in the cointegration vector and the cointegration test will no longer be appropriate (Perron 2005). Fortunately, Johansen, Mosconi, and Nielsen (2000) have generalized the Johansen (1988) and Johansen and Juselius's (1990) likelihood-based cointegration analysis to account for up to 2 structural breaks, and provided new asymptotic tables.

$$\Delta x_t = \prod \prod_j \begin{pmatrix} x_{t-1} \\ D_{t-k} \end{pmatrix} + \Sigma_{i=1}^{k-1} \prod_i \Delta x_{t-i} + \varepsilon_t \qquad 0.2$$

where,

$D_t = 1, \ldots, D_{q,t}$ where (q-1) are the breaks present

$$D_{j,t} = \begin{cases} 1 & for\ T_{j-1} + 1 \leq t \leq T_j j \\ 0 & otherwise \end{cases}$$

$\prod = \alpha\beta'$ and $\prod_j = \alpha\gamma'$

It can also be written as: $\Delta x_t = \alpha \begin{pmatrix} \beta \\ \gamma \end{pmatrix}' \begin{pmatrix} x_{t-1} \\ D_{t-k} \end{pmatrix} + \Sigma_{i=1}^{k-1} \prod_i \Delta x_{t-i} + \varepsilon_t$

This method uses the fact that if futures prices and spot prices are cointegrated, the rank of matrix $\prod$ will be (n-r) where n is the number of variables and r is the number of cointegrating vectors. (n-r) has be greater than 0 (otherwise there is no cointegrating relation) but less than full rank (implies all vectors are stationary). I use

[34] KPSS: Kwiatkowski–Phillips–Schmidt–Shin

the trace statistic to the null hypothesis that the number of cointegrating vectors is less than or equal to r against a general alternative.

After establishing that a cointegrating vector exists (after accounting for structural breaks), I will estimate the error correction model, along with the cointegrating vector (β) and speed of adjustment parameters (α_s and α_f). The cointegrating vector (β) establishes the long-run relationship between the two variables while α tells us about the direction of causality. For example if $\alpha_s > 0$ and $\alpha_f = 0$ indicates that in the short-run spot prices adjust to maintain the long-run relationship given by the cointegrating vector.[35] This empirical analysis will allow us to examine both the long term relationship between spot and futures prices and the short-run adjustments that take place to maintain this relationship.

Finally, in the last step of the empirical analysis I seek to understand the causality relations between spot and futures prices during the identified time periods. However, Granger causality test based on the Wald principal is not valid for I(1) series due to nonstandard asymptotic properties. To correct for this, I use Toda and Yamamoto (1995) causality tests by adding extra lag (d_{max}), based on the maximum order of integration, to the VAR(k) model then carry out the Wald test which will have an asymptotic chi-square distribution.

$$S_t = \gamma_0 + \Sigma_{i=1}^{k} \gamma_{1i} S_{t-1} + \Sigma_{j=k+1}^{k+dmax} \gamma_{2j} S_{t-j} + \delta_{1j} F_{t-1} + \Sigma_{j=k+1}^{k+dmax} \delta_{2j} F_{t-j}\, \gamma_2 \varepsilon_{1t}$$

$$F_t = \alpha_0 + \Sigma_{i=1}^{k} \alpha_{1i} F_{t-1} + \Sigma_{j=k+1}^{k+dmax} \alpha_{2j} F_{t-j} + \beta_{1j} S_{t-1} + \Sigma_{j=k+1}^{k+dmax} \beta_{2j} S_{t-j}\, \gamma_2 \varepsilon_{2t}$$

The null hypothesis is that futures do not Granger cause spot prices ($\delta_{11} = \delta_{12} = 0$), and spot prices do not Granger cause futures prices ($\beta_{11} = \beta_{22} = 0$). The benefit of this approach is that cointegration between the two price-series is not necessary to

[35] See Joyuex (2007) for more details on the implementation of cointegration tests accounting for structural breaks.

carry out causality tests, which means we can carry out these tests also for commodities that are not cointegrated. While for cointegrated commodities, Toda-Yamamoto test will serve as a robustness check of the VEC methodology, as cointegration implies Granger causality in at least one direction.

2.4 Empirical Results

Key results of the empirical analysis are: i) all commodities are I(1) after accounting for up to two structural breaks; ii) for most commodities the identified breaks correspond to the 2008 rise and fall in prices, thus highlighting the extraordinary scale of the event; iii) spot and futures prices of 16 of the 19 commodities share a long-run cointegrating relationship; and iv) although there are bidirectional information flows, for a majority of commodities, futures prices lead spot prices. This implies that future prices are more influential than spot prices for price determination. These results are discussed in more detail below.

Traditional Dickey-Fuller based tests and Clemente-Montanes-Reyes unit root tests show that spot and futures price series of all 19 commodities are integrated of order 1 or I(1), after accounting for up to 2 structural breaks. Table 2.1 below summarizes the number of identified structural breaks for each commodity. Table 2A and 2B in Appendix 2.4 have the detailed unit-root test results.

Table 0.1: Number of Identified Structural Breaks

No. of breaks	Commodities
2	CBOT wheat, KCBOT wheat, corn, soybeans, soybean oil, coco coffee, sugar, crude oil, heating oil, RBOB gasoline, natural ga aluminum
1	soybean meal, oats, and copper
0	lean hogs, feeder cattle, and cotton

The Clemente-Montanes-Reyes unit root test is carried out with a trim of 0.15, meaning 15% of the data are trimmed on each side. This implies that for most commodities, the test takes into account data between 1993 and mid-2009 and ignores the spike in price in early 2011. Appendix 2.2 plots spot and futures prices of each commodity, along with the identified breaks. The shaded regions in the graphs are the trimmed areas of the test.

The results, overall, are clear. We see that the identified breaks for most commodities correspond to the rise and subsequent fall of prices in 2008. For CBOT and KCBOT wheat the identified break dates are identical, the first one is identified in May 2007 as the price bubble grows, and the second one in early March 2008 as the bubble finally bursts. Corn closely follows trends in wheat, although with a lag. For oats one break is identified in August 2006. Soybeans and soybean oil follow similar trends, and their break dates match exactly. While soybean meal does not follow trends in soybeans/oil, and only one break is identified in July 2007. For the four soft commodities (cotton, sugar, coffee, cocoa) the price rise in 2011 was more important in scale than the one in 2008. However, this part of the data is in the trimmed region, and is not taken into account by the test. For cocoa two breaks are identified in October 2001 and November 2007. Coffee also has two breaks in May 1997 and October 2004. No breaks are identified for cotton, while for sugar two breaks are identified in May 2005 and March 2009. Among energy commodities, crude oil, heating oil and RBOB gasoline witness similar price trends. Crude oil witnessed two significant breaks in December 2004 and September 2008; heating oil followed crude oil with a lag. For RBOB gasoline, due to lack of data, one break is identified as the bubble burst in August 2008 and the second one in 2010 as prices rose again. Finally, trends in natural gas seem to be disconnected from other energy commodities with two breaks identified in November 2003 and June 2008. Livestock (feeder cattle and lean hogs) prices have been quite stable and did not witness the 2008 price bubble, no breaks were identified for these two commodities. The two metals (copper and aluminum) witnessed similar price trends, although only one break is significant for copper (September 2005) while two breaks are significant for aluminum (September 2005 and June 2008).

Table 2.2 summarizes the results of adjusted Johansen's cointegration test. Except for soybean oil, coffee, and aluminum the null hypothesis of cointegration (with rank=1) cannot be rejected for all other commodities. Table 2C in Appendix 2.4 has the detailed results.

Table 0.2: Summary of Adjusted Johansen's Cointegration Test (Trace Test)

	Commodities
Rank = 1	CBOT wheat, KCBOT wheat, corn, oats, soybeans, soybean meal, cocoa, sugar, crude oil, heating oil, RBOB gasoline, natural gas, lean hogs, feeder cattle, and copper
Rank = 0	soybean oil, coffee, and aluminum

VECM for these 16 cointegrated commodities to understand the long run relationship and short run adjustment mechanisms. As expected, the cointegrating vector is close to -1 and significant for all 16 commodities, which implies that spot and futures prices share a long-run relationship. In terms of the adjustment mechanism, for most commodities the speed of adjustment parameter for spot price (α_s) is significant. This implies that if there is a deviation from the long-run relationship, spot prices will adjust to maintain the long-run relationship. In the literature, this has been interpreted as futures prices leading in price determination, with spot prices following. For cocoa and natural gas, price determination occurs simultaneously in both the markets while for CBOT wheat, cotton, and sugar, the spot market is more important for price determination. Table 2D in Appendix 2.4 has the detailed results.

Table 0.3: Summary of VECM Results

Result	**Commodities**
α_s is significant	KCBOT wheat, corn, oats, soybeans, soybean meal, feeder cattle, lean hogs, crude oil, heating oil, RBOB gasoline, and copper

α_f is significant	CBOT wheat, cotton, and sugar
Both α_s and α_f are significant	cocoa and natural gas

Toda-Yamamoto causality tests do not require cointegration between the variables which means we can apply it to soybean oil, coffee, and aluminum, the three commodities that showed no cointegration. For soybean oil, results show there is no causality between spot and futures prices at any of the time periods, there are bidirectional flows for coffee, while for aluminum there are bidirectional flows only in recent years. As expected all commodities that are cointegrated show causality in at least one direction, thus reinforcing our results. For most cases where VECM was able to identify lead-lag relations, Toda-Yamamoto causality test shows that there are bi-directional flows between the two markets. For example for KCBOT wheat, corn, oats, soybeans, soybean meal, feeder cattle, crude oil, heating oil, RBOB gasoline the coefficient of adjustment for spot prices were significant in VECM. However, Toda-Yamamoto test shows bidirectional causality between the prices, although in most cases causality is stronger from futures to spot prices. For CBOT wheat, cotton, sugar VECM showed spot prices lead, again Toda-Yamamoto test suggests bidirectional causality between the two prices. For cocoa, natural gas both VECM and Toda-Yamamoto tests show bidirectional flow of information and imply that both markets are equally important for price determination. Table 2E in Appendix 2.4 has the detailed results.

Although these results may seem contradictory or inconsistent, we have to keep in mind that cointegration is a long-run relationship and causality in the short-run might change. In addition, cointegration and Granger causality are different ways of analyzing the data, and causality has a power problem of not being able to reject the null hypothesis. It is thus reasonable to expect different results from the two tests, with cointegration giving stronger results. (Lütkepohl 2004, p. 150)

2.5 Conclusion

In this chapter, I studied the relationship between spot and futures prices of 19 commodities, consisting of agriculture, energy, livestock, and metals from 1991-2012. The empirical analysis accounted for up to two structural breaks that have been ignored in most of the previous work. The results are clear. For most commodities structural breaks are identified that correspond to the 2008 rise and fall in prices, thus highlighting the extraordinary scale of the event. I also find that besides soybean oil, coffee, and aluminum, spot and futures prices for all other commodities are cointegrated. For KCBOT wheat, corn, oats, soybeans, soybean meal, feeder cattle, lean hogs, crude oil, heating oil, RBOB gasoline, and copper futures markets are more influential than spot markets for price determination. In the case of cocoa and natural gas, price determination occurs simultaneously in both markets. With 3 commodities — CBOT wheat, cotton, and sugar — spot markets are more influential than futures markets. From these results, I conclude that for a majority of commodities, spot and futures prices share a long-run equilibrium. In terms of price determination, although there are bidirectional information flows, futures markets are more influential in most cases.

These results suggest market participants perceive futures prices to contain valuable information regarding supply-demand fundamentals. This "price discovery" contribution implies that if there are speculative dynamics in the futures market, it will most likely be transmitted to the spot market.

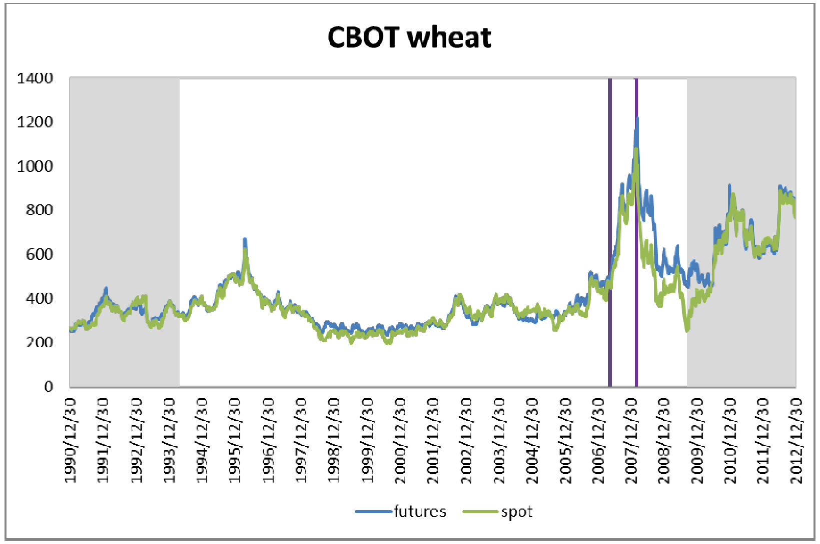
Appendix 2

Appendix 0.1: Empirical Literature Summary

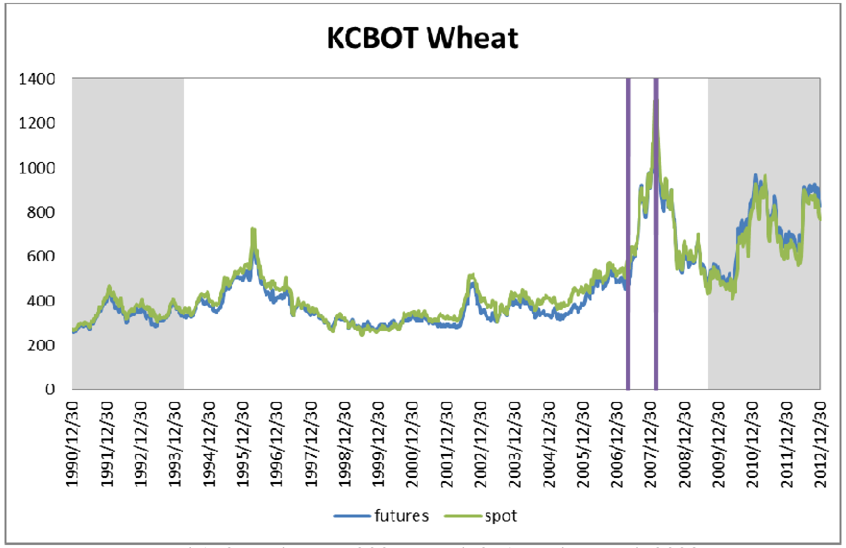
	Authors	Markets	Methodology	Findings
1	Garbade and Silber (1983)	7 commodities	variant of Granger causality	wheat, corn, orange juice, and gold: futures Granger causes spot prices. oat, copper, and silver: bidirectional causality
2	Brorsen, Bailey, and Richardson (1984)	Cotton	Granger causality tests	futures Granger causes spot prices
3	Bopp and Sitzer (1987)	heating oil		futures has predictive information on future spot price
4	Oellermann, Brorsen, and Ferris (1989)	feeder cattle	Granger causality and Garbade and Silber method	futures Granger causes spot prices
5	Schroeder and Goodwin (1991)	live hogs	Garbade and Silber method & Engel and Granger cointegration	no cointegration, futures Granger causes spot prices
6	Quan (1992)	crude oil	Engle-Granger cointegration	cointegrated, spot leads
7	Crowder and Hamed (1993)	crude oil	cointegration	cointegrated, futures leads
8	Schwartz and Szakmary (1994)	crude oil, heating oil, gasoline	Engle-Granger cointegration	cointegrated, futures leads
9	Walls (1995)	natural gas	cointegration	cointegrated, futures leads
10	Crain and Lee (1996)	CBOT wheat	Granger causality	futures Granger causes spot prices
11	Silvapulle and Moosa (1999)	crude oil	cointegration, linear and non-linear causality tests	cointegrated. linear causality: futures Granger causes spot prices. non-linear causality: bidirectional flows
12	Mohan and Love (2004)	Coffee	residual based cointegration	spot prices lead
13	Wu and McCallum (2005)	crude oil	4 prediction models for prices	futures-spot spread model has the best prediction
14	Kaufmann and Ullman (2009)	crude oil	cointegration	Dubai-Fateh (spot) and WTI (futures) are market leaders
15	Maslyuk and Smyth (2009)	crude oil	Gregory-Hansen cointegration	cointegration with one structural break

16	Alquist and Kilian (2010)	crude oil	compare different models of forecasting	futures prices are not significantly better than simple no-change forecasts.
17	Hernandez and Torero (2010)	wheat, corn, soybeans	Granger-causality tests	Futures prices Granger cause spot prices
18	Baldi, Peri and Vandone (2011)	corn & soybeans	cointegration with multiple breaks and Toda- Yamamoto causality tests	cointegration with breaks. causality depends on the sub-period.
19	Chinn and Coibion (2013)	14 commodities	basis as a predictor of spot prices, OLS	futures prices unbiased predictor of spot prices for energy commodities only.

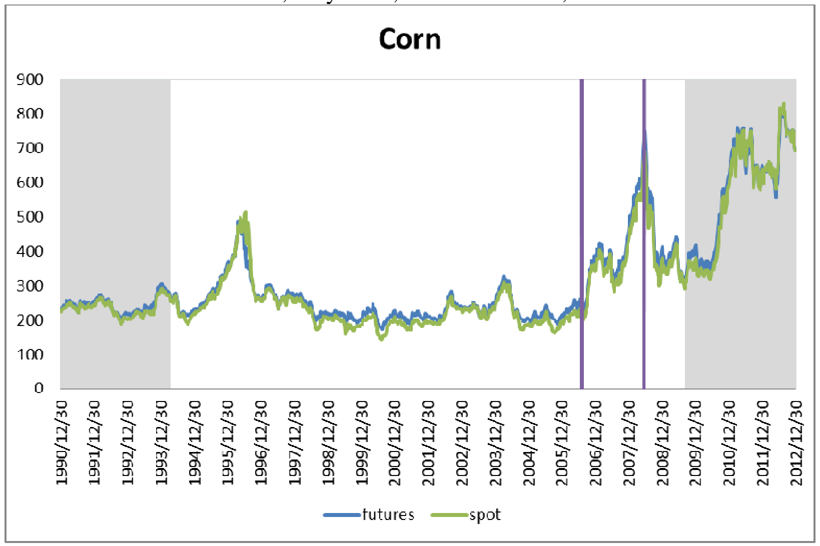
Appendix 0.2: Trends in Commodity Spot and Futures Prices: Grains



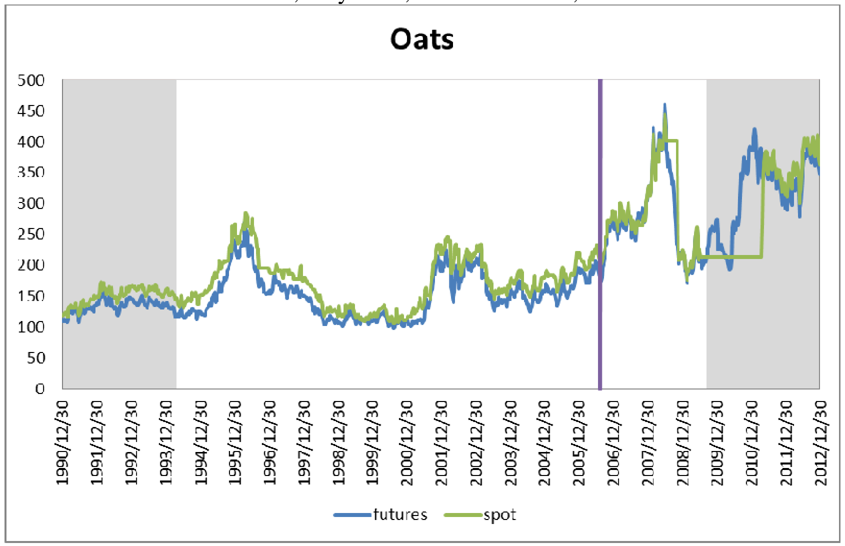
Break1: 2 week, May 2007; Break 2: 1 week, March 2008



Break1: 2 week, May 2007; Break 2: 1 week, March 2008

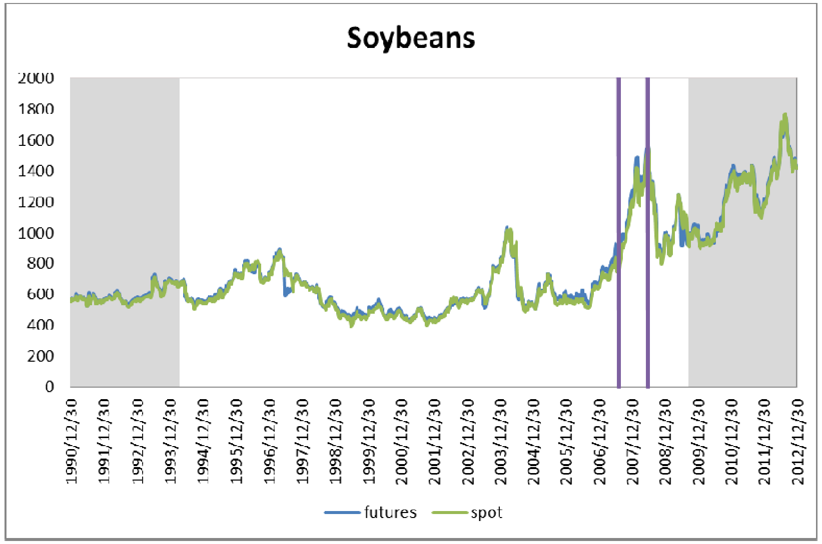


Break 1: 1 week, August 2006; Break 2: 4 week June 2008

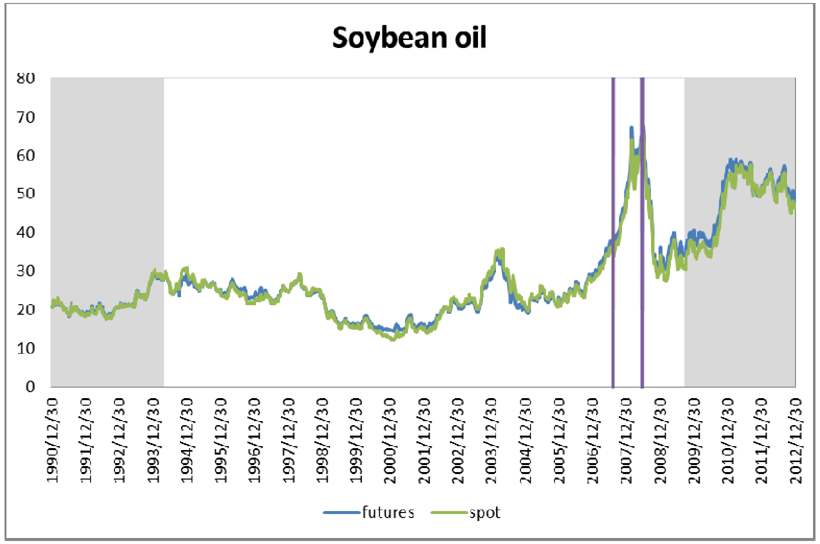


Break 1: 2 week August 2006

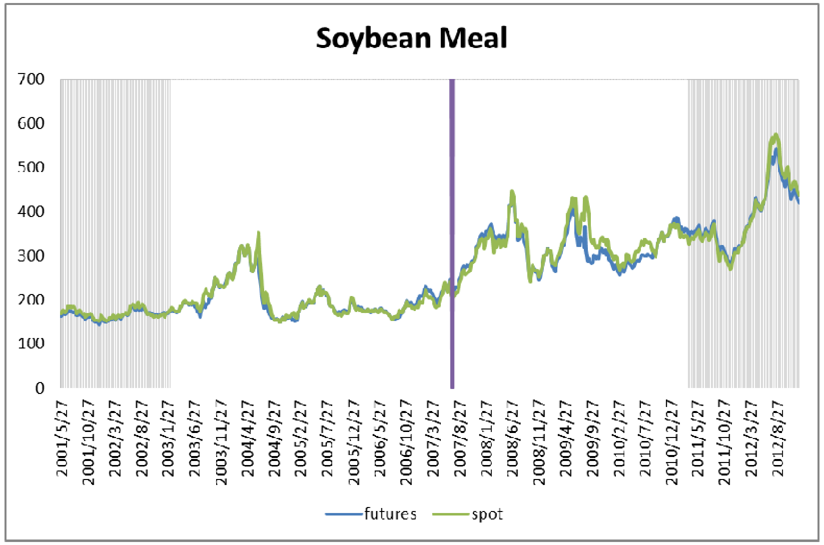
Trends in Commodity Spot and Futures Prices: Soybeans and products



Break 1: 2 week, Aug 2007; Break 2: 3 week, June 2008

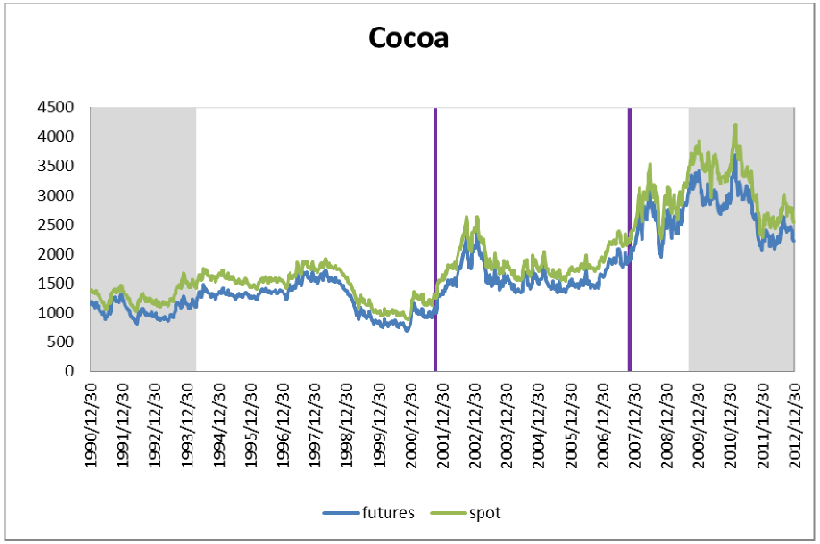


Break 1: 2 week Aug 2007; Break 2: 3 week June 2008

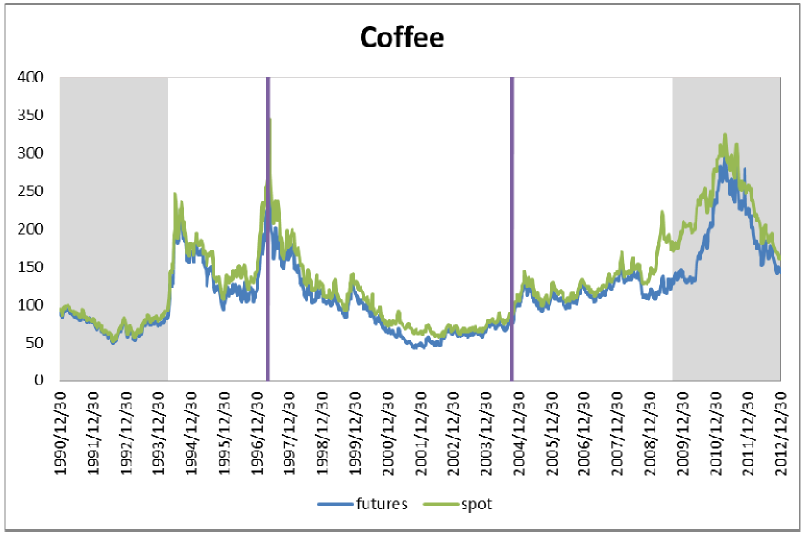


Break1: 3 week, July 2007

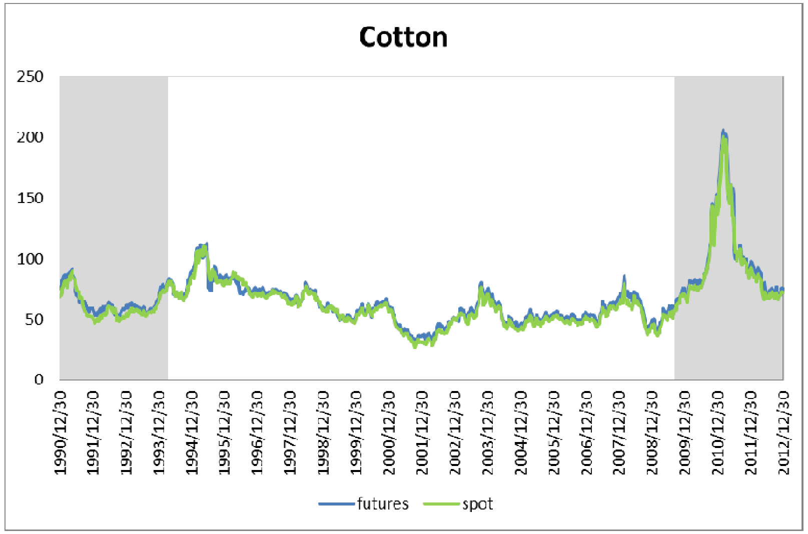
Trends in Commodity Spot and Futures Prices: soft commodities



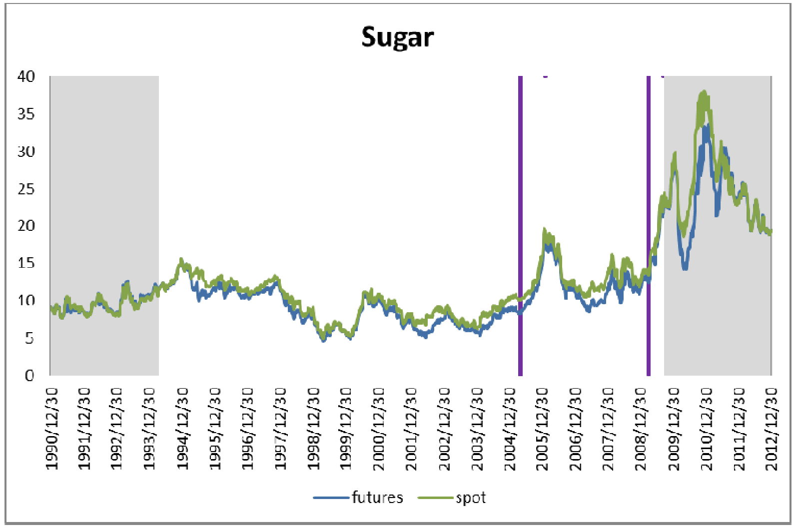
Break 1: 2 week, Oct 2001; Break 2: 1 week, Nov 2007



Break 1: 3 week, May 1997; Break 2: 4 week, October 2004

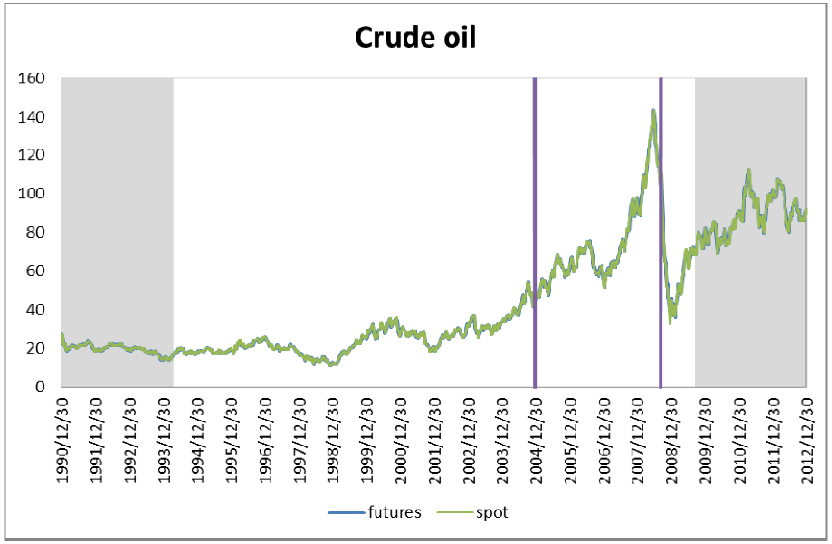


No breaks

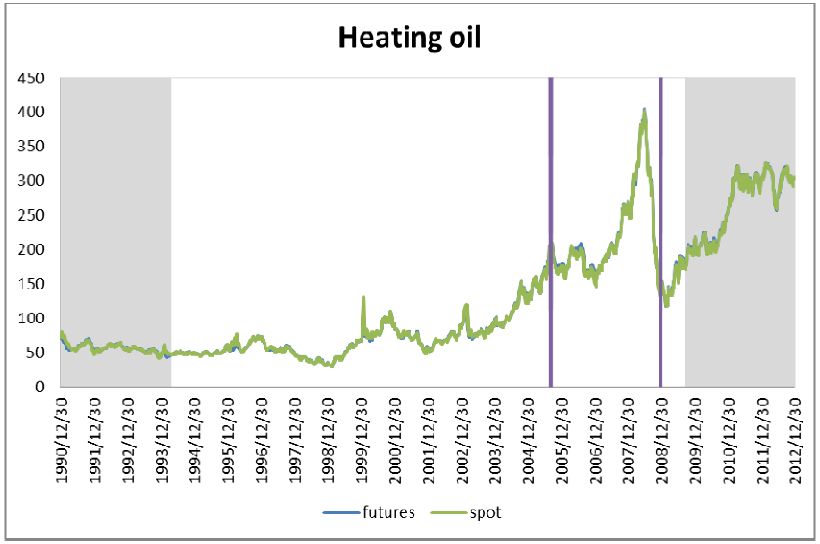


Break 1: 1 week, May 2005; Break 2: 5 week, March 2009

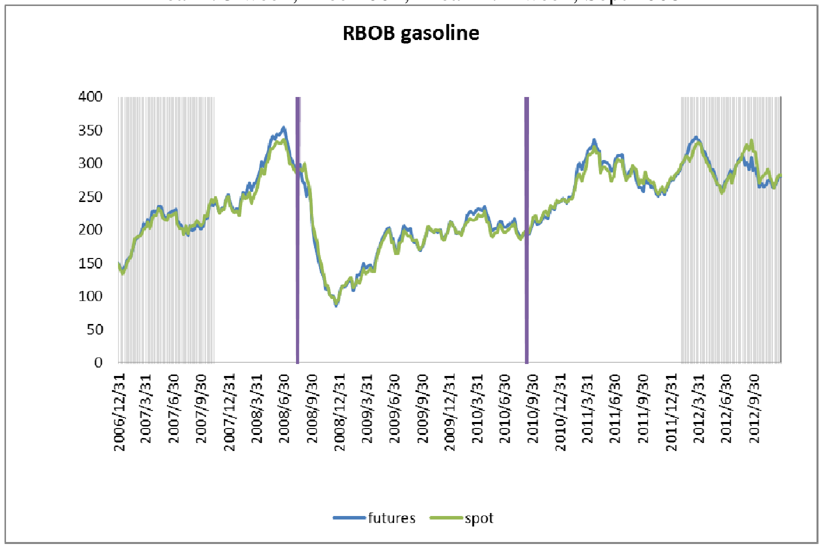
Trends in Commodity Spot and Futures Prices: energy commodities



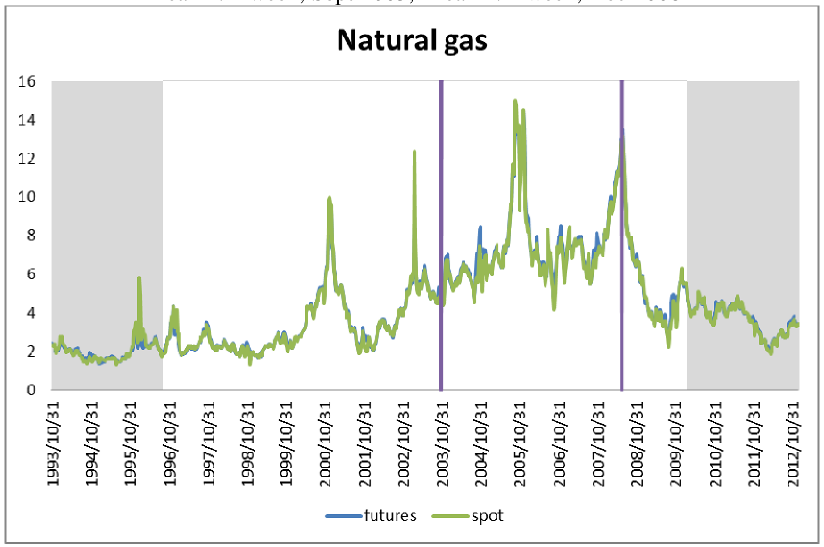
Break1: 5 week, Dec 2004; Break 2: 2 week, Sept 2008



Break 1: 1 week, Sept 2005, Break 2: 4 week, Dec 2008

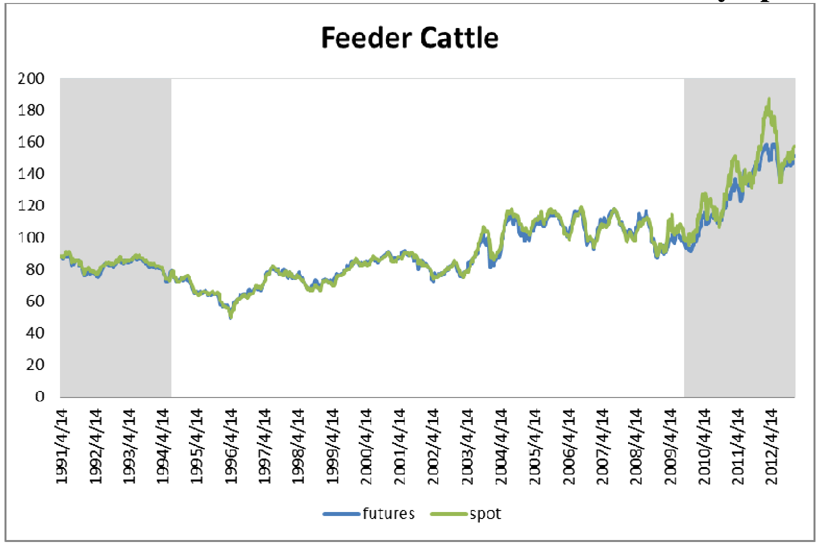


Break 1: 3 week, Aug 2008; Break 2: 2 week, September 2010

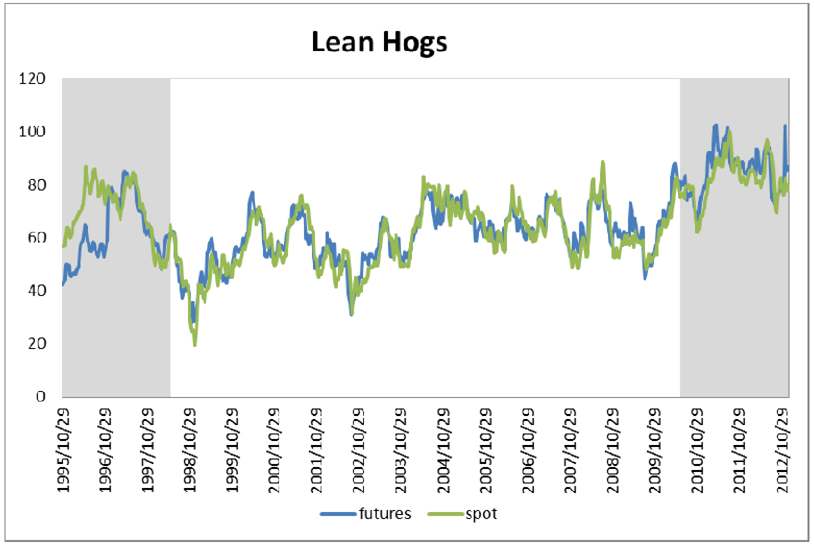


Break 1: 1 week, Nov 2003; Break 2: 3 week, June 2008

Trends in Commodity Spot and Futures Prices: livestock

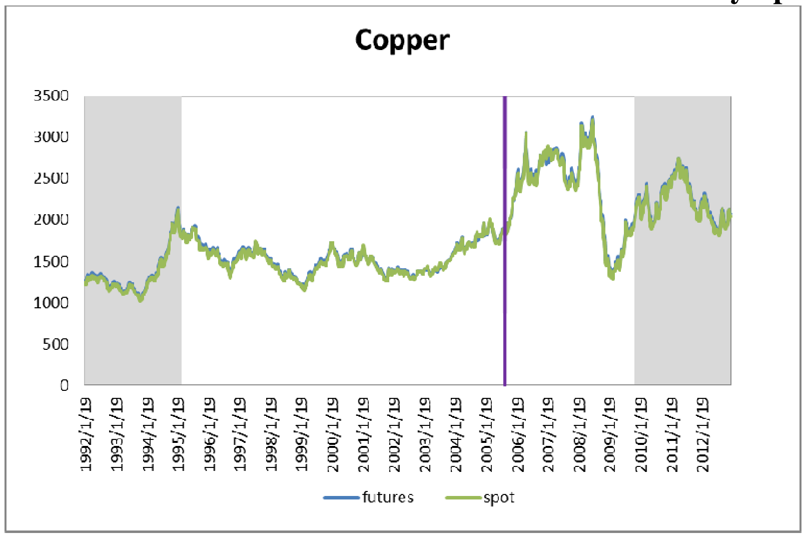


No breaks

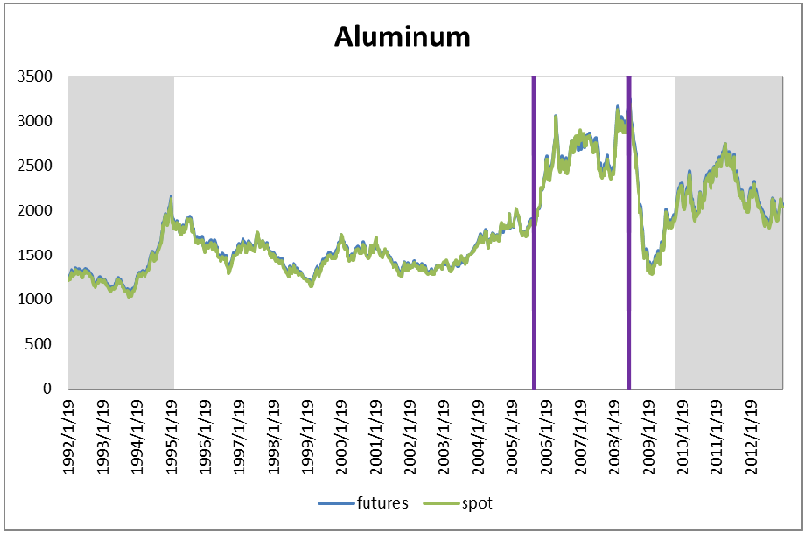


No breaks

Trends in Commodity Spot and Futures Prices: metals



1 break: 1 week, September 2005



1 break: 2 week, September 2005; 2 break: 5 week, June 2008

Appendix 0.3: Data details

	Spot prices	Futures prices		
		Exchange	contract months	contract size
1	Wheat, # 2 Soft red winter, St. Louis, Bushel	CBOT	H, K, N, U, Z	5,000 bushels
2	Wheat, # 2, Hard red winter, Kansas City, Bushel	KCBOT	H, K, N, U, Z	5,000 bushels
3	Corn, # 2 Yellow, Central Illinois, Bushel	CBOT	H, K, N, U, Z	5,000 bushels
4	Oats, # 2 Milling, Mpls, Bushel	CBOT	H, K, N, U, Z	5,000 bushels
5	Soybeans, #1 Yellow, Central Illinois, Bushel	CBOT	F, H, K, N Q, U, Z	5,000 bushels
6	Soybean oil, Crd., Decatur, Illinois, Lb.	CBOT	F, H, K, N Q, U, V, Z	60,000 pounds
7	Soybean meal, Central Illinois, 48% Protein, Ton	CBOT	F, H, K, N Q, U, V, Z	100 short tons
8	Cocoa, Ivory Coast, $/Metric Ton	ICE	H, K, N, U, Z	10 metric tons
9	Coffee, Colombian, New York, Lb.	ICE	H, K, N, U, Z	37,500 pounds
10	Cotton, 1 1/16 Str. Lw. Medium, Memphis, Lb.	ICE	H, K, N, V, Z	50,000 pounds
11	Sugar, raw cane sugar 11, New York, Lb.	ICE	H, K, N, V	112,000 pounds
12	Crude oil, West Texas Intermediate, Texas-Okl., Ch Avt Crush	NYMEX	all months	1,000 barrels
13	Heating oil, fuel oil # 2, New York, Gal.	NYMEX	all months	42,000 gallons
14	Unleaded Regular, New York, Gal. RBOB gasoline	NYMEX	all months	42,000 gallons
15	Natural gas, Henry Hub, $ Per Mmbtu.	NYMEX	all months	10,000 million British thermal units
16	Feeder cattle index, 650-849 pound steers, medium-large #1 and #1-2	CME	F, H, J, K, Q, U, V, Z	50,000 pounds
17	Lean hog index, (barrow and gilt) carcasses	CME	G, J, K, M, N, Q, V, Z	40,000 pounds
18	Copper, Grade A	LME	All months	25 tonnes
19	Aluminum, high grade primary	LME	All months	25 tonnes

January (F), February (G), March (H), April (J), May (K), June (M), July (N), August (Q), September (U), October (V), November (X), December (Z)

Appendix 0.4: Results

Table 2A: Clemente-Montanes-Reyes unit-root test with double mean shifts, IO model

		Break 1	Break1 coeff.	Break1 test	Break 2	Break 2 coeff.	Break 2 test	Unit-root test	Optimal lag	Result
CBOT wheat	Futures	2w May 07	29.8060	7.2673**	1w March 08	-19.6084	-5.4569**	-5.5693**	22	UR, 2 breaks
	Spot	2w May 07	20.8983	5.6969**	1w March 08	-14.8126	-4.3185**	-4.8302	20	
KCBOT wheat	Futures	2w May 07	26.7435	7.1138**	1w March 08	-18.4872	-5.5007**	-4.9687	18	UR, 2 breaks
	Spot	2w July 07	29.8195	6.7388**	1w March 08	-23.1144	-5.7403**	-5.1231	20	
corn	Futures	3w Nov 07	12.6863	4.7042**	3w June 08	-9.14959	-3.4756**	-2.6331	22	UR, 2 breaks
	Spot	1w Aug 96	-1.5351	-1.6034	1w Aug 06	5.31664	-3.9246**	-3.5700	22	
oats	Futures	2w Aug 06	5.7788	4.8553**	4w June 08	-1.7811	-1.6860	-4.8171	17	UR, 1 break
	Spot	2w Aug 06	4.4745	3.7945**	4w Oct. 08	-2.3153	-2.1908*	-3.9556	13	
soybeans	Futures	2w Aug 07	24.4716	4.9843**	4w June 08	-12.8701	-3.0411**	-3.8213	13	UR, 2 breaks
	Spot	2w Aug 07	23.5445	5.1001**	4w June 08	-10.7801	-2.5126*	-4.1289	19	
soybean oil	Futures	2w Aug 07	1.0182	5.3840**	4w June 08	-0.5608	-3.4542**	-4.4244	22	UR, 2 breaks
	Spot	2w Aug 07	0.9217	5.0649**	4w June 08	-0.5611	-3.4284**	-4.1999	22	
soybean meal	Futures	2w June 04	-1.0486	-0.9125	4w July 07	5.7154	3.5426**	-3.7306	7	UR, 1 break
	Spot	4w June 04	-1.4962	-1.1744	2w Aug 07	7.7990	4.2446**	-4.4143	14	
cocoa	Futures	2w Oct 01	15.4053	2.9180**	1w Nov 07	31.4436	3.3500**	-4.2169	22	UR, 2 breaks
	Spot	2w Oct 01	16.2332	2.8059**	1w Nov 07	32.9860	3.1953**	-4.0687	21	
coffee	Futures	2w May 97	-1.3578	-2.7019**	3w Oct 04	1.5973	3.0905**	-3.6698	20	UR, 2 breaks
	Spot	4w Jan 97	9.3813	5.5401**	3w May 97	-9.6508	-5.7736**	-2.7958	21	
cotton	Futures	2w Nov 94	1.3433	2.1900*	3w June 95	-1.2682	-2.1952*	-3.6522	20	UR, no breaks
	Spot	2w May 95	-0.0097	-0.0348	3w June 98	-0.0677	-0.2885	-3.2853	20	
sugar	Futures	1w May 05	0.12345	2.6550**	1w June 09	0.3918	4.2130**	-5.2380	21	UR, 2 breaks
	Spot	2w May 05	0.11185	2.4420**	4w March 09	0.3332	4.0950**	-5.2030	21	
feeder cattle	Futures	2w Apr. 96	0.1996	1.4790	1way 99	0.3130	1.1913	-1.9700	21	UR, no breaks
	Spot	1w May 99	0.1759	1.0140	3w June 99	0.3662	1.7360	-2.0460	21	
lean hogs	Futures	4wNov 98	-0.0938	-0.3460	4 Jan 04	0.5948	2.4040	-3.9980	19	UR, no

	Spot	4w Dec 98	0.0014	0.0060	3w Dec 03	0.3078	1.6310	-3.3660	5	breaks
crude oil	Futures	4w Dec 04	1.3267	4.5960**	2w Sept 08	0.1384	0.6660**	-4.9390	20	UR, 2 breaks
	Spot	4w Dec 04	1.4030	4.8550**	2w Sept 08	0.1634	0.7810**	-5.3730	17	
heating oil	Futures	1w Sep 05	152.2434	42.8700**	4w Dec 08	24.6236	5.6777**	-4.2227	18	UR, 2 breaks
	Spot	1w Sep 05	150.0928	41.8790**	4w Dec 08	25.2809	5.7761**	-4.2256	18	
RBOB gasoline	Futures	3w Aug 08	-4.9628	-3.2660**	2w Sept 10	6.8165	4.1010**	-4.9240	6	UR, 2 breaks
	Spot	5w Aug 08	-5.3693	-3.4120**	3w Nov 11	8.0321	4.4610**	-5.1860	8	
natural gas	Futures	5w Aug 04	0.19756	4.8313**	4w June 08	-0.1929	-4.9470**	-5.4360	14	UR, 2 breaks
	Spot	1w Nov 03	0.24439	4.5369**	4w June 08	-0.2307	-4.5334**	-5.2226	11	
copper	Futures	1w Sept 05	100.3344	4.4165**	2w Aug 2008	-1.0680	-0.0726	-4.5492	20	UR, 1 break
	Spot	1w Sept 05	101.0795	4.3510**	2w Aug 2008	-2.3450	-0.1568	-4.5127	20	
aluminum	Futures	2w Sep 05	39.1734	5.6591**	5w June 2008	-22.0909	-4.3465**	-5.9127	21	UR, 2 breaks
	Spot	2w Sep 05	39.3377	5.5544**	5w June 2008	-22.4668	-4.2833**	-5.8427	21	

** 1% significance level, * 5% significance level. Critical value: -5.49, max-lag given by Ng-Perron, trim: 0.15, UR: unit root, #w: week

Table 2B: DFGLS, Dickey-Fuller and KPSS unit root tests

		Lags	DFGLS test	Dfuller w/ constant	Dfuller w/o constant	Dfuller w/ trend	KPSS	Result
CBOT wheat	Future (L)	22	-2.7599	-1.8610 (0.3506)	-0.0928	-2.764 (0.2103)	0.6410**	I(1)
	Futures (diff)	21	-5.4968**	-6.609 (0.0000)**	-6.5826**	-6.6202 (0.0000)**	0.0310	
	Spot (L)	20	-2.7679	-1.8874 (0.3380)	-0.0781	-2.7743 (0.2065)	0.5920**	
	Spot (diff)	22	-4.9244**	-6.242 (0.0000)**	-6.2203**	-6.2619 (0.0000)**	0.0286	
KCBOT wheat	Future (L)	20	-2.8159	-1.7752 (0.3928)	-0.0191	-2.822 (0.1887)	0.6120**	I(1)
	Futures (diff)	17	-7.5624**	-7.739 (0.0000)**	-7.7103**	-7.7503 (0.0000)**	0.0288	
	Spot (L)	22	-3.2919	-2.3470 (0.1572)	-0.2907	-3.2878 (0.0683)	0.4910**	
	Spot (diff)	22	-6.8392**	-7.0769 (0.0000)**	-7.0583**	-7.0776 (0.0000)**	0.0283	
corn	Future (L)	22	-1.9971	-1.01164 (0.7490)	0.3710	-2.1333 (0.5274)	0.7930**	I(1)
	Futures (diff)	21	-7.2634**	-7.21746(0.0000)**	-7.1696**	-7.2837 (0.0000)**	0.0276	
	Spot (L)	22	-1.8891	-0.96307 (0.7665)	0.3657	-1.9854 (0.6094)	0.7800**	
	Spot (diff)	21	-6.7657	-7.2888 (0.0000)**	-7.2414**	-7.3618 (0.0000)**	0.0298	
oats	Future (L)	18	-3.5587**	-2.1503 (0.2248)	-0.3063	-3.6869 (0.0232)*	0.6840**	I(1)
	Futures (diff)	17	-5.5204**	-6.4419 (0.0000)**	-6.4220**	-6.4515 (0.0000)**	0.0233	
	Spot (L)	18	-3.5587**	-2.1503 (0.2248)	-0.3063	-3.6869 (0.0232)*	0.4330**	
	Spot (diff)	17	-5.5204**	-6.4419 (0.0000)**	-6.4220**	-6.4515 (0.0000)**	0.0282	
soybeans	Future (L)	13	-2.04945	-1.08381 (0.72148)	0.36442	-2.30758 (0.4297)	0.8860**	I(1)
	Futures (diff)	12	-9.60110**	-9.79421 (0.0000)**	-9.76316**	-9.83175 (0.0000)**	0.0234	
	Spot (L)	20	-2.50274	-1.54535 (0.51097)	0.10228	-2.75291(0.2148)	0.8730**	
	Spot (diff)	18	-7.24630**	-7.22829 (0.0000)**	-7.19298**	-7.26121 (0.0000)**	0.0238	
soybean oil	Future (L)	22	-2.5353	-1.7111 (0.4254)	-0.0831	-2.7680 (0.2089)	0.7980**	I(1)
	Futures (diff)	21	-6.3130**	-6.4962 (0.0000)**	-6.4695**	-6.5032 (0.0000)**	0.0283	
	Spot (L)	22	-2.6766	-1.9001 (0.3320)	-0.1937	-2.8937 (0.1643)	0.7370**	
	Spot (diff)	21	-6.2497**	-6.3807 (0.0000)**	-6.3592**	-6.3834 (0.0000)**	0.0283	
soybean meal	Future (L)	18	-3.1502	-1.4416 (0.5622)	0.3799	-3.3747 (0.0549)	0.1810	I(1)
	Futures (diff)	17	-4.6821**	-5.757 (0.0000)**	-5.6953**	-5.7521 (0.0000)**	0.0242	
	Spot (L)	14	-3.2704	-1.6435 (0.4604)	0.1763	-3.5310 (0.0362)*	0.1940	
	Spot (diff)	13	-5.3034**	-6.156 (0.0000)**	-6.1148**	-6.1568 (0.0000)**	0.0242	

cocoa	Future (L)	22	-2.0440	-1.3710 (0.5959)	0.1470	-2.2700 (0.4507)	0.556**	I(1)
	Futures (diff)	22	-7.2260**	-8.473 (0.0000)**	-26.6270**	-8.4640 (0.0000)**	0.0492	
	Spot (L)	21	-2.013	-1.3230 (0.6185)	0.2150	-2.092 (0.5508)	0.5800**	
	Spot (diff)	20	-6.314**	-8.017 (0.0000)**	-7.9820**	-8.007 (0.0000)**	0.0554	
coffee	Future (L)	21	-2.4562	-2.2706 (0.1816)	-0.6480	-2.4592 (0.3486)	0.5730**	I(1)
	Futures (diff)	20	-6.9573**	-7.4729 (0.0000)**	-7.4719**	-7.4676 (0.0000)**	0.0423	
	Spot (L)	21	-2.1698	-1.9762 (0.2971)	-0.5045	-2.1671 (0.5084)	0.6270**	
	Spot (diff)	20	-7.3577**	-7.7997 (0.0000)**	-7.7965**	-7.7955 (0.0000)**	0.0514	
cotton	Future (L)	20	-3.1178	-3.3251 (0.0138)	-1.1331	-3.4483 (0.0453)*	0.4920**	I(1)
	Futures (diff)	22	-6.3526	-6.6164 (0.0000)**	-6.6191**	-6.6204 (0.0000)**	0.0259	
	Spot (L)	20	-3.1176	-3.2144 (0.0192)	-1.1509	-3.3090 (0.0648)	0.4780**	
	Spot (diff)	19	-6.9469	-7.1426 (0.0000)**	-7.1449**	-7.1503 (0.0000)**	0.0282	
sugar	Future (L)	21	-2.26383	-1.7864 (0.3872)	-0.29558	-2.40604 (0.3764)	0.8700**	I(1)
	Futures (diff)	21	-7.87113**	-8.0003 (0.0000)**	-7.98670**	-8.00632 (0.00000)**	0.0298	
	Spot (L)	21	-2.45856	-1.9452 (0.3111)	-0.42019	-2.56025 (0.2985)	0.8050**	
	Spot (diff)	20	-6.36272**	-6.7768 (0.0000)**	-6.76377**	-6.77380 (0.0000)**	0.0416	
feeder cattle	Future (L)	21	-1.0504	0.0847 (0.9650)	1.1703	-2.0416 (0.5786)	0.5250**	I(1)
	Futures (diff)	20	-7.5558**	-8.6183 (0.0000)**	-8.5361**	-8.7612 (0.0000)**	0.0283	
	Spot (L)	21	-1.1418	-0.0869 (0.9507)	1.0494	-2.1738 (0.5046)	0.5760**	
	Spot (diff)	20	-8.0903**	-9.7566 (0.0000)**	-9.6938**	-9.8678 (0.0000)**	0.0190	
lean hogs	Future (L)	19	-3.5891**	-2.9404 (0.0409)*	-0.0604	-3.8677 (0.0134)*	0.2360**	I(1)
	Futures (diff)	18	-5.8587**	-7.1893 (0.0000)**	-7.1761**	-7.1840 (0.0000)**	0.0229	
	Spot (L)	6	-3.3629*	-2.9755 (0.0372)*	-0.4390	-3.3476 (0.0588)	0.2990**	
	Spot (diff)	5	-12.1502**	-12.6302 (0.0000)**	-12.6365**	-12.6259 (0.0000)**	0.0205	
crude oil	Future (L)	20	-2.5869	-1.3808 (0.5914)	-0.1776	-3.8119 (0.0160)*	0.6610**	I(1)
	Futures (diff)	17	-4.3448**	-6.9221 (0.0000)**	-6.8941**	-6.9343 (0.0000)**	0.0194	
	Spot (L)	17	-2.7428	-1.5119 (0.5276)	-0.2903	-3.9722 (0.0096)**	0.6590**	
	Spot (diff)	22	-4.4260**	-7.5368 (0.0000)**	-7.4956**	-7.5507 (0.0000)**	0.0192	
heating	Future (L)	21	-2.1897	-0.9795 (0.7607)	0.1602	-3.2387 (0.0770)	0.7400**	I(1)

oil	Futures (diff)	17	-3.9171**	-6.9114 (0.0000)**	-6.8619**	-6.9411 (0.0000)**	0.0177	
	Spot (L)	18	-2.3828	-1.1839 (0.6805)	-0.0051	-3.4386 (0.0464)*	0.7290**	
	Spot (diff)	17	-4.3489**	-6.9420 (0.0000)**	-6.8928**	-6.9688 (0.0000)**	0.0175	
RBOB gasoline	Future (L)	6	-2.6935	-2.6127 (0.0904)	-0.1904	-2.8806 (0.1689)	0.3540**	I(1)
	Futures (diff)	5	-4.8416**	-5.4165 (0.0000)**	-5.4078**	-5.4069 (0.0000)**	0.0627	
	Spot (L)	8	-2.8810*	-2.5309 (0.1081)	-0.3303	-3.0024 (0.1314)	0.3190**	
	Spot (diff)	7	-3.8639**	-4.8172 (0.0001)**	-4.8233**	-4.7985 (0.0005)**	0.0567	
natural gas	Future (L)	21	-2.5990	-2.4389 (0.1310)	-1.0281	-2.5476 (0.3046)	0.5650**	I(1)
	Futures (diff)	13	-7.2719**	-8.3256 (0.0000)**	-8.3294**	-8.3336 (0.0000)**	0.0297	
	Spot (L)	11	-2.9011	-2.6940 (0.0751)	-1.2260	-2.892 (0.1647)	0.5430**	
	Spot (diff)	21	-7.3581**	-7.4985 (0.0000)**	-7.5015**	-7.5125 (0.0000)**	0.0261	
copper	Future (L)	20	-1.9112	-1.1083	0.0213	-2.5548	0.9210**	I(1)
	Futures (diff)	19	-6.6065**	-6.9314 (0.0000)**	-6.8907**	-6.9552 (0.0000)**	0.0333	
	Spot (L)	20	-1.9353	-1.1435	-0.0027	-2.5670	0.9090**	
	Spot (diff)	19	-6.3521**	-7.0274 (0.0000)**	-6.9882**	-7.0479(0.0000)**	0.0328	
aluminum	Future (L)	21	-3.3340	-2.4703	-0.2800	-3.3307	0.2610**	I(1)
	Futures (diff)	20	-4.4470**	-6.3974(0.0000)**	-6.3904**	-6.3971(0.0000)**	0.0345	
	Spot (L)	21	-3.3654	-2.4959	-0.2958	-3.3607	0.2510**	
	Spot (diff)	20	-4.5813**	-6.4260(0.0000)**	-6.4194**	-6.4261(0.0000)**	0.0337	

** 1% significance level, * 5% significance level.

Table 2C: Johansen's Cointegration test (trace test)

	Rank	Johansen's test	result	Adj. Johansen's test	result
CBOT wheat	r = 0	22.94 (0.0191)*	cointegration	50.34 (0.0000)**	cointegration
	r = 1	3.95 (0.4309)		14.79 (0.0429)	
KCBOT wheat	r = 0	13.44 (0.3371)	no cointegration	48.66 (0.0000)**	cointegration
	r = 1	1.68 (0.8318)		16.36 (0.0241)	
corn	r = 0	26.31 (0.0054)**	cointegration	58.52 (0.0000)**	cointegration
	r = 1	2.18 (0.7413)		11.83 (0.1367)	
oats	r = 0	28.66 (0.0021)**	cointegration	45.14 (0.0000)**	cointegration
	r = 1	3.71 (0.4689)		14.06 (0.0282)	
soybeans	r = 0	65.78 (0.0000)**	cointegration	80.73 (0.0000)**	cointegration
	r = 1	10.71(0.0240)		14.43 (0.0487)	
soybean oil	r = 0	23.94 (0.0132)	no cointegration	33.74 (0.0103)	no cointegration
	r = 1	4.11 (0.4081)		12.23 (0.1033)	
soybean meal	r = 0	26.27 (0.0055)**	cointegration	35.65 (0.0001)**	cointegration
	r = 1	2.89 (0.6099)		15.50 (0.0166)	
cocoa	r = 0	22.28 (0.0242)**	cointegration	36.88 (0.0081)**	cointegration
	r = 1	2.39 (0.7022)		13.99 (0.1041)	
coffee	r = 0	24.74 (0.0098)**	no cointegration	30.31 (0.0635)	no cointegration
	r = 1	5.59 (0.2327)		8.56 (0.4966)	
cotton	r = 0	48.76 (0.0000)**	cointegration	No breaks	
	r = 1	10.33 (0.0287)*			
sugar	r = 0	20.45 (0.0454)*	no cointegration	41.06 (0.0017)**	cointegration
	r = 1	4.31(0.3795)		17.48 (0.0236)	
feeder cattle	r = 0	44.14 (0.0000)**	cointegration	No breaks	
	r = 1	1.29 (0.8957)			
lean hogs	r = 0	33.64 (0.0003)**	cointegration		
	r = 1	7.79 (0.0922)			
crude oil	r = 0	57.75 (0.0000)**	cointegration	95.32 (0.0000)**	cointegration
	r = 1	2.34 (0.7117)		18.66 (0.0159)	
heating oil	r = 0	51.95 (0.0000)**	cointegration	67.75(0.0000)**	cointegration
	r = 1	1.98 (0.7778)		11.27 (0.1827)	
RBOB gasoline	r = 0	27.95 (0.0028)**	cointegration	52.35(0.0000)**	cointegration
	r = 1	5.71(0.2223)		13.56 (0.1276)	
natural gas	r = 0	93.02 (0.0000)**	cointegration	107.62(0.0000)**	cointegration
	r = 1	8.12 (0.0793)		19.12 (0.0160)*	
copper	r = 0	36.76 (0.0001)**	cointegration	62.71 (0.0000)**	cointegration
	r = 1	6.49 (0.161)		20.75 (0.0238)*	
aluminum	r = 0	35.76 (0.0001)**	cointegration	55.96 (0.0000)**	no cointegration
	r = 1	6.49 (0.1611)		20.07 (0.0088)**	

** 1% significance level, * 5% significance level.

Table 2D: VECM

	Lags	B	α spot	α futures	trend	constant	Result
CBOT wheat	14	-1.1738 (0.000)**	0.0020 (0.870)	-0.026 (0.035)*		31.3825	Spot leads
		-1.1775 (0.000)**	0.0021 (0.865)	-0.026 (0.036)*	-.02626	47.6641	
KCBOT wheat	11	-1.1338 (0.000)**	0.054 (0.003)**	0.0316 (0.059)		83.9692	Bi-directional, spot adjusts
		-1.1578 (0.000)**	0.054 (0.002)**	0.034(0.034)*	0.0302	78.0107	
Corn	11	-0.9828 (0.000)**	.0528 (0.068)	-.0009(0.974)		-14.130	weak cointegration
		-0.9438 (0.000)**	.0264 (0.432)	-0.0460(0.174)	-.0327	-14.532	
Oats	9	-1.1040 (0.000)**	.0368 (0.000)**	.0074 (0.336)		39.2535	Futures leads
		-0.9519 (0.000)**	.0387 (0.000)**	.0013 (0.880)	-0.0328	26.1611	
Soybeans	11	-1.0048 (0.000)**	0.139 (0.000)**	.0319 0.0364)		-4.0089	Futures lead
		-0.9947 (0.000)**	0.1322(0.000)**	.0204 (0.569)	.00003	-11.364	
Soybean meal	8	-.9479 (0.000)**	.1255 (0.000)**	0.066(0.042)*		-6.6395	Futures leads
		-.8267 (0.000)**	.0768 (0.033)*	0.0072 (0.825)	-0.0493	-22.514	
Cocoa	8	-0.897 (0.000)**	0.0519 (0.158)	-0.0571 (0.121)		72.564	Spot leads
		-.8755 (0.000)**	0.0362 (0.328)	-0.075(0.043)*	-.0559	58.5706	
Cotton	21	-0.9872 (0.000)**	-0.0150 (0.722)	-0.17 (0.000)**		-3.495	Spot leads
		-0.980 (0.000)**	-0.0392 (0.394)	-0.222(0.000)**	-.002768	-2.4065	
Sugar	21	-0.9293 (0.000)**	-0.0258 (0.109)	-0.051(0.002)**		-.12667	Spot leads
		-0.9669 (0.000)**	-0.0191 (0.247)	-0.047(0.006)**	.00077	-.09241	
Crude oil	17	-1.0013 (0.000)**	2.124 (0.001)**	1.4580 (0.027)*		0.0642	Futures lead
		-1.0019 (0.000)**	2.293(0.000)**	1.6504 (0.011)*	0.0001	0.0332	
Heating oil	9	-1.0066 (0.000)**	0.1707 (0.033)*	0.0018 (0.981)		1.1543	cointegration
		-1.0032 (0.000)**	0.1497 (0.065)	-0.0213 (0.783)	0.00089	0.1903	
RBOB gasoline	5	-1.0046 (0.000)**	0.1855 (0.010)**	0.0347 (0.625)		1.2155	Futures lead
		-1.0291 (0.000)**	0.223(0.003)**	0.0661 (0.372)	0.0192	3.7134	
Natural gas	5	-1.0265 (0.000)**	0.3877 (0.000)**	0.1050 (0.008)**		0.0602	Bidirectional, futures leads
		-1.0192 (0.000)**	0.392(0.000)**	0.1022 (0.012)*	-0.0001	0.1055	
Feeder cattle	21	-0.917 (0.000)**	0.100(0.000)**	-0.0485 (0.013)		-6.2538	Futures lead
		-0.9097 (0.000)**	0.102(0.000)**	-0.049 (0.0130)	-0.0000	-6.8936	
Lean hogs	19	-1.0783 (0.000)**	0.05027 (0.000)**	-0.0013 (0.931)		4.4052	Futures leads
		-0.8745 (0.000)**	0.059(0.000)**	-0.0348 (0.088)	-0.0104	-4.1933	
copper	14	-1.0027 (0.000)**	0.1268 (0.076)	0.0907 (0.196)		55.144	Futures leads
		-1.012 (0.000)**	0.1579 (0.017)*	0.1252 (0.053)	0.1359	9.0518	

Table 2E: Toda-Yamamoto Granger Causality Tests

	Time period	Futures → Spot		Spot → Futures		Result
		χ^2	p-value	χ^2	p-value	
CBOT wheat	1 period	31.5	0.0047**	43.7	6.7e-05**	Bidirectional, spot leading stronger
	2 period	1.2	0.54	1.3	0.52	
	3 period	16.5	0.29	28.3	0.013*	
	Full	40.1	0.00025**	69.5	2.9e-10**	
KCBOT wheat	1 period	31.2	0.071	32.9	0.047*	Bi-directional causality
	2 period	64.2	2.9e-06**	87.6	4.3e-10**	
	3 period	63.8	3.4e-06**	87.0	5.3e-10**	
	Full	64.2	2.9e-06**	87.8	3.9e-10**	
Corn	1 period	120.6	0.0**	41.7	1.8e-05**	Bi-directional causality
	2 period	13.8	0.24	9.7	0.56	
	3 period	9.6	0.57	13.3	0.27	
	Full	26.9	0.0048**	31.5	0.00093**	
Oats	1 period	27.9	0.00049**	26.7	0.00079**	Bidirectional, futures leading stronger
	2 period	12.1	0.21	7.8	0.55	
	Full	24.6	0.0018**	18.5	0.018*	
Soybeans	1 period	70.5	1e-10**	22.3	0.022*	Bidirectional, futures leading stronger
	2 period	28.3	0.0029**	29.3	0.002**	
	3 period	6.9	0.81	21.8	0.026*	
	Full	31.4	0.00095**	31.1	0.001**	
Soybean oil	1 period	20.0	0.52	23.5	0.32	No causality
	2 period	28.5	0.13	25.7	0.22	
	3 period	14.3	0.86	13.3	0.9	
	Full	38.1	0.013*	35.9	0.022*	
Soybean meal	1 period	53.6	8.3 e-09**	38.5	6.1e-06**	Futures leads
	2 period	10.1	0.26	6.0	0.65	
	Full	26.6	0.00084**	16.4	0.037*	
Cocoa	1 period	299.5	0.0**	43.5	7.2e-07**	Bidirectional causality
	2 period	299.0	0.0**	43.4	7.3e-07**	
	3 period	299.6	0.0**	43.5	7.2e-07**	

	Full	299.7	0.0**	43.6	6.7e-07**	
Coffee	1 period	46.4	0.00015**	25.3	0.089	Bidirectional causality
	2 period	48.5	7.3e-05**	33.4	0.01*	
	3 period	32.4	0.013*	47.7	9.5e-05**	
	Full	44.5	0.00028**	67.1	6.8e-08**	
Cotton	Full	58.8	1.9e-05**	168.8	0.0**	Bidirectional causality
Crude oil	1 period	67.1	6.7 e-08**	35.4	0.0055**	Bidirectional, futures leading stronger
	2 period	28.4	0.04*	24.3	0.11	
	3 period	26.7	0.062	20.3	0.26	
	Full	155.8	0.0**	88.2	1.3e-11**	
Heating oil	1 period	64.1	2.1e-10**	26.0	0.002**	Futures leads
	2 period	9.6	0.38	10.8	0.29	
	3 period	9.1	0.42	15.1	0.089	
	Full	27.1	0.0013**	12.4	0.19	
RBOB gasoline	1 period	4.0	0.6	3.2	0.66	Bidirectional causality
	2 period	8.3	0.14	13.3	0.021*	
	3 period	12.1	0.031*	6.8	0.23	
	Full	15.4	0.0087**	15.8	0.0075**	
Natural gas	1 period	82.1	3.33e-16**	16.6	0.0053**	Bidirectional, futures leading stronger
	2 period	21.4	0.00069**	12.0	0.035*	
	3 period	34.3	2.1e-06**	6.7	0.24	
	Full	151.8	0.0**	17.7	0.0034**	
Feeder cattle	Full	318.4	0.0**	62.7	5e-06**	Bidirectional causality
Lean hogs	Full	202.1	0.0**	30.9	0.042*	Futures leads
Copper	1 period	22.9	0.062	6.6	0.95	No causality. Futures leads very weakly in first period.
	2 period	17.6	0.23	16.3	0.3	
	Full	13.8	0.46	11.6	0.63	
Aluminum	1 period	22.9	0.062	6.6	0.95	No causality, bidirectional in the last period
	2 period	12.1	0.6	10.8	0.71	
	3 period	31.8	0.0043**	32.1	0.0039**	
	Full	13.8	0.46	11.6	0.63	

** 1% significance level, * 5% significance level.

CHAPTER 3
LIQUIDITY AND PRICES IN COMMODITY FUTURES MARKETS

3.1 Introduction

In the last two chapters of this dissertation, I established that: i) commodities futures market witnessed a vast inflow of money, along with the emergence of new classes of traders and financial instruments. I refer to this phenomenon as financialization. ii) Commodities futures markets play a crucial role in price determination, so developments in the futures markets have implications for spot prices. In this chapter, I will attempt to answer the central question that motivated this dissertation: if financialization of the commodities futures market can explain the tremendous rise in the magnitude of commodity prices in 2008.

There have been a plethora of recent empirical studies (Irwin and Sanders 2010, Kilian and Murphy 2010, Stoll and Whaley 2011, Mayer 2009) that seek to understand the role of financialization on recent commodity prices. Results are mixed, depending on the data, methodology, and commodities analyzed. A majority of papers, study the correlation between trading positions of different categories of traders and prices to understand how the activity of traders may affect commodity prices. However, these empirical studies suffer from an important problem; they use the publicly available CFTC net positions data that cannot accurately identify between different trading positions. This makes it almost impossible to isolate the effects of different groups of traders or trading strategies on prices. In this chapter, I will take a different approach: I will focus on the general inflow of liquidity into each commodity futures market by studying developments in total open interest instead of trying to divide open interest among trader categories.

Besides data issues there are two more reasons why I use open interest instead of traders' net positions of data. First, although the rise of institutional investors is an important aspect of financialization, other aspects that were discussed in Chapter 1 such as the changing role of "bonafide hedgers" and the entry of money managers and hedge funds into the market, are just as important. Taking the entire open interest into consideration enables me to explore the implication of financialization in this broader sense instead of focusing just on the activities of index traders. Second, as discussed in Chapter 1, Keynesian and Post-Keynesian schools of thought point to the possibility of self-fulfilling asset bubbles during times of exuberance. Studying developments in open interest and prices allows me examine if the rapid inflow of liquidity into commodity markets lead to price bubbles.

For the empirical analysis, I use the cointegration framework to understand the relations between open interest and prices for 16 commodities for a time period of 15 years (1995-2012). An important limitation of the existing literature is that most papers do not take into account the possibility of structural breaks in the data. This may cause a number of problems -- first conventional unit-root tests lack the power to reject the (false) null hypothesis of unit-root in the presence of structural breaks. Second, structural break may lead to changes in the cointegration vector and affect the power of the cointegration test. In the empirical analysis I allow for up to two structural breaks in the unit-root tests and cointegration tests.

Results show that for a majority of commodities analyzed, prices and open interest share a long-run cointegrating relationship. More importantly for most commodities, if there is a deviation from the long run relationship, prices adjust to maintain the relationship. These results imply that the overall increase in liquidity in recent years increased demand for long positions more than could have been met by demand for short positions, creating an upward pressure on prices. The initial increase in liquidity could have been motivated by an increase in prices or an expectation of an increase in prices in the future, due to some fundamental changes in demand or supply. However, this increase in liquidity pushed prices up and leading to a bubble-like feedback mechanism between liquidity and prices.

The rest of the chapter is organized as follows: Section 3.2 explores data issues related to CFTC net positions data. In Section 3.3, I survey the literature highlighting different approaches, data, and methodologies used. Section 3.4 and 3.5 detail the empirical strategy and data respectively. Finally in Section 3.6, I summarize the results of the empirical analysis, before concluding in section 3.7.

3.2 Weaknesses of the CFTC Net Positions Data

The CFTC publishes three major weekly reports on trader positions: Commitments of Traders (COT) reports, Supplementary Commodity Index Trader (CIT) reports, and Disaggregated Commitments of Traders (DCOT) reports. All three reports are based on the large trader reporting system (LTRS), where CFTC collects daily information from reporting firms, clearing members, futures commission merchants, and foreign brokers, which covers between 70-90% of any market.[36]

COT reports divide traders into two categories: commercial traders (hedgers) and non-commercial traders[37] (speculators). Traditionally, the commercial category consisted of “bonafide hedgers”, producers and consumers of commodities who have commercial interest in the underlying commodities. The non-commercial category consisted of speculators, who do not have any commercial interest in the physical commodity, and are in the market to profit from changes in the prices. However, after

[36] the rest is covered by small traders called non-reporting traders.

[37] CFTC classifies merchants, manufacturers, producers, and commodity swaps and derivative dealers as commercial, and all other traders including hedge funds, floor brokers and traders as non-commercial.

index traders entered the commodities futures market in 2001/02, the boundary between hedgers and speculators was blurred and trader designations of the COT reports were no longer a good representation of the activities of traders in the market. For example, swap dealers were classified as commercial traders although they were hedging risks associated with OTC derivative positions, and did not really fit the "bonafide hedgers" description.

Responding to complaints about inaccurate trader designations, in 2007 CFTC started to publish CIT reports for 12 agriculture markets.[38] CIT reports classify traders into three categories: index traders, commercial traders excluding index traders, and non-commercial traders excluding index traders. The CIT category includes pension funds, previously classified as non-commercial traders and swap dealers previously classified as commercial traders. CIT reports are available from 2006. Although the CIT category is an improvement over the previous disaggregation of commercial and non-commercial traders, there are still major flaws with the data. CFTC itself admits that traders assigned to the category of index traders are engaged in other futures activity that cannot be disaggregated, and CIT will not include many other traders who are engaged in index trading activity. Another important weakness is that CIT reports are only available from 2006 onwards, but the rapid inflow of money into the commodities market started in 2001/2002. This implies that the data are truncated and provide us with biased view of the causal links between index trading and prices. Finally, CIT data are only available for 12 agriculture commodities and not for other important commodity markets like energy and precious metals.

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[38] Chicago Board of Trade (CBOT) corn, CBOT soybeans, CBOT soybean oil, CBOT wheat, Kansas City Board of Trade (KCBOT) wheat, New York Board of Trade (NYBOT) cotton, Chicago Mercantile Exchange (CME) live cattle, CME feeder cattle, CME lean hogs, NYBOT coffee, NYBOT sugar, and NYBOT cocoa.

CFTC also started publishing DCOT reports from September 2009, providing data from 2006. The DCOT data are available for the 12 agriculture markets covered by CIT reports plus some energy and metal markets. DCOT report classifies traders into swap dealers, managed money processors, merchants, and other reporting traders. Although the DCOT and CIT reports have been helpful in estimating the magnitude and nature of financial investment in the commodities market, these data sets are still highly aggregate. The major weakness of all three net-position datasets that CFTC reports -- COT, CIT, and DCOT -- is their inability to accurately identify trader positions into different categories. The datasets also do not distinguish between positions of traders for futures contracts of different maturities. As nearby futures are more important for price determination, not knowing the positions of traders for nearby futures, is an important weakness.

Some papers resolve this weakness to some extent by using CFTC proprietary data that identifies positions of each trader category in each futures contract for every contract maturity on each day (Brunetti, Buyuksahin, and Harris 2010 and Buyuksahin and Harris 2011). These papers are a marked improvement over papers that use the aggregate public data. However, the fundamental data problems remain – positions are still classified based on entity and not on trading strategies. If a trader takes positions on behalf of both traditional hedgers and index traders, CFTC will allocate *all* of its positions to one of the trader categories depending on whether CFTC decides the trader is primarily a hedger, a swap dealer, or belongs to some other trade category. It is impossible to differentiate between positions of a particular trader at the aggregate level. For example in 2003 Cargill -- a major grain trading company, established Black River Asset Management, a hedge fund (Oxfam 2012). Black River Asset Management provides external investors a range of financial and asset management services. CFTC categories Cargill as a hedger and allocates *all* of its trading positions, including through its hedge fund, to the commercial trader category.

The problem with internal netting of positions by swap dealers also persists with the proprietary data. In addition, the CFTC dataset are limited to the US futures market, which is just one venue for speculators to be involved in the commodities market. OTC derivatives contracts and foreign boards of trade are other activities that may impact futures trading and commodity prices in the US, which are outside of the purview of the CFTC. This limitation is especially important for some markets like crude oil and industrial metals— a majority of financial investment is known to take place through OTC trades for crude oil, while London Metals Exchange is the major market for industrial metals.

Figure 3A (appendix 3.2) illustrates this data weakness. The first graph shows the net long positions in CBOT wheat futures for CIT and Swap Dealers. The third line in the graph represents data from the CFTC "Special Call" request that includes net positions of 43 entities.[39] These entities were requested to provide information on the total notional value and the equivalent number of futures contract for their entire OTC commodity index business, not just the netted amount that may ultimately be managed in the futures market. Unfortunately this data are only available from December 2007 on quarterly basis, and on a monthly basis from June 2010. For the CBOT wheat market, comparison of CIT, DCOT and the Special Call data reveals that the CIT and DCOT datasets underestimate the total index related investment in the market, although the CIT net positions data are quite close to the

[39] 16 of these entities are large swap dealers who are known to the CFTC to have a significant commodity index swap business, 14 are known commodity index funds while 13 others are large swap dealers who are not known to engage in significant commodity index swap business

Special Call data. However, in the crude oil market the difference between the swap dealers positions and special call data is quite stark and reveals that the DCOT data are simply inadequate in trying to estimate the level of index investment in the market. The difference between the Special Call data and DCOT also reveals the fact that the OTC market for crude oil is very large and that only a small fraction the OTC contracts end up in the futures exchange market.

In the next section, I provide a brief literature review of major papers in this area. Although, my focus is on papers that study correlation between positions of traders and prices, I also discuss papers that use other approaches.

3.3 Literature Review

There has been a flurry of research on the links between financialization and commodity prices since the 2008 price developments. The field has been fast evolving, with papers using different methodologies, data, and arguing on both sides of the debate. For example, Einloth (2009); Phillips, Wu, and Yu (2009); Gilbert (2010a) look for evidence of trend-following behavior in the price process. In contrast, Kilian and Murphy (2010), Lombardi and Robays (2011), and Juvenal and Petrella (2011) use structural VAR models to detangle effects of various demand and supply shocks on oil prices. While, Buyuksahin, Haigh, and Robe (2010); Silvennoinen and Thorp (2010); Hong and Yogo (2012) study the rise in correlation between commodity and financial markets as they become increasingly inter-related. Some other papers study the rise in correlation between commodity prices themselves (Ai, Chatrath, and Song 2006; Lescaroux 2009; Frankel and Rose 2009; Lombardi, Osbat, and Schnatz 2010; Tang and Xiong 2010).[40] Finally, another strand of the literature examines if there are

[40] I use this approach in chapter 4 of this dissertation.

price pressure during the so called "Goldman Roll"[41] (Stoll and Whaley 2010; Irwin, Garcia, Good, and Kunda 2009; Hamilton and Wu 2012; Mou 2011).

A majority of papers have tried to determine if the inflow of investment into the commodities futures markets through commodity indices have impact on prices by checking for Granger causality between the net positions of different categories of traders and futures prices. Most of the papers in this category utilize COT, CIT, or DCOT data published by the CFTC and are subject to data issues discussed in the previous section.

The OECD working paper by Irwin and Sanders (2010) is one of the first empirical papers that uses this approach. Using CIT data for 12 commodities, they show that only for corn and cotton, the activity of index traders Granger causes futures returns.[42] Although the paper acknowledges that increased flow of index fund investment represents a structural change of the commodities market, they argue that it did not lead to a price bubble. This paper has been cited widely as evidence of lack of a bubble in the futures market and has fueled the argument that prices in 2008 can be explained by supply and demand fundamentals. In a series of papers, Irwin and Sander have continued their analysis using different data-sets and empirical methodologies and have reinforced their argument that positions of traders do not lead to changes in futures returns.[43]

A number of papers have followed this methodology of looking at the correlation between trader positions and change in prices. Stoll and Whaley (2011)

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[41] Goldman Roll is the period during which index funds replicating the S&P-GSCI must replace expiring futures contracts with new contracts, following the rolling strategy of the GSCI which is public. For example, under the Goldman Roll, if March contracts are being replaced by April contracts, all index traders will seek to sell March contracts and buy April contracts.

[42] Returns in period t $(R)_t = \log(P_t) - \log(P_{t-1})$, where P_t: price in period t

[43] Sanders and Irwin (2011a), Irwin (2013), and Sanders and Irwin (2011b) are some other papers. They use cross-sectional regression on CIT and quarterly index investment data in Sanders and Irwin (2011a) and Irwin (2013) respectively. Sanders and Irwin (2011b) use the same CIT data, but extended from 2004-2009 for CBOT corn, wheat, and soybeans.

use CIT data and conclude that index fund trading does not cause increase in futures prices. Out of the 12 commodities, they find evidence only for cotton that net positions of traders Granger-cause futures returns; while for KCBOT wheat, the causality is reversed. In contrast other papers, that use similar methodology, have found that net position changes of traders does lead to future price changes. In a UNCTAD discussion paper, Mayer (2009) finds significant impact of financial traders on prices of both agricultural and non-agricultural commodities. Similarly, Robles, Torero, and Braun (2009) use four indicators: volume, open interest, ratio of monthly volume to open interest, and positions of non-commercial traders and conclude that speculative activities seem to have been influential, but accept that the evidence is far from conclusive.

Other papers use the net position of trader data along with other predictors of futures prices to check if net positions are correlated to price changes. Gilbert (2010b) carries out OLS, 2SLS, and 3SLS estimation of change in the agricultural food price index vs. changes in the oil price, the exchange rate, and the futures investment index. He arrives at similar conclusions from all three regressions – estimates show a statistically significant impact of index investment on both the food price index and oil price. Singleton (2011) computes excess returns from holding positions in futures at different maturity points along the yield curve and includes a range of predictor variables: returns on the S&P500 and MSCI emerging market indices, change in overnight repo positions of treasury bonds, 13-week change in open interest, change in average basis, 13-week changes in the imputed positions of index traders and money managers. Results show that correlation between changes in oil futures prices and both index and money manager net positions are positive. Finally, Hamilton and Wu (2012) follow Singleton's use of holdings, which are in essence notional positions of index investors rather than net positions, to explain returns of commodity futures. They carry out the analysis for the 12 commodities covered by CIT data and find that there are no relations between notional positions and returns. However, using a similar technique to Masters (2008) to estimate notional positions of index traders in crude oil shows that notional positions can predict returns for crude oil during 2006-2009.

As we can see, results of papers that use net positions data are mixed. Some like Irwin and Sanders (2010) and Stoll and Whaley (2011) show no evidence of causality between net positions and futures prices, while others like Mayer (2009), Robles, Torero, and Braun (2009), Gilbert (2010b), and Singleton (2011) show causality running from net positions to prices, for at least some commodities. The major weakness of studies that use this methodology is the net positions data itself.

Brunetti, Buyuksahin, and Harris (2010) use CFTC proprietary data for crude oil, natural gas, and corn[44] that identifies positions of each trader category in each futures contract for every contract maturity on each day. They carry out Granger causality in the context of VAR from Jan 2005 to March 2009 using returns, positions, and realized volatility data. The paper concludes that speculative activity does not affect prices, and further that swap dealers and hedge funds reduce volatility. Similarly, Buyuksahin and Harris (2011) use the same daily trader level position data and conduct Granger causality tests at daily and multiple day intervals for crude oil. They carry out tests in two sub-periods: 2000-2004 and 2004-2009, and the entire sample. Results indicate that there is no evidence that hedge funds and other non-commercial position changes Granger-cause prices, instead they find that price changes precede position changes. As discussed before, although these papers are an

[44] They also include Eurodollar and mini-DOW in their analysis.

improvement over papers that use the aggregate public data, the fundamental data problems still remain – positions are still classified based on entity and not on trading strategies.

Given the data limitation, another strategy would be to give up on trying to divide open interest among different types of traders, and use total open interest itself as a determinant of futures prices for the commodities market. Hong and Yogo (2012) argue that open interest contains information about future economic activity that is not fully revealed by net supply-demand imbalances among hedgers in the futures market. Their thesis is based on the assumption of limited risk absorption capacity by speculators, in other words that there are limits to arbitrage. Using data for 30 commodities from 1964, they show that movements in open interest predict movements in prices even after controlling for other know predictors of returns such as short rate, yield spread, and basis. In this chapter, I will follow Hong and Yogo's (2012) approach and use total open interest as a measure of total inflow of liquidity into the market, instead of trying to divide the open interest among different types of traders.

3.4 Empirical Strategy

In this chapter, I seek to understand the impact of financialization of the commodities market on explaining the 2008 price developments. My approach follows previous literature, in trying to understand the lead-lag dynamics between prices and positions of traders, the major difference being that instead of examining the correlation between positions of different groups of traders and price, I focus on the general inflow of money by using the open interest in each commodity market. Open interest measures the total number of futures contracts, long or short, that have been entered into and that have not yet been liquidated by an offsetting transaction or fulfilled by delivery. There are three reasons why I have decided to take this approach instead of following previous studies and attempt to decompose open interest into position of traders.

First, as mentioned before three are several issues with the CFTC net positions data which makes it almost impossible to accurately differentiate between positions of different groups of traders and their trading strategies. Without knowing accurately the long and short positions of the traders, it would be almost impossible to determine their impact on prices.

The second reason is somewhat related to the first point. Most of the literature in this field has tried to understand the implication of the inflow of institutional investors on prices. As mentioned in the introduction chapter, financialization is a much broader development and represents a general increase in influence of the financial sector in the commodity markets. The rise of institutional investors is certainly an important part of the story; however other aspects of financialization such as the changing role of "bonafide hedgers" and other traders such as money managers and hedge funds are just as important. Taking the entire open interest instead of decomposing it into net long or short positions of a particular group of traders will enable me to examine the implication of financialization in this broader sense.

The third reason is more theoretical. As discussed in Chapter 1, unlike the mainstream theory of efficient financial markets, the Keynesian and Post-Keynesian school of thought hold a more critical view of finance. They highlight the role of uncertainty and the possibility of price bubbles during times of exuberance. Especially relevant to our analysis is the notion of capital market inflation of Toporowski (2002). Toporowski argues that prices in the securities markets are determined by financial inflows, rather than the other way around. Excess inflow of funds into the market, driven by pension funds, pushes prices up leading to capital market inflation.

In the case of the commodities futures market, an increase in open interest does not automatically represent financialization. Open interest may increase due to an increase in production of commodities, leading to higher activity by producers and consumers. It may also simply represent an increase in popularity of the futures market for hedging needs of commodity producers and consumers. However, the recent increase in market liquidity across many commodity futures markets,[45] make it difficult to argue that commodity specific factors are behind it. Financialization is a more plausible argument. The initial price development of 2008 may have been grounded in fundamentals -- demand from emerging market, bio-fuel, supply problems. Whatever the reason the initial increase in prices attracted more money into the market. The collapse of the housing market and the promotion of commodities as a safe asset by the financial sector further meant that new classes of traders such as institutional traders and hedge funds also became interested in commodities, leading to higher liquidity in the futures market.

This increase in market liquidity doesn't necessarily lead to an increase (or decrease) in prices. Toporowski developed his theory of capital market inflation primarily for the equities market. Futures contracts unlike stocks and bonds are not debt securities; they do not represent ownership of an underlying asset. A futures contract represents positions of two sides, the buyer side or the long position and the seller side or the short position. The impact of higher trading activity on prices, if any, depends on the balance between the demand for long and short positions. We can

[45] see Figure 3B (appendix 3.2) and Table 3.1 for a general trend in open interest across various commodity futures markets.

represent the relationship between prices and market liquidity by the following equation:

$$\dot{P} = \alpha \, [D_L(\lambda, P) - D_S(\lambda, P)] \qquad 0.\text{Error! Bookmark not defined.}1$$

where, (P) represents futures prices and $(\dot{P})$ is the change in futures price over time. (D_L) and (D_S) represent demand for long and short positions respectively, and λ is a measure for trading activity in the market. If the demand for long positions is higher than the demand for short positions, prices will rise. While, a higher demand for short positions relative to long positions leads to a fall in prices. The impact of higher trading activity on futures prices depends on how it affects this balance between long or short positions. If financialization leads to a higher demand for long positions (perhaps due to the activity of index investors, who are concentrated in the long side of the market), then it will lead to an upward pressure on prices. However, if financialization leads to a higher demand for short positions, then we may witness a decrease in commodity prices.

Given this formulation, it seems more logical to test for correlation between the inflow of money in the commodities market and the corresponding price developments rather than trying to focus on the actions of a particular group of traders. It would not be surprising to find correlation between open interest and prices – if price of an asset goes up, more liquidity might flow into the market to profit from the rise in prices. However, our interest is in reverse causality- does the rapid inflow of liquidity in the market cause prices to rise? Hong and Yogo (2012) is the only paper of which I am aware that shows that movements in open interest predict movements in commodity prices even after controlling for other know predictors of returns such as short rate, yield spread, and basis. Caballerao, Farhi, and Gourinchas (2011) also argue that the collapse of the housing bubble in 2008 led to a rapid influx of money into the commodities market which led to a speculative bubble.

The empirical analysis consists of three major steps. The first step determines the stationarity properties of the individual price series. I carry out both conventional unit root tests and those that take structural breaks into account. After establishing that most of the prices series are integrated of order 1, I carry out cointegration tests that take structural breaks into account, to understand the long-run relations between open interest and futures prices. Finally, I use vector error correction model (VECM) and Toda-Yamamoto (1995) causality tests to understand the direction of causality between open interest and futures prices. These steps are discussed below in more detail.

Structural breaks have been mostly ignored in the previous literature, although a visual inspection points to possible breaks. In the presence of structural breaks, traditional Dickey-Fuller-type unit-root tests lack the power to reject the (false) null hypothesis of unit-root (Perron 1989).[46] To correct this problem, I use Clemente-Montanes- Reyes (1998) unit root test, which is an extension of the Perron and Vogelsang (1992) test for 2 unknown structural breaks. The test assumes the following equation for innovative outlier model (IO)[47]:

$$y_t = \mu + \rho y_{t-1} + \delta_1 DTB_{1t} + \delta_2 DTB_{2t} + d_1 DU_{1t} + d_2 DU_{2t} + \Sigma_{i=1}^{k} c_j \Delta y_{t-i} + e_t \qquad 0.\text{Error! Bookmark not defined.}2$$

DTB_{it} is a pulse variable which is equal to 1 if t = $TB_i + 1$ (i=1, 2), 0 otherwise. DU_{it} =1 if t > TB_i (i =1, 2) and 0 otherwise. TB_1 and TB_2 are the break dates. The null hypothesis is that the series has a unit root with structural break(s) against the

[46] See Perron (2005) for an exhaustive literature review on unit root tests and structural breaks.
[47] The test allows for both Additive outlier model: change to the trend function occurs instantaneously; and Innovative outlier model: change to the new trend function is gradual.

alternative hypothesis that they are stationary with break(s):

$$H_0: y_t = y_{t-1} + \delta_1 DTB_{1t} + \delta_2 DTB_{2t} + u_t$$

$$H_A: y_t = y_{t-1} + d_1 DU_{1t} + d_2 DTB_{2t} + e_t$$

The test is carried out for each possible break date, choosing the date with strongest evidence against the null hypothesis of unit root, i.e. where the t-stat from the augmented Dickey-Fuller test is at the minimum. If Clemente-Montanes-Reyes unit root test suggests less than two breaks in the series, results from Perron–Vogelsang unit root tests with 1 break are considered. If there is no evidence of structural breaks in the data, results of traditional Dickey-Fuller tests with the null hypothesis of unit root, are considered. I also carry out the KPSS[48] test with the null hypothesis of stationarity, as a robustness check.

Results of unit-root tests show that almost all the series except feeder cattle open interest and MGEX wheat price are I(1), after accounting for 2 structural breaks. I drop these two commodities from the rest of the analysis as cointegration requires variables to be integrated of the same order. The next step in the analysis is to test for cointegrating relationships between individual futures prices and open interest. However, as the series consist of structural breaks, we need to take these breaks into account when we carry out test for cointegration, because structural breaks may lead to changes in the cointegration vector and the cointegration test will no longer be appropriate (Perron 2005). Fortunately, Johansen, Mosconi, and Nielsen (2000) have generalized the Johansen (1988) and Johansen and Juselius's (1990) likelihood-based cointegration analysis to account for up to 2 structural breaks, and provided new asymptotic tables.

[48] KPSS: Kwiatkowski–Phillips–Schmidt–Shin

$$\Delta x_t = \prod\prod_j \binom{x_{t-1}}{D_{t-k}} + \Sigma_{i=1}^{k-1}\prod_i \Delta x_{t-i} + \varepsilon_t \qquad 0.\text{Error! Bookmark not defined.}3$$

where,

$D_t = 1,\ldots, D_{q,t}$ where (q-1) are the breaks present

$$D_{j,t} = \begin{cases} 1 & for\ T_{j-1} + 1 \le t \le T_j j \\ 0 & otherwise \end{cases}$$

$\prod = \alpha\beta'$ and $\prod_j = \alpha\gamma'$

It can also be written as: $\Delta x_t = \alpha \binom{\beta}{\gamma}' \binom{x_{t-1}}{D_{t-k}} + \Sigma_{i=1}^{k-1}\prod_i \Delta x_{t-i} + \varepsilon_t$ 0.1

This method uses the fact that if prices and open interest are cointegrated, the rank of matrix $\prod$ will be (n-r) where n is the number of variables and r is the number of cointegrating vectors. (n-r) has be greater than 0 (otherwise there is no cointegrating relation) but less than full rank (implies all vectors are stationary). I use the trace statistic to the null hypothesis that the number of cointegrating vectors is less than or equal to r against a general alternative.

After establishing that a cointegrating vector exists (after accounting for breaks), I estimate the error correction model, along with the cointegrating vector (β) and speed of adjustment parameters (α_s and α_f). The cointegrating vector (β) establishes the long-run relationship between the two variables while α tells us about the direction of causality. For example if $\alpha_{oi} > 0$ and $\alpha_f = 0$ indicates that if there is a short-run deviation from the cointegrating relationship, only open interest adjusts to maintain the relationship. This implies that there is no feedback mechanism between liquidity and prices that may lead to asset price bubbles. However, $\alpha_{oi} > 0$ and $\alpha_f > 0$ implies that both open interest and futures prices adjust to maintain the long-run cointegrating relationship.[49] This result points to the existence of bubble-like feedback

[49] See Joyuex (2007) for more details on the implementation of cointegration tests accounting for structural breaks.

mechanism between open interest and prices.

Finally, in the last step of the empirical analysis I seek to understand the causality relations between open interest and futures prices during the identified time periods. However, Granger causality test based on the Wald principal is not valid for I(1) series due to nonstandard asymptotic properties. To correct for this, I use Toda and Yamamoto (1995) causality tests by adding extra lag (d_{max}), based on the maximum order of integration, to the VAR(k) model then carry out the Wald test which will have an asymptotic chi-s

$$OI_t = \gamma_0 + \Sigma_{i=1}^{k} \gamma_{1i} OI_{t-1} + \Sigma_{j=k+1}^{k+dmax} \gamma_{2j} OI_{t-j} + \delta_{1j} F_{t-1} + \Sigma_{j=k+1}^{k+dmax} \delta_{2j} F_{t-j} \gamma_2 \varepsilon_{1t}$$

$$F_t = \alpha_0 + \Sigma_{i=1}^{k} \alpha_{1i} F_{t-1} + \Sigma_{j=k+1}^{k+dmax} \alpha_{2j} F_{t-j} + \beta_{1j} OI_{t-1} + \Sigma_{j=k+1}^{k+dmax} \beta_{2j} S_{t-j} \gamma_2 \varepsilon_{2t}$$

The null hypothesis is that futures prices do not Granger cause open interest ($\delta_{11} = \delta_{12} = 0$), and open interest do not Granger cause futures prices ($\beta_{11} = \beta_{22} = 0$). The benefit of this approach is that cointegration between the two series is not necessary to carry out causality tests, which means we can carry out these tests also for commodities that are not cointegrated. While for cointegrated commodities, Toda-Yamamoto test will serve as a robustness check of the VEC methodology, as cointegration implies Granger causality in at least one direction.

3.5 Data Sources

Futures prices: I use weekly prices of 16 commodities from Pinnacle Data[50], for a 15 year period (1995-2012). These includes 12 agricultural commodities (CBOT[51] corn, wheat, soybeans, soybean oil, soybean meal, oats; KCBOT[52] wheat; MGEX[53] wheat; ICE[54] cocoa, coffee, sugar, cotton), 1 livestock (CME[55] feeder cattle), and 3 energy

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[50] https://www.pinnacledata.com/
[51] CBOT: Chicago Board of Trade
[52] KCBOT: Kansas City Board of Trade
[53] MGEX: Minneapolis Grain Exchange
[54] ICE: Intercontinental Exchange

commodities (NYMEX[56] crude oil, heating oil, and natural gas). Besides oats and MGEX wheat all other commodities are part of S&P-GSCI and/or DJ-UBS commodity index and thus have witnessed rapid inflow of investment through index funds into their futures markets. I extract end-of-day prices from nearby futures[57] contract and take the weekly mean. For more details on the data and sources, refer to Appendix 3.1.

Measure of liquidity: Since I am not working with trader positions and I am only interested in the total inflow of money into the commodities futures markets, CFTC COT options and futures report, that are available from 1995, provide the longest and broadest dataset. Figure 3B (appendix 3.2) shows the overall trend in open interest in select commodities. Starting from 2004 open interest of commodities rose at a scale unseen in the past, this process accelerated between 2006 and 2008. After the peaking in 2008, it fell for a short time only to rise again in early 2011. Table 3.1 below, provides a more quantitative measure of the increase in open interest over the years. Open interest in sugar rose by more than 600 percent between January 2001 and the peak in 2008. Similar trends can be seen in other commodities that include grains, livestock, and energy.

Table 0.1: Percent Increase in the Open Interest of Select Commodities

	Wheat	Corn	Soybeans	Sugar	Coffee	Crude oil
% increase between Jan 2001 and peak in 2008	269	303	349	648	389	465
% increase between Jan 2006 and peak in 2008	80	129	141	100	151	129

** corn, wheat, and soybeans peak was in 2011.

[55] CME: Chicago Mercantile Exchange
[56] NYMEX: New York Mercantile Exchange
[57] Nearby futures contract is the contract with the closest settlement date, and it is by far the most heavily traded contract, so it is considered most important for price determination. I switch to the next-to-nearby contract as the delivery dates comes close, as open interest falls rapidly as the date of delivery nears.

3.6 Empirical Results

Key results of the empirical analysis are: i) both futures prices and open interest are I(1) after accounting for up to two structural breaks for 14 of the 16[58] commodities analyzed; ii) for most commodities the identified breaks correspond to the 2008 rise and fall in prices, thus highlighting the extraordinary scale of the event; iii) prices and open interest for all commodities share a long-run cointegrating relationship; and iv) most importantly for a majority of commodities (12/14), prices adjust to maintain the long run relationship. This provides support to the thesis that a process of capital market inflation took place in the commodities market, where the inflow of liquidity created an upward pressure on prices.

To understand the stationarity properties of the price series and open interest, I carry out Clemente-Montanes-Reyes unit root test that allows for up to two structural breaks. I set a trim of 0.15, meaning 15% of the data are trimmed on each side. This implies that for most commodities, the test takes into account data between November 1997 and April 2010 and ignores the spike in price in early 2011. Figure 3C (appendix 3.2) plots spot and futures prices of each commodity, along with the identified breaks. The shaded regions in the graphs are the trimmed areas of the test. Results are detailed in Table 3A (appendix 3.3).

For most commodities, the identified breaks in the price series correspond to the rise and subsequent fall of prices in 2008, while the breaks in open interest usually lead the ones in prices. For example for the CBOT and KCBOT wheat prices, the identified break dates are identical, the first one is identified in May 2007 as the price bubble grows, and the second one in early March 2008 as the bubble finally bursts. While, the breaks in open interest for CBOT wheat are in December 2004 and January

[58]MGEX wheat and feeder cattle are stationary after accounting for two structural breaks.

2006, and for KCBOT wheat it is in June 2005. Breaks in corn and MGEX wheat prices, are close to those in K/CBOT wheat, but with a lag. For oats one break is identified in August 2006. Prices of soybeans and soybean oil follow similar trends, and share the exact break dates. While soybean meal does not follow trends in soybeans/oil, and only one break is identified in July 2007. Breaks in open interest for soybeans and soybean oil are identified in August 2003, July 2006 and March 2006, November 2008 respectively. Again, most of these dates correspond to the 2008 price boom. For the four soft commodities (cotton, sugar, coffee, cocoa) the price rise in 2011 was more important in scale than the one in 2008. However, this part of the data is in the trimmed region, and is not taken into account by the test. A majority of soft commodities (cocoa, coffee, cotton) also had price hikes between 1997 and 2001, these are identified as breaks. For cocoa breaks are identified in October 2001 and November 2007 in prices, and October 1999 and February 2005 in open interest. Coffee prices have two breaks in May 1997 and October 2004; while breaks in open interest are in August 2003 and September 2006. Cotton prices and open interest have two breaks each on June 1998, August 2009 and November 2006, September 2008 respectively. For sugar, there are no breaks in the price series, but two in open interest: March 2004 and October 2006. Feeder cattle prices have been quite stable and did not witness the 2008 price bubble, no breaks were identified in the price series, while open interest is stationary after accounting for 2 breaks. Among energy commodities, crude oil, heating oil and RBOB gasoline witness similar price trends. Crude oil witnessed two significant breaks in December 2004 and September 2008; heating oil closely followed trends in crude oil. Open interest in crude oil: January 2005 and September 2008; heating oil: June 2006 and May 2009. Finally, trends in natural gas seem to be disconnected from other energy commodities with two breaks identified in August 2004 and June 2008; and for open interest January 2000 and February 2005.

Traditional Dickey-Fuller based tests and KPSS (Table 3B in appendix 3.3) confirm the results that prices and open interest both are I(1) for 14 of the 16 commodities analyzed. Open interest of MGEX wheat and price series of feeder cattle are stationary after accounting for up to 2 structural breaks. These two commodities are excluded from the rest of the empirical analysis.

In the next step, I use the Johansen's cointegration test, adjusted to take up to 2 structural breaks in account, to check if open interest and prices series of individual commodities are cointegrated. Results show open interest and futures prices of all 14 commodities examined are cointegrated. Table 3C in Appendix 3.3 has the detailed results for both Johansen's test and Adjusted Johansen's test.

After establishing that a cointegrating vector exists, in the second step I estimate the error correction model, along with the cointegrating vector (β) and speed of adjustment parameters (α_s and α_f). The cointegrating vector (β) establishes the long-run relationship between the two variables while α tell us about the direction of causality. I carry out Johansen's maximum likelihood VEC model, with rank =1 and the same lag lengths as before given by AIC, HQIC, and SBIC.

Results of the VEC model are summarized in Table 3D in Appendix 3.3. The cointegrating vector is significant and has a negative sign for all 14 commodities examined. This implies that open interest and futures prices share a long-run relationship and they move in the same direction. As expected for most of the cases (8/14) the speed of adjustment parameter for open interest (α_{oi}) is significant. This implies that for these 8 commodities, open interest adjusts in the short-run to maintain the long-run relationship. If prices move up, traders enter the market to gain from the rise in prices, so the overall liquidity in the market rises. Surprisingly, our variable of interest, the speed of adjustment parameter for prices (α_{price}) is also significant for a majority of the cases (12 out of 14). This implies that for these 12 commodities, if there is a deviation from the long run relationship between liquidity and prices, prices respond and adjust to maintain the relationship. For cocoa and oats, there seems to be no price adjustment. Oats is the only commodity among the 14 analyzed that is not part of the GSCI or the DJ-UBSCI, while cocoa is included in the GSCI but not in the DJ-UBSCI. Among the 12 commodities that show price adjustment, all except soybean oil and soybean meal are included in both the GSCI and the DJ-UBSCI. Soybean meal and soybean oil are in included in the DJ-UBSCI, but not in the GSCI.

I also carry out the Toda-Yamamoto causality tests on the entire sample period, and various sub-periods identified by structural breaks. The overall results are consistent with VECM results; Toda-Yamamoto tests show causality running at least in one direction for all the commodities that are cointegrated, thus reinforcing our results. For most of the commodities (cotton, coffee, corn, sugar, CBOT wheat, soybeans, soybean oil, crude oil), results show bidirectional causality between prices and open interest. While for some commodities (cocoa, oats, KCBOT wheat, soybean meal, heating oil, natural gas) causality only runs from prices to open interest. Although these results may seem contradictory or inconsistent, we have to keep in mind that cointegration is a long-run relationship and causality in the short-run might change. In addition, cointegration and Granger causality are different ways of analyzing the data, and causality has a power problem of not being able to reject the null hypothesis. It is thus reasonable to expect different results from the two tests, with cointegration giving stronger results. (Lütkepohl 2004, p. 150) Table 3E in Appendix 3.3 has the detailed results.

In summary, the results of this chapter suggest that the overall increase in liquidity in recent year, has led to disequilibrium between demand for long and short positions in the commodities futures market. Going back to equation 3.1, as market liquidity rose, it increased demand for long positions more than could have been met by demand for short positions, creating an upward pressure on prices. The initial increase in liquidity could have been motivated by an increase in prices or an expectation of an increase in prices in the future, due to some fundamental changes in demand or supply. However, this increase in liquidity pushed prices up and leading to a bubble-like feedback mechanism between liquidity and prices.

3.7 Conclusion

In recent years, the commodities futures markets have undergone a phenomenal increase in liquidity, along with the emergence of new classes of traders and trading strategies. During the same time, a range of commodities witnessed a rapid rise in prices, peaking in mid-2008 before dropping precipitously. In this chapter of the dissertation, I sought to understand the relationship between these two developments.

Most previous studies use the publicly available CFTC data on net positions of traders, which suffers from a very important data flaw: it cannot accurately identify between different trading positions. This makes it almost impossible to isolate the effects of different groups of traders or trading strategies on prices. In this chapter, I take a different approach. I focus on the general inflow of money in each commodity futures market by studying developments in total open interest. Using total open interest also allows me to explore the implication of financialization in a broader context instead of focusing just on index traders.

I use the cointegration framework to understand the relation between open interest and prices for 16 commodities for a time period of 15 years (1995-2012). Results show that prices and open interest for 14 commodities analyzed, share a long-run cointegrating relationship. More importantly for most commodities, if there is a deviation from the long run relationship, prices adjust to maintain the relationship. This implies is that an initial rise in prices, perhaps due to a demand or supply shock, led to an increase in the overall liquidity in the market as more traders enter the market to gain from the rise in prices. This rise in liquidity increased demand for long positions more than could have been met by demand for short positions, creating an upward pressure on prices. As futures prices act as a benchmark for spot prices (established in Chapter 2), this development in the futures market is transmitted to the spot market, leading to a rise in spot prices. In conclusion, this paper provides strong empirical evidence to support the thesis that the 2008 rise in commodity prices were partly driven by the financialization of the commodities futures market.

Appendix 3

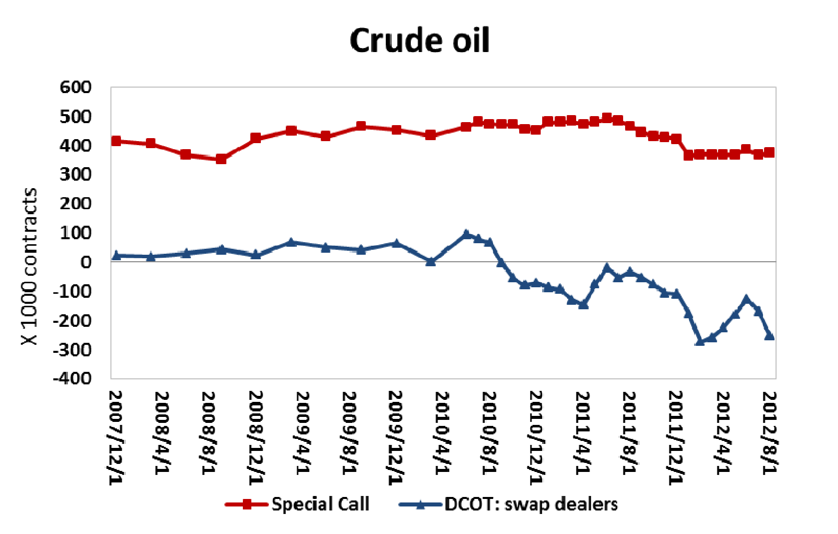
Appendix 3.1: Data details

	Futures contract specification	Exchange	contract months	contract size
1	Wheat, # 2 Soft red winter	CBOT	H, K, N, U, Z	5,000 bushels
2	Wheat, # 2, Hard red winter	KCBOT	H, K, N, U, Z	5,000 bushels
3	Wheat, #2 Hard red spring	MGEX	H, K, N, U, Z	5,000 bushels
4	Corn, # 2 Yellow	CBOT	H, K, N, U, Z	5,000 bushels
5	Oats, # 2 Milling	CBOT	H, K, N, U, Z	5,000 bushels
6	Soybeans, #1 Yellow	CBOT	F, H, K, N Q, U, Z	5,000 bushels
7	Soybean oil	CBOT	F, H, K, N Q, U, V, Z	60,000 pounds
8	Soybean mea	CBOT	F, H, K, N Q, U, V, Z	100 short tons
9	Cocoa	ICE	H, K, N, U, Z	10 metric tons
10	Coffee, Colombian	ICE	H, K, N, U, Z	37,500 pounds
11	Cotton, 1 1/16 Str. Lw. Medium	ICE	H, K, N, V, Z	50,000 pounds
12	Sugar, raw cane sugar 11	ICE	H, K, N, V	112,000 pounds
13	Crude oil, WTI	NYMEX	all months	1,000 barrels
14	Heating oil	NYMEX	all months	42,000 gallons
15	Natural gas	NYMEX	all months	10,000 million British thermal units
16	Feeder cattle index, 650-849 pound steers, medium-large #1 and #1-2	CME	F, H, J, K, Q, U, V, Z	50,000 pounds

January (F), February (G), March (H), April (J), May (K), June (M), July (N), August (Q), September (U), October (V), November (X), December (Z)

Appendix 3.2: Tables and Figures

Figure 3A: Net Long Positions of Traders in CBOT Wheat and NYMEX Crude Oil



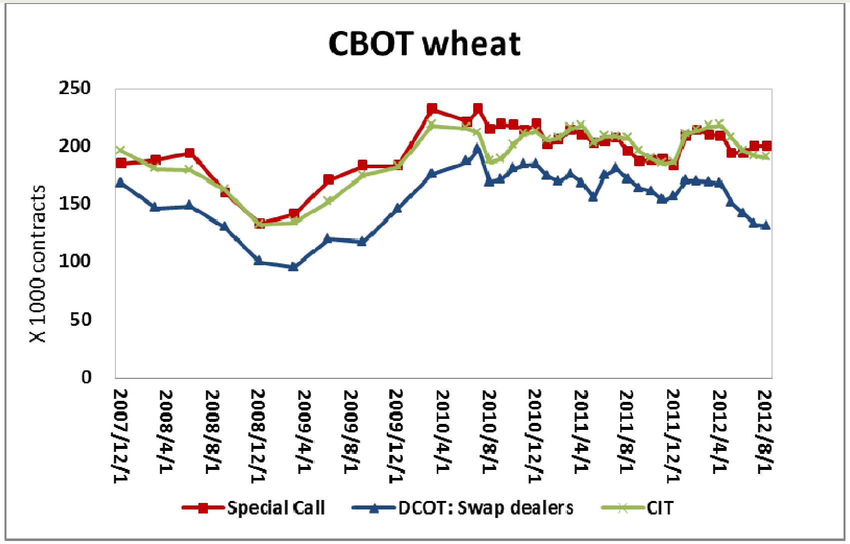
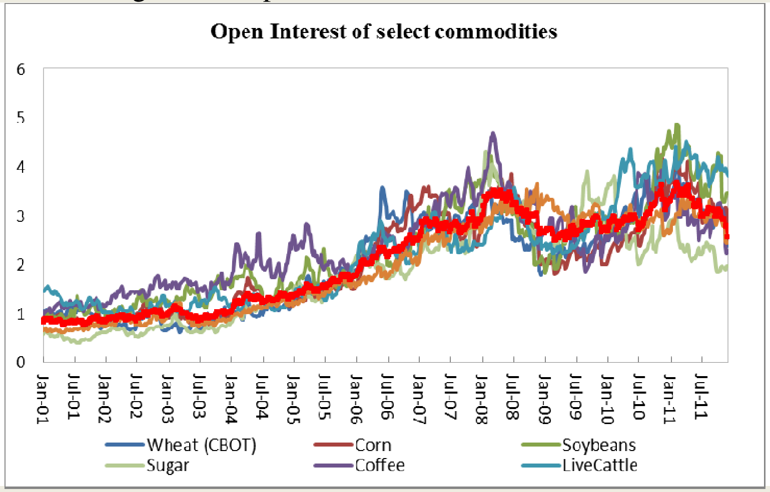
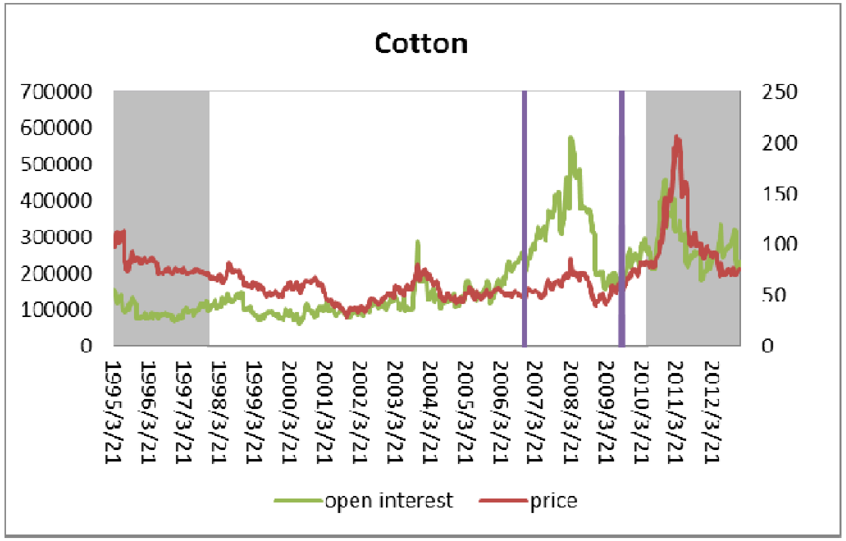


Figure 3B: Open Interes of select commodities

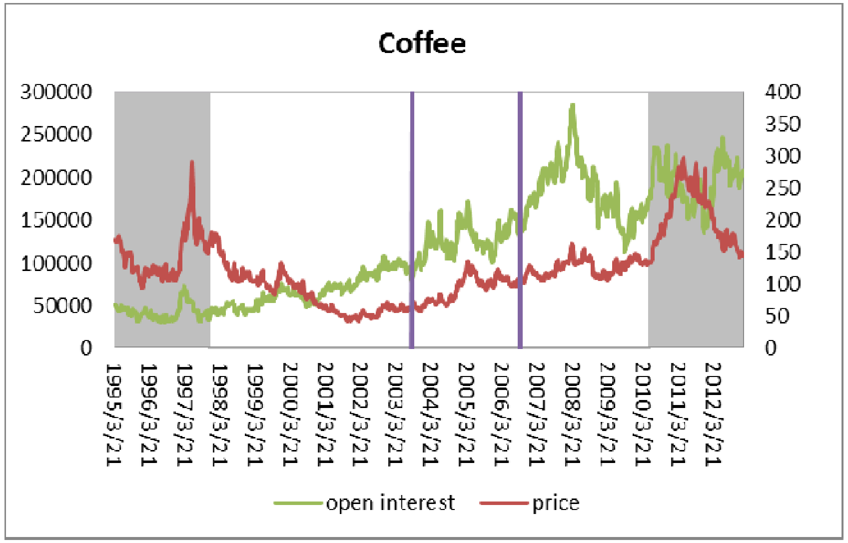


Standardized: demean and divided by standard deviation
Source: CFTC COT reports, all: sums up OI across the 6 commodities.

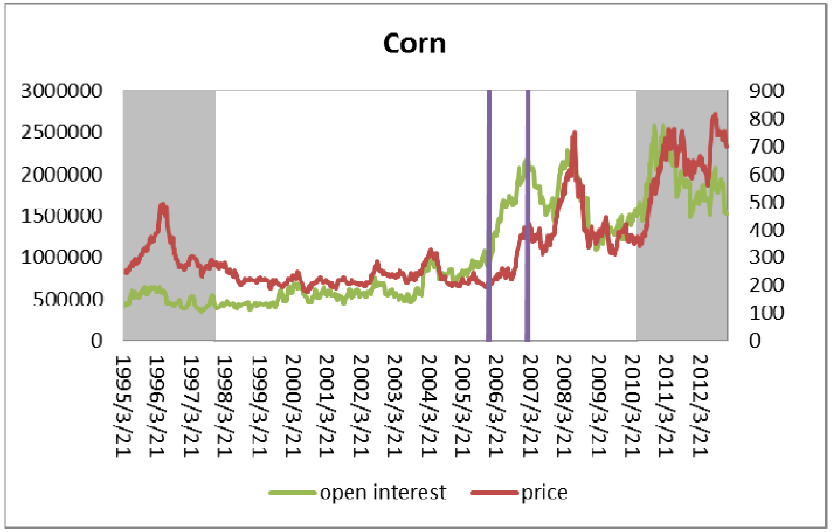
Figure 3C: Trends in Commodity Spot and Futures Prices



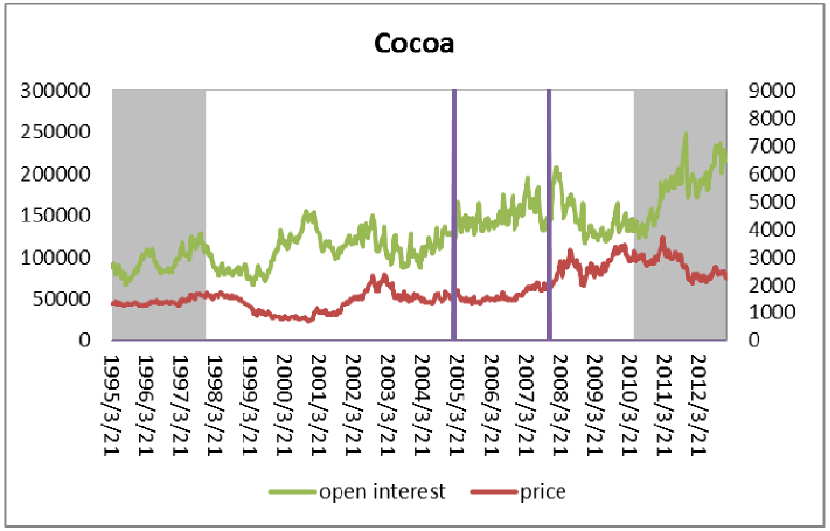
Break1: 2006 w48; Break 2: 2009 w36



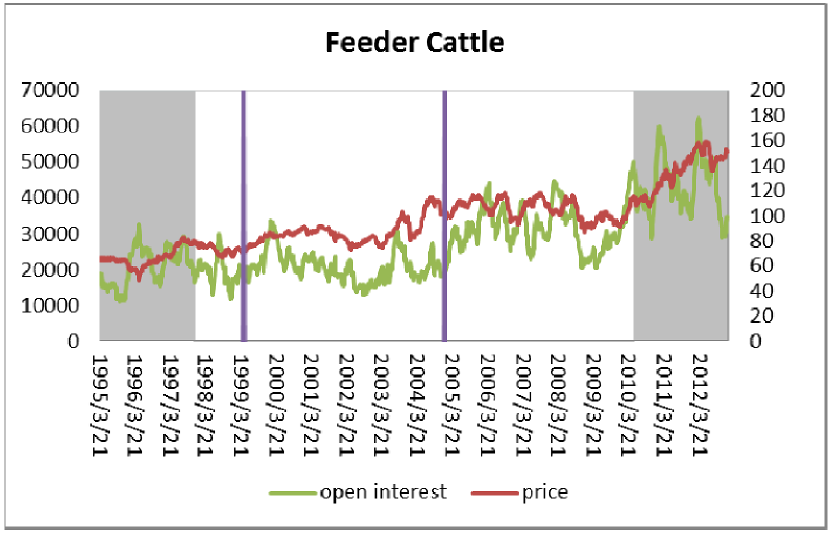
Break1: 2003 w35; Break 2: 2006 w38



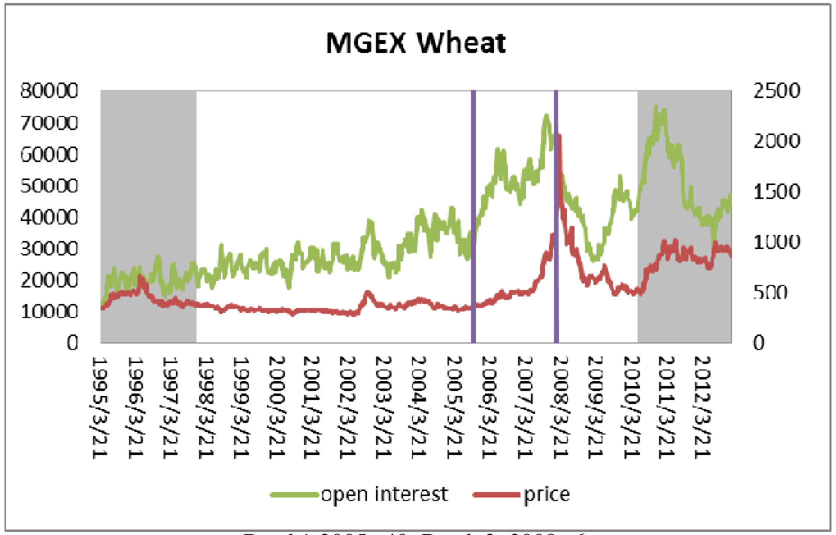
Break 1:2006w1; Break 2:2007w9



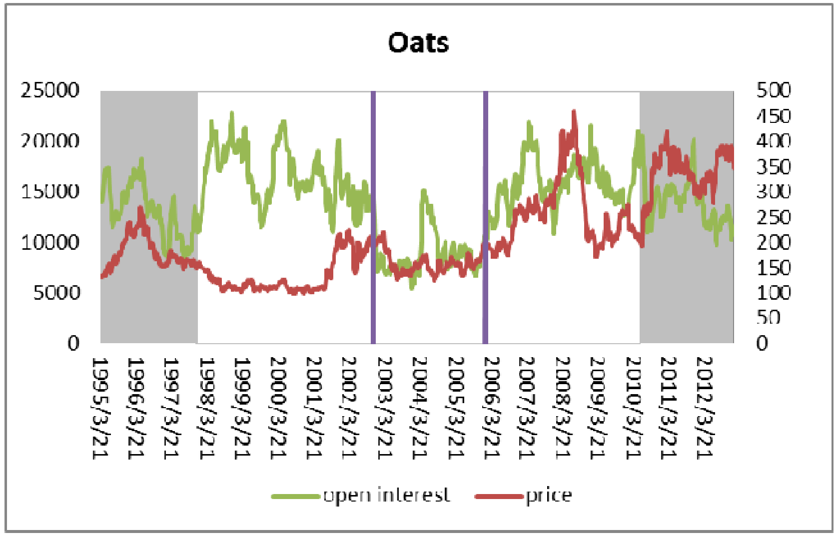
Break 1: 2005 w8; Break 2: 2007 w48



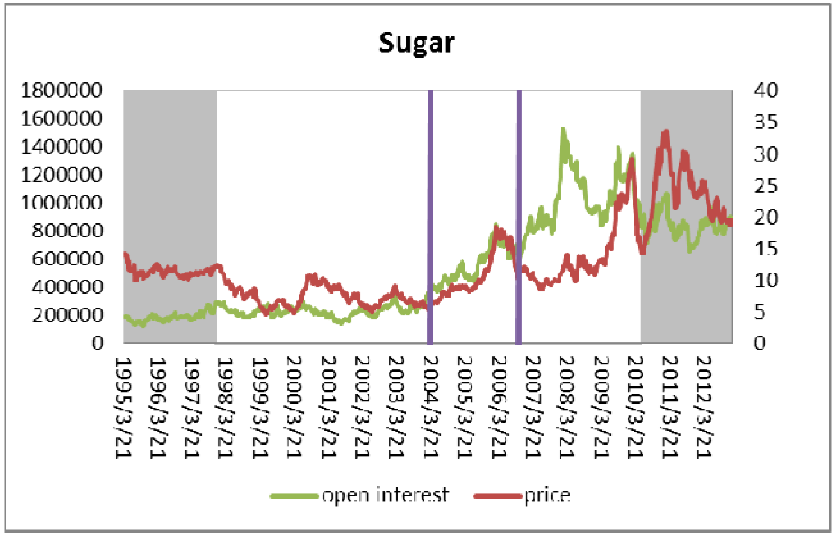
Break1: 2005 w1; Break 2: 2010 w8



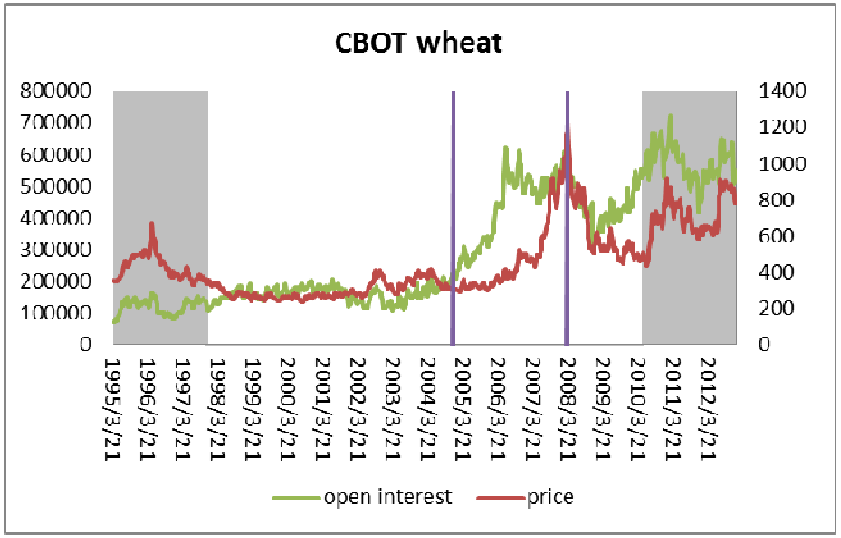
Break1:2005w40; Break 2: 2008w6



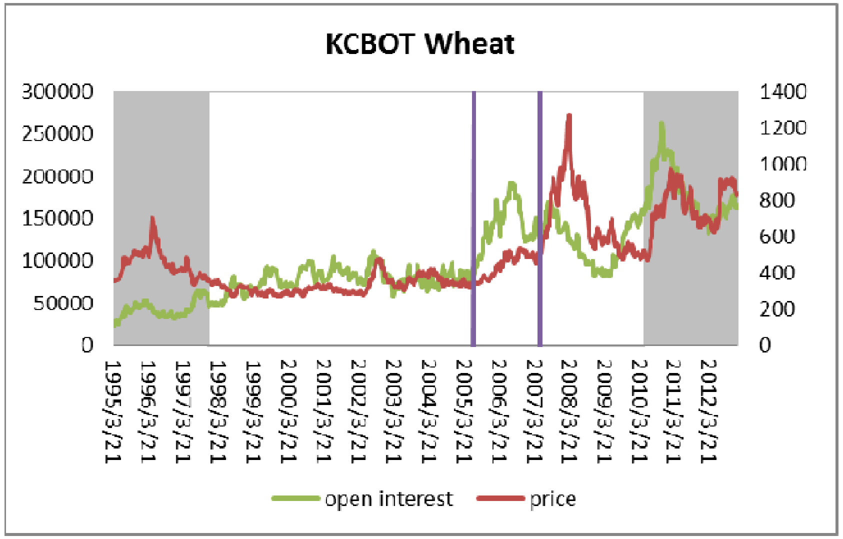
Break 1: 2002 w46; Break 2: 2006 w3



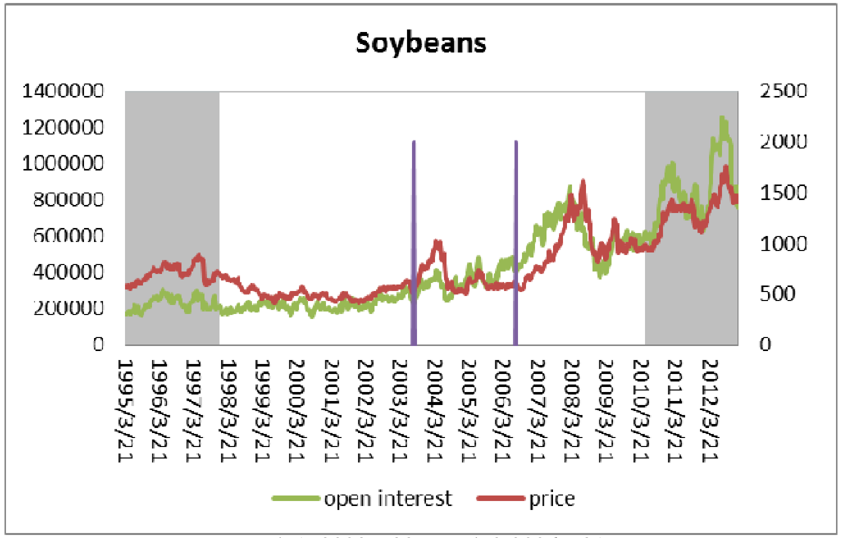
Break 1: 2004 w11; Break 2: 2006 w42



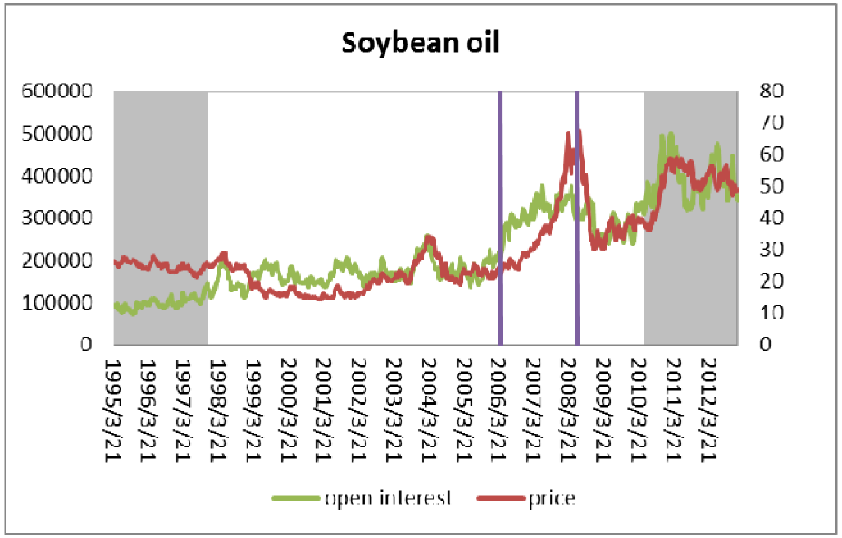
Break1:2004w50; Break 2:2008w12



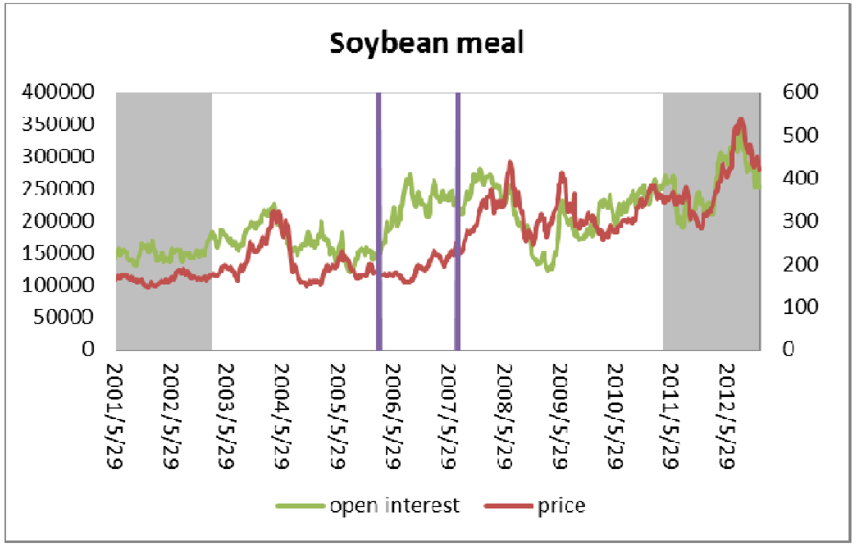
Break1: 2005 w27 ; Break 2: 2007 w22



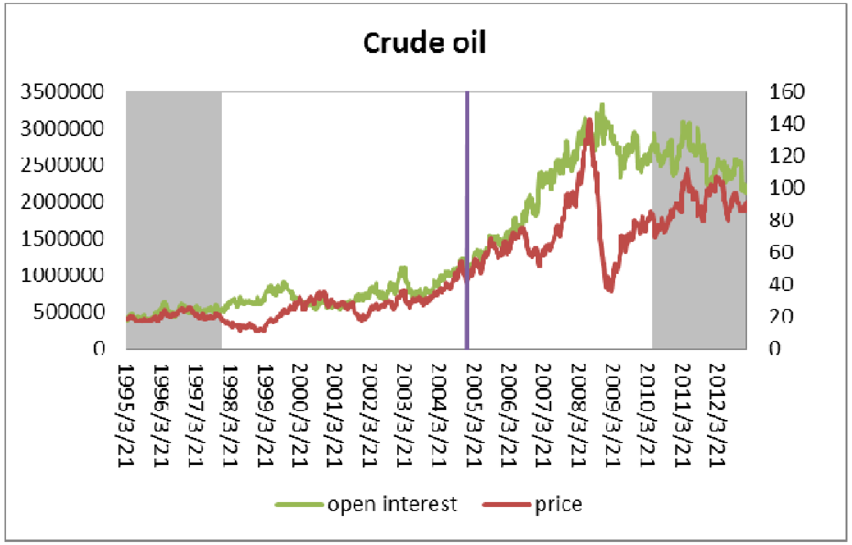
Break 1: 2003 w33; Break 2:2006 w31



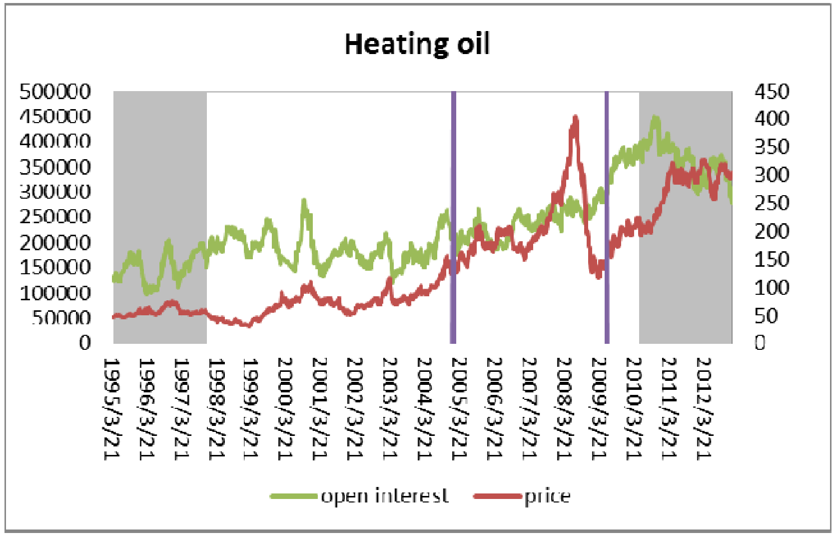
Break 1: 2006 w15; Break: 2008 w28



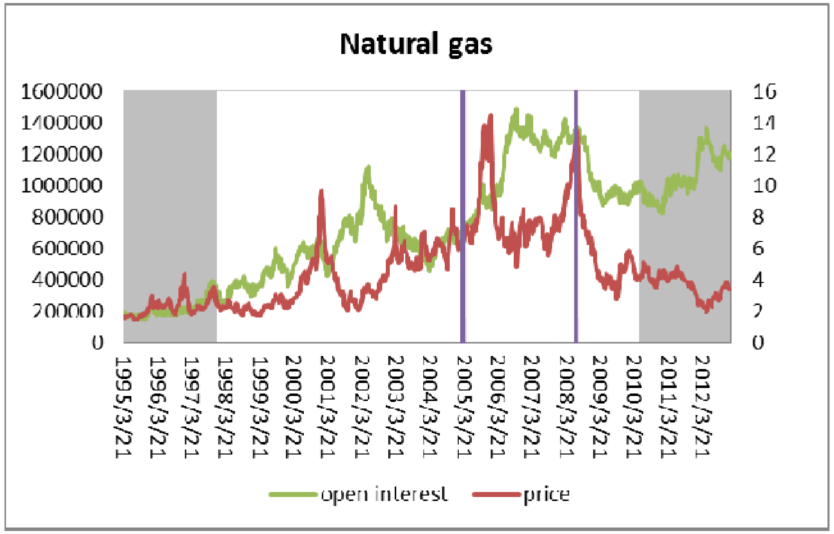
Break1: 2006 w10; Break 2: 2007 w32



Break1: 2005 w1



Break 1: 2005 w2; Break 2: 2009 w24



Break 1: 2005 w10; Break 2: 2008 w28

Appendix 3.3: Results

Table 3A: Clemente-Montanes-Reyes unit-root test with double mean shifts, IO model

		Break 1	Break1 coeff.	Break1 test	Break 2	Break 2 coeff.	Break 2 test	Unit-root test stat	Lag	Result
Cotton	Price	2000/ 1998w25	-0.7352	-2.4079*	2583/ 2009w36	1.4238	3.8377**	-4.9747	16	UR, 2 breaks
	OI	2439/ 2006w48	11989.6	4.3695**	2536/ 2008w41	-6870.98	-3.6717**	-4.3445	15	
Coffee	Price	2075/ 1999w48	-1.3907	-2.0063*	2330/ 2004w43	1.8381	2.7524**	-3.4387	18	UR, 2 breaks
	OI	2270/ 2003w35	2985.9	3.2011**	2429/ 2006w38	2377.1	2.5658**	-3.9188	17	
Corn	Price	2492/ 2007w9	12.7204	4.2707**	2523/ 2008w28	-8.7094	-3.0124**	-2.8419	20	UR, 2 breaks
	OI	2392/ 2006w1	42679.5	4.5639**	2521/ 2008w26	-10856.9	-1.9487*	-4.2574	19	
Cocoa	Price	2174/ 2001w43	15.3584	2.5449*	2491/ 2007w48	32.6551	3.2139**	-4.01563	15	UR, 2 breaks
	OI	2069/ 1999w42	968.34	1.6858	2347/ 2005w8	1437.8	2.3586*	-3.22563	13	UR, 1 break
Feeder cattle	Price	2043/ 1999w16	0.1868	1.0448	2302/ 2004w15	0.3501	1.8008	-2.106	18	UR, no breaks
	OI	2340/ 2005w1	813.1	4.545**	2607/ 2010w8	943.6	4.0181**	-5.805**	18	Stationary
MGEX wheat	Price	2491/ 2007w48	119.2	12.3139	2505/ 2008w10	-107.2	-11.936	-6.1204**	17	Stationary
	OI	2379/ 2005w40	1108.1	4.1093**	2501/ 2008w6	-525.5	-2.5079*	-4.205	17	UR, 2 breaks
Oats	Price	2426/ 2006w35	5.6698	4.3889**	2523/ 2008w28	-1.7108	-1.4933	-4.426	17	UR, 1 break
	OI	2229/ 2002w46	-389.08	-3.7516**	2394/ 2006w3	370.92	3.6527**	-4.823	19	UR, 2 breaks
Sugar	Price	2360/ 2005w21	0.141852	2.653308	2563/ 2009w16	0.405934	4.21124	-5.03816	19	UR, no breaks
	OI	2298/ 2004w11	13699.18	3.6641**	2433/ 2006w42	13751.67	3.2319**	-4.69411	15	UR, 2 breaks
CBOT wheat	Price	2465/ 2007w22	30.625	6.780**	2507/2008w12	-22.297	-5.878**	-4.59897	11	UR, 2 breaks
	OI	2337/ 2004w50	7981.489	3.204**	2392/ 2006w1	7510.973	2.315*	-4.25504	17	
KCBOT wheat	Price	2465/2007w22	27.065	6.5353**	2507/2008w12	-18.8752	-5.168**	-4.63597	13	UR, 2 breaks
	OI	2366/2005w27	2014.24	3.2589**	2481/2007w38	-337.582	-0.6568	-3.96811	17	UR, 1 break
Soybeans	Price	2478/ 2007w35	24.030	4.4810**	2523/ 2008w28	-12.785	-2.7827**	-3.42237	13	UR, 2 breaks
	OI	2268/ 2003w33	5469.272	2.2447**	2422/ 2006w31	11935.31	3.5028**	-4.90649	18	
Soybean oil	Price	2478/ 2007w35	1.04961	5.08395**	2523/ 2008w28	-0.5152	-2.9795**	-4.62832	19	UR, 2 breaks
	OI	2406/ 2006w15	5556.4	3.2517**	2542/ 2008w47	141.2521	0.1125	-3.46711	15	UR, 1 break
Soybean	Price	2313/ 2004w26	-1.048	-0.9125	2475/ 2007w32	5.7154	3.5426**	-3.7306	7	UR, 1 break

meal	OI	2401/ 2006w10	3239.5	2.8362**	2521/ 2008w26	-1014.81	-1.1004	-3.8276	4	
Crude oil	Price	2340/ 2005w1	1.3739	4.3682**	2535/ 2008w40	0.16834	0.7391	-4.9381	17	UR, 1 break
	OI	2344/ 2005w5	38702.39	3.5605**	2444/ 2007w1	23590.59	1.6726	-3.0544	20	
Heating oil	Price	2341/ 2005w2	2.9298	3.5725**	2535/ 2008w40	0.5712	0.9017	-4.0206	18	UR, 1 break
	OI	2419/ 2006w28	4123.54	3.6485**	2571/ 2009w24	5054.5	3.0950**	-4.5153	19	UR, 2 breaks
Natural gas	Price	2324/2004w37	0.2013	4.7469**	2523/2008w28	-0.20289	-4.9707**	-5.5015	14	UR, 2 breaks
	OI	2080/2000w1	7982.64	2.6378**	2349/2005w10	8679.314	2.8712**	-3.7376	16	

** 1% significance level, * 5% significance level. Critical value: -5.49, max-lag given by Ng-Perron, trim: 0.15, UR: unit root

Table 3B: DFGLS, Dickey-Fuller and KPSS unit root tests

		Lags	DFGLS test	Dfuller w/ constant	Dfuller w/o constant	Dfuller w/ trend	KPSS	Result
Cotton	Price (L)	20	-2.1388	-2.7925 (0.0593)	-0.8746	-2.9351 (0.1511)	0.518	I(1)
	Price (diff)	15	-1.9849	-6.2327 (0.0000)**	-6.2406**	-6.2223 (0.0000)**	0.0386**	
	OI (L)	19	-1.9475	-1.6095 (0.4788)	-0.4162	-2.4694 (0.3434)	0.269	
	OI (diff)	20	-5.1042**	-6.8971 (0.0000)**	-6.8906**	-6.8892(0.0000)**	0.0495**	
Coffee	Price (L)	20	-1.7784	-2.1184 (0.2372)	-0.8065	-2.4112 (0.3737)	0.78	I(1)
	Price (diff)	19	-4.8337**	-5.9474 (0.0000)**	-5.9507**	-5.9415 (0.0000)**	0.0564**	
	OI (L)	17	-2.6897	-1.080 (0.7228)	0.3999	-3.4229 (0.0484)	0.256	
	OI (diff)	16	-7.1737**	-8.2239 (0.0000)**	-8.1591**	-8.2215 (0.0000)**	0.0277**	
Corn	Price (L)	20	-2.2817	-1.3603 (0.6012)	0.0658	-2.5505 (0.3032)	0.749	I(1)
	Price (diff)	19	-5.5990**	-5.9396 (0.0000)**	-5.9036**	-5.9947 (0.0000)**	0.0244**	
	OI (L)	19	-2.4768	-1.3759 (0.5937)	-0.1816	-2.8175 (0.1906)	0.381	
	OI (diff)	20	-5.6611**	-5.9558 (0.0000)**	-5.9366**	-5.9470 (0.0000)**	0.0534**	
Cocoa	Price (L)	15	-2.0265	-1.4466 (0.5597)	-0.027	-2.2974 (0.4354)	0.609	I(1)
	Price (diff)	17	-6.4158**	-7.1324 (0.0000)**	-7.1164**	-7.1247 (0.0000)**	0.0635**	
	OI (L)	15	-2.9192	-1.1010 (0.7147)	0.7842	-2.9819 (0.1372)	0.167	
	OI (diff)	14	-8.983**	-9.2882 (0.0000)**	-9.2212**	-9.3031 (0.0000)**	0.0231**	
Oats	Price (L)	18	-3.3607*	-2.0670 (0.2579)	-0.3633	-3.6036 (0.0295)	0.517	I(1)

	Price (diff)	17	-4.7685**	-5.7615 (0.0000)**	-5.7516	-5.781 (0.0000)**	0.0266**	
	OI (L)	19	-2.9526*	-2.9375 (0.0412)*	-0.7657	-2.9462 (0.1477)	0.275	
	OI (diff)	18	-8.3620**	-8.4367 (0.0000)**	-8.4407**	-8.4356 (0.0000)**	0.026**	
Sugar	Price (L)	19	-1.6307	-1.4849 (0.5409)	-0.2982	-2.4878 (0.3341)	0.785	I(1)
	Price (diff)	20	-5.8161**	-6.8453 (0.0000)**	-6.8386**	-6.8596 (0.0000)**	0.0352**	
	OI (L)	15	-2.2405	-1.3316 (0.6146)	-0.0716	-2.5195 (0.3183)	0.557	
	OI (diff)	20	-6.5226**	-6.7423 (0.0000)**	-6.6925**	-6.7389 (0.0000)**	0.0557**	
CBOT wheat	Price (L)	13	-2.1868	-1.4418 (0.5621)	-0.0459	-2.5117 (0.3221)	0.759	I(1)
	Price (diff)	19	-5.7423**	-6.7041 (0.0000)**	-6.6892**	-6.7479 (0.0000)**	0.032**	
	OI (L)	17	-2.1316	-0.7127 (0.8434)	0.5958	-2.3833 (0.38854)	0.524	
	OI (diff)	20	-4.9554**	-6.0341 (0.0000)**	-5.9523**	-6.0393 (0.0000)**	0.0506**	
KCBOT wheat	Price (L)	20	-2.5145	-1.5874 (0.4899)	-0.1304	-2.8301 (0.1861)	0.525	I(1)
	Price (diff)	19	-6.1362**	-6.4252 (0.0000)**	-6.4112**	-6.4654 (0.0000)**	0.0292**	
	OI (L)	17	-4.1401**	-2.04645 (0.2666)	-0.3296	-4.1789 (0.0048)**	0.108	
	OI (diff)	16	-3.7239**	-5.4511 (0.0000)**	-5.4224**	-5.4467 (0.0000)**	0.0304**	
Soybeans	Price (L)	13	-2.0471	-1.0647 (0.7289)	0.3587	-2.3569 (0.4027)	1.09	I(1)
	Price (diff)	12	-8.3605**	-8.7785 (0.0000)**	-8.7442**	-8.8112 (0.0000)**	0.0236**	
	OI (L)	18	-3.5968**	-1.8879 (0.3377)	-0.4693	-4.1374 (0.0055)**	0.643	
	OI (diff)	20	-5.0125	-6.1030 (0.0000)**	-6.0578**	-6.0766 (0.0000)**	0.0241**	
Soybean oil	Price (L)	19	-2.4633	-1.8546(0.3537)	-0.3424	-3.3369 (0.0604)	0.679	I(1)
	Price (diff)	18	-4.3333**	-5.3112 (0.0000)**	-5.2980**	-5.3254 (0.0000)**	0.0336**	
	OI (L)	19	-3.0931*	-1.3019 (0.6283)	0.4268	-3.316(0.064)	0.345	
	OI (diff)	16	-6.2640**	-8.0985 (0.0000)**	-8.0396**	-8.0914 (0.0000)**	0.0254**	
Soybean meal	Price (L)	18	-3.150*	-1.442 (0.5622)	0.380	-3.375 (0.0549)*	0.168	I(1)
	Price (diff)	17	-4.682**	-5.757 (0.0000)**	-5.695**	-5.752 (0.0000)**	0.0241**	
	OI (L)	6	-3.417*	-2.237 (0.1931)	-0.013	-3.202 (0.0840)	0.242	
	OI (diff)	16	-3.328 *	-5.929 (0.0000)**	-5.902**	-5.914 (0.0000)**	0.0278**	
Crude oil	Price (L)	17	-3.585**	-1.652 (0.4559)	-0.2361	-4.3304 (0.0028)**	0.324	I(1)
	Price (diff)	15	-6.7940**	-7.1025 (0.0000)**	-7.064**	-7.1017 (0.0000)**	0.023**	

	OI (L)	20	-0.9549	-0.7429 (0.8353)	1.2039	-0.9076 (0.9553)	0.588	
	OI (diff)	17	-5.4369**	-8.3194 (0.0000)**	-8.1481**	-8.3186 (0.0000)**	0.16	
Heating oil	Price (L)	18	-3.2111*	-1.3038 (0.6274)	0.0193	-3.8889(0.0125)*	0.364	I(1)
	Price (diff)	20	-6.1335**	-6.2775 (0.0000)**	-6.2099**	-6.2909 (0.0000)**	0.0215**	
	OI (L)	19	-2.7045	-1.5478 (0.5097)	0.1285	-2.7426 (0.2188)	0.632	
	OI (diff)	20	-3.0119*	-7.8591 (0.0000)**	-7.8361**	-7.8526 (0.0000)**	0.042**	
Natural gas	Price (L)	14	-2.6275	-2.7691 (0.0628)	-1.1168	-2.7954 (0.1986)	0.82	I(1)
	Price (diff)	13	-7.2871**	-7.9997 (0.0000)**	-8.0026**	-8.0188 (0.0000)**	0.0237**	
	OI (L)	19	-2.2154	-1.3831 (0.59036)	0.5319	-2.2104 (0.4840)	0.356	
	OI (diff)	20	-4.5644**	-8.2605 (0.0000)**	-8.1214**	-8.2687 (0.0000)**	0.0416**	

OI: open interest. ** 1% significance level, * 5% significance level.

Table 3C: Johansen's Cointegration test (trace test)

	rank	Johansen's test	result	Adj. Johansen's test	result
Cotton	r = 0	16.27	no cointegration	30.94**	cointegration
	r = 1	5.73		14.52	
Coffee	r = 0	11.07	no cointegration	34.22**	cointegration
	r = 1	3.75		9.98	
Corn	r = 0	7.46	no cointegration	37.30**	cointegration
	r = 1	2.28		0.2274	
Cocoa	r = 0	10.44	no cointegration	33.28**	cointegration
	r = 1	2.58		14.18	
Oats	r = 0	16.76	no cointegration	32.68**	cointegration
	r = 1	3.98		10.48	
Sugar	r = 0	16.76	no cointegration	40.91**	cointegration
	r = 1	3.98		13.02	
CBOT wheat	r = 0	7.46	no cointegration	47.40***	cointegration
	r = 1	2.28		11.90	
KCBOT wheat	r = 0	16.76	no cointegration	46.14***	cointegration
	r = 1	3.98		18.58	
Soybeans	r = 0	15.19	no cointegration	37.19*	cointegration
	r = 1	4.23		13.34	
Soybean oil	r = 0	16.76	no cointegration	36.58***	cointegration
	r = 1	3.98		16.84	
Soybean meal	r = 0	16.76	no cointegration	37.33***	cointegration
	r = 1	3.98		13.16	
Crude oil	r = 0	27.66***	cointegration	38.24***	cointegration
	r = 1	4.72		14.50	
Heating oil	r = 0	7.46	no cointegration	44.00***	cointegration
	r = 1	2.28		10.61	
Natural gas	r = 0	20.05	no cointegration	28.84 (0.0880)*	Weak cointegration
	r = 1	5.23		10.75	

*** 1% significance level, ** 5% significance level, * 10% significance level.
Lags base don HQIC, but results are consistent with lags based on AIC and SBIC, except for coffee and cocoa. For corn, no cointegration if we take different structural breaks.

Table 3D: VECM Results

	β	α_{oi}	α_{prices}	constant	result
Cocoa	-42.6959 (0.008)***	-.01461**	.0000885	-61809.28	OI → prices
Oats	.27323 (0.000)***	-.0951 ***	-.0004825	-3987.126	OI → prices
Cotton	-5248.64 (0.001)***	-.00023	2.54e-06***	49.66395	prices → OI
Coffee	-1443.63 (0.016)**	-.00148	6.46e-06**	-54200.39	prices → OI
KCBOT Wheat	-219.1871(0.000)***	-.00150	.0000688***	-75932.7	prices → OI
Soybeans	-751.884 (0.000)***	-.00891	.0000339***	111518.9	prices → OI
Sugar	-53627.41(0.001)***	-.00073	1.79e-07***	-679426.5	prices → OI
Natural gas	-274500 (0.000)***	-.00056	6.61e-08***	-1106086	prices → OI
Corn	-9360.1 (0.000)***	.00509***	9.12e-07**	2188855	OI ↔ prices
CBOT Wheat	-1264.79 (0.000)***	.00915**	.0000169***	334157.2	OI ↔ prices
Soybean oil	-6868.08 (0.000)***	-.0187***	1.83e-06***	-27775.58	OI ↔ prices
Soybean meal	-364.309 (0.000)***	-.0276***	.0000274**	-109192.5	OI ↔ prices
Crude oil	-32344.9 (0.000)***	-.0144***	7.35e-07***	-62856.46	OI ↔ prices
Heating oil	-757.236 (0.000)***	-.01299**	.0000101**	-138702.2	OI ↔ prices

*** 1% significance level, ** 5% significance level, * 10% significance level. Lags based on HQIC

Table 3E: Toda-Yamamoto Granger Causality Tests

	Time period	χ^2 OI → prices	χ^2 Prices → OI	Result
Cotton	all	19.8 (0.0006)***	2.2 (0.7)	Prices ↔ OI
	1995-2006w48	16.4 (0.0025)**	13.5 (0.0092)***	
	2006w48-2009w36	10.6 (0.032)**	15.4 (0.0039)***	
	2009w36-2012	17.6 (0.0015)***	1.2 (0.88)	
Coffee	all	5.8 (0.054)**	3.6 (0.17)	Prices ↔ OI weak
	1995-2003w35	0.17 (0.92)	1.3 (0.52)	
	2003w35-2006w38	3.5 (0.17)	9.5 (0.0087)***	
	2006w38-2012	4.9 (0.085)*	1.2 (0.54)	
Corn	All	34.9 (0.0008)**	64.6 (0.0000)**	Prices ↔ OI
	1995-2006w1	20.1 (0.093)*	19.8 (0.14)	
	2006w1-2007w9	14.2(0.36)	13.2 (0.51)	
	2007w9-2012	14.8 (0.32)	24.9 (0.035)*	
Cocoa	All	3.1 (0.54)	19.2 (0.0007)***	Prices → OI
	1995-2005w8	6.1 (0.19)	4.1 (0.39)	
	2005w8-2007w48	3.3 (0.5)	10.9 (0.027)**	
	2007w48-2012	3.9 (0.42)	7.9 (0.094)*	
Oats	All	3.2 (0.2)	21.7 (0.0000)**	Prices → OI
	1995-2002w46	2.7 (0.26)	15.6 (0.0004)**	
	2002w46-2006w3	1.2 (0.55)	0.52 (0.77)	
	2006w3-2012	2.0 (0.36)	6.3 (0.044)**	
Sugar	all	9.1 (0.01)**	13.6 (0.0011)**	Prices ↔ OI
	1995-2004w11	3.3 (0.19)	7.3 (0.026)**	
	2004w11-2006w42	1.9 (0.38)	19.9 (0.0000)***	
	2006w42-2012	4.6 (0.098)*	4.1 (0.13)	
CBOT wheat	All	37.4 (0.0003)***	34.2 (0.0019)**	Prices ↔ OI
	1995-2004w50	7.2 (0.89)	49.1 (0.0000)***	
	2004w50-2007w22	7.6 (0.87)	17.8 (0.21)	
	2007w22-2012	16.3 (0.23)	12.6 (0.55)	
KCBOT wheat	All	3.0 (0.22)	4.8(0.09)*	Prices → OI weak
	1995-2005w27	0.56(0.76)	0.15 (0.93)	
	2005w27-2007w22	0.78 (0.68)	0.65 (0.72)	
	2007w22-2012	2.5(0.28)	2.1 (0.35)	
Soybeans	All	65.9 (0.0000)***	115.3 (0.0000)***	
	1995-2003w33	29.1 (0.086)*	63.7(0.0000)***	Prices ↔ OI

	2003w33-2006w31	31.7 (0.047)**	28.6(0.096)*	
	2006w31-2012	36.9 (0.012)**	50.3 (0.0000)***	
Soybean oil	all	7.4 (0.024)**	12.3(0.0021)**	Prices ↔ OI
	1995-2006w15	2.6 (0.27)	3.2 (0.2)	
	2006w15-2008w28	1.9 (0.39)	8.5 (0.014)**	
	2008w28-2012	0.91 (0.63)	4.4 (0.11)	
Soybean meal	all	1.2 (0.55)	15.1 (0.0005)***	Prices → OI
	2001-2006w10	0.36 (0.84)	8.4 (0.015)**	
	2006w10-2007w32	3.6 (0.16)	0.83 (0.66)	
	2007w32-2012	4.7 (0.097)*	8.5 (0.014)**	
Crude oil	All	49.7 (0.0000)**	36.9 (0.0035)**	Prices ↔ OI
	1995-2005w1	11.6 (0.82)	44.9 (0.0002)**	
	2005w1-2012	32.3 (0.014)**	22.0 (0.18)	
Heating oil	All	4.5 (0.99)	31.5 (0.0047)**	Prices → OI
	1995-2005w2	11.1 (0.6)	30.9 (0.0056)**	
	2005w2-2009w24	7.1 (0.89)	9.9 (0.77)	
	2009w24-2012	7.1 (0.9)	20.9 (0.11)	
Natural gas	all	18 (0.21)	13.6 (0.55)	Price → OI until 2005
	1995-2005w2	17.2 (0.24)	36.4 (0.0015)**	
	2005w2-2009w24	19.0 (0.17)	16.7 (0.34)	
	2009w24-2012	6.5 (0.95)	21.3 (0.13)	

*** 1% significance level, ** 5% significance level, * 10% significance level. Lags based on HQIC, but results are consistent with lags based on AIC and SBIC.

CHAPTER 4
FINANCIALIZATION AND CO-MOVEMENT OF COMMODITY PRICES

4.1 Introduction

One of the distinctive features of the 2008 commodity boom is that it covered a broad range of unrelated commodities. Prices of commodities ranging from agriculture (wheat, soybeans, coffee), energy (crude oil), and metals (copper) all rose and fell together (see figure 4A, Appendix 4.2). In this chapter, I seek to explore the links between financialization and the comovement of commodity prices. Unlike the previous chapter, where I analyzed commodity markets individually, in this chapter I take a broader approach and examine developments across commodity markets.

Prices of two commodities may move together, if they are *related* -- they are either substitutes or complements in production or consumption. Idiosyncratic demand or supply shocks in a particular commodity may be transmitted to other *related* commodities. For example, prices of certain industrial metals may move together if they are jointly used to produce alloys. Similarly, prices of grains such as corn, wheat, rice, and barley may move together if they are substitutes in consumption. However, these commodity-specific shocks cannot explain recently observed broad co-movements across *unrelated* commodities. Drought in Australia, use of corn and oil-seeds to produce biofuels and several other commodity-specific shocks that were initially provided as explanation for the 2008 rise in commodity prices, have now been questioned, as they are unable to explain this synchronized behavior across commodity prices (Gilbert 2010b, Frankel and Rose 2009). Instead, economists have emphasized the importance of factors that affect many commodity markets simultaneously such as: rise in demand from emerging economies, devaluation of the

USD, and the focus of this dissertation: financialization of the commodities futures market.

I have identified three ways in which behavior of commodity futures traders' may cause co-movement between commodity prices. First, if commodity futures are bought and sold not based on commodity-specific demand and supply fundamentals, but based on other portfolio considerations or due to herd behavior, then prices of commodities may co-move. This is especially true for index traders who buy and sell commodity derivatives not individually but as a group of securities based on pre-set weights of one of the popular commodity indices like the S&P GSCI and DJ-UBS commodity index. This implies that commodity derivatives are traded based on expectations for the entire index of commodities. If a large portion of "investment" in the commodities derivatives market are controlled by such passive index trading (like they did in 2008), then it is likely that prices of commodities will move together. This phenomenon is also called the weight-of-money effects. Second, if commodity speculators trade in two or more commodity markets, a fall in the price of one commodity may cause the price of other commodity to also fall due to liquidity effects. For example, if price of commodity A rises, speculators might have to sell commodity B to cover margin calls in commodity A in which they are long, thus leading B to move with A. Third, as the weight of energy commodities like crude oil is high in commodity indices,[59] shocks (supply or speculative bubbles) in energy markets might be transmitted to other commodity markets, even if there are no changes in the fundamentals of those specific commodities (UNCTAD 2009a). [60]

Furthermore, if commodity derivatives are traded based on other considerations like performance of traditional asset class, it is likely that correlation

[59] Brent and NYMEX crude oil made up more than 50% of S&P GSCI returns in 2008

[60] Note that this transmission of oil shocks to other commodities is different from the real transmission of oil shocks through cost of production.

between commodity and other assets will increase. As commodity and financial markets become increasingly inter-related, shocks from financial markets get transmitted to the commodities market. There is evidence that in recent years correlation between commodity prices and stocks (S&P 500) have increased substantially.[61] Buyuksahin and Robe (2011) take a step further and show that energy-equity comovements are positively related to greater market participation by speculators in general, and hedge funds in particular that trade in both equity and commodity markets.

In this chapter, I examine if financialization of the commodity futures market can explain the recent rise in comovement in commodity prices. Following recent developments in the literature, I extract common factors from prices of 41 commodities using the Panel Analysis of Nonstationary and Idiosyncratic Components (PANIC) method of Bai and Ng (2004). The extracted factor is then included in a factor-augmented VEC (FAVEC) model along with macroeconomic variables. Instead of assuming the *excess* comovement that is unexplained by macroeconomic factors is due to speculation, like previous studies, I also add a measure of financialization in the FAVEC model. This will be a stronger and more direct piece of evidence of the role of financialization in explaining comovement of commodity prices, than previously provided in the literature.

Results are robust for the common factor (Factor 1) extracted using all 41 commodities; both proxies of financialization are significant and have the expected negative sign. This result provide strong evidence to support the thesis that financialization of the commodities futures market led to increasing comovement between unrelated commodity prices. However, results for the group-specific factors

[61] Buyuksahin, Haigh and Robe (2009); Silvennoinen and Thorp (2010); Hong and Yogo (2012)

are not as strong. The proxies of financialization are significant with the expected sign only for 10 of the 16 cases. One reason for the inconsistent results for group-specific factors may be that as commodities included in the groups are related, commodity specific factors may be more important in explaining comovement between these commodities rather than macroeconomic factors.

The rest of the chapter is organized as follows: Section 4.2 provides a brief review of the relevant literature. Section 4.3 and 4.4 contain details on data and empirical strategy respectively. In Section 4.5, I summarize the results of the empirical exercise, and conclude in Section 4.6.

4.2 Literature Review

Pindyck and Rotemberg (1990) were one of the first to contribute towards the literature on co-movement of commodity prices. They regress monthly commodity prices of 7 commodities (wheat, cotton, copper, gold, crude oil, lumber, and cocoa) on macroeconomic variables such as the consumer price index, industrial production, interest rate, money supply, and S&P stock index and observe that pair-wise correlations between the residuals of the regression are statistically significant. Pindyck and Rotemberg term this tendency of unrelated commodities[62] to move together, even after accounting for macroeconomic variables, "excess" co-movement. They suggest this may be because "traders are alternatively bullish or bearish on all commodities for no plausible reason," (p.1173).

Pindyck and Rotemberg's paper inspired a wave of research on co-movement of commodities. However subsequent research in this area has weakened the thesis of excess co-movement. Palaskas and Varangis (1991) use cointegration and error correction model and find that the amount of co-movement attributed to

[62] For Pindyck and Rotemberg unrelated commodities meant cross-price elasticities of demand and supply are close to zero.

macroeconomic variables increases and excess co-movement decreases when moving from high frequency (monthly) to low frequency (annual) data. Similarly, Deb, Trivedi, and Varangis (1996) argue that Pindyck and Rotemberg's approach is not suitable for commodity price data that have heteroskedastic and non-normal errors. Instead Deb et al. use a multivariate GARCH approach and conclude that there is only weak evidence for excess co-movement. Cashin, McDermott, and Scott (1999) take a step further and claim that there is no co-movement between unrelated commodities, let alone excess co-movement. They use Bry-Boschan procedure, a business cycle dating technique, to identify turning points in price series. Using "concordance," which measures the proportion of time that prices of commodities are concurrently in the same boom or slump period, they conclude that commodity price series do not co-move. Cashin et al. argue that concordance is a better measure of co-movement than correlation because a one-time shift in level of two series due to a shock can induce significant correlation in an otherwise unrelated series. In the case of concordance, the one-time shift will be only important to the extent that the commodities are in the same phase for a lengthy period of time. It may be true that correlation may over-estimate co-movement because of a one-time shock, but it may also not be wise to completely ignore the changes in levels. This is especially true for the recent rise in prices that reached levels unseen in three decades, across most commodities. Furthermore, if the purpose of our research is to unveil the effects of shocks in the system, for example the demand shock due to financialization of commodities, concordance is not a suitable tool.

A strand of literature that uses similar business cycle dating methodology argues that a range of industrial metals move together through "super" cycles (20-70 year cycles). For example, Cuddington and Jerrett (2008) use a BP filtering technique on prices of 6 base metals traded at the London Metal Exchange (LME) to decompose prices into different frequency components. They then analyze the super-cycle component using Principle Component Analysis (PCA) and find one common factor that explains over 60 percent of variance. The paper concludes that there have been 3 metal super cycles in the past 150 years that have coincided with demand-side shocks: economic growth of the US, reconstruction of Europe and Japanese expansion, and the current- rapid growth of China.

Recent developments in commodity prices have rekindled interest in understanding the determinants of commodity prices. Some have tried to account for co-movement by controlling for both macro variables and micro-level inventory and harvest data (Ai, Chatrath, and Song 2006; Lescaroux 2009; Frankel and Rose 2009). Ai, Chatrath, and Song (2006) use inventory and harvest data in addition to macroeconomic variables for five commodities: wheat, corn, oats, soybeans, and barley. They claim that macroeconomic variables alone fail to explain these correlations, while supply factors in conjunction with macroeconomic variables capture a majority of co-movement between commodities. Using monthly data for 51 commodities, Lescaroux (2009) explores if there is excess co-movement between oil and other commodity prices. Lescaroux observes very high correlation between commodities and oil, especially metals and agriculture raw materials. Correlation is not as strong for sugar, meat, and seafood prices, and it is consistently weak for cereal prices. However, after taking into account stock level data, correlation is significantly reduced. Both these papers conclude that co-movement between commodities is due to common demand and supply shocks. However, a closer look reveals that the commodities included in the analysis may have consumption and production complementarity/substitutability and may not be “unrelated.” Four out of five commodities used in the analysis of Ai et al. (2006) belong to the grains category, and Lesacroux (2009) paper includes stock level data for industrial metals only. If commodities are related, it is not surprising to find that common demand/supply shocks can explain a majority of their co-movement. The more interesting question is if macro and micro factors can explain co-movement between *seemingly unrelated* commodities.

Frankel and Rose (2010) use both macro (global GDP, interest rate) and micro (inventory levels, measures of uncertainty, spot-forward spread) determinants of prices for 11 commodities. They run regression using different statistical techniques and specifications (bivariate regression, panel regression, vector error correction model, with log and first-difference specification). Although macro factors like global demand are significant, they find that micro factors are more important. Furthermore, by adding into the model rate of change of spot price in the previous period, as a measure of bandwagon effects, they also find evidence of speculation.

Another approach that has been common in recent years is to use factor analysis to separate out common factors and idiosyncratic trends between prices of a large number of commodities. This methodology makes it possible to assess the importance of common factors in explaining commodity prices and how it has evolved over time. The extracted factors are then included in a vector autoregression (VAR) model to examine if they can be explained by macroeconomic variables. Lombardi, Osbat, and Schnatz (2010) use principal component analysis to identify common factors that account for developments in 15 non-energy commodity prices from 1975-2008. They find that two factors are important in explaining a majority of price developments in the metals and food category. Factor augmented VAR (FAVAR) models that include these factors reveal, among other things, that shock to global economic activity increases the price of oil and metals factor; but there is less evidence of its impact on the food factor. Surprisingly they find no evidence of impact of oil-shocks on non-energy commodity prices. Byrne, Fazio, and Fiess (2011) use Panel Analysis of Nonstationary Idiosyncratic Components (PANIC), a method developed by Bai and Ng (2004) that allows for non-stationarity in time-series data, on annual historical prices of more than 100 years: 1900-2008. The extracted common factor is then included in a FAVAR model along with macroeconomic variables (interest rate, demand-supply shocks). Impulse response functions from the FAVAR model reveal that interest rate and uncertainty have significant effects on prices.

Vansteenkiste (2009) uses dynamic factor analysis on monthly price data for 32 non-oil commodities for a period 1957-2008. The 32 commodities are first divided into 4 sub-groups[63] that are formed exogenously by pooling together commodities which are known to be related. The idea is that the common factor affects all commodities, while there might also be other shocks that are transmitted within a subgroup. Vansteenkiste claims that the common factor is more important than the sub-group-specific factors, although variance decomposition shows that the common factor is only important for 9 of the 32 commodities. The common factor was very important during the 70s-80s, and in recent years it has become increasingly important in driving non-fuel commodity prices. FAVAR reveals that macroeconomic variables explain about 70 percent of the variance in the common factor. The paper concludes that co-movement is due to macroeconomic fundamentals and there is no “excess” co-movement due to speculation.

Criticizing Vansteenkiste’s exogenous clustering method, Savascin (2011) argues that if subgroup-specific factors are not taken into account, then the

[63] coffee-cocoa, cotton-maize-sugar-wheat, palm oil-soybean oil, copper-zinc-lead

importance of common factor in explaining cross-commodity co-movements is overestimated. Savascin uses an endogenous clustering method first used by Francis, Owyang, and Savascin (2011) on 42 non-energy commodity prices for 1980-2011 and finds four clusters: (1) timber (logs and wood), (2) grains and vegetables, (3) food, metals and agricultural materials (except iron); (4) coffee and iron. This clustering method reveals that the sub-groups formed are quite different from that of an exogenous clustering method, as it includes seemingly unrelated products into the same group. Variance decomposition shows that the sub-group-specific factors are more important than the common factor in explaining commodity price developments. Based on this result, Savascin claims that explanations for the 2008 price rise based on world demand are invalidated as the world factor does have a strong effect on corn, rice, wheat, meat, soybeans, soybean meal.

Tang and Xiong (2010) is one of the few papers that seek to determine the role of speculation in the commodity prices by studying the differences in co-movements between commodities that are on or off the S&P-GSCI. They carry out panel regression of returns of commodities on returns of crude oil, along with a set of macroeconomic variables: emerging market equity index, S&P500 equity index, bond index, US dollar index. Results show that before 2004, most non-energy commodities had a small and positive correlation with oil, while some soft and livestock commodities even had a small negative correlation. After 2004 there was a significant increase in correlation of non-energy commodities with oil, a trend which is more pronounced for index commodities than for non-indexed. Tang and Xiong thus conclude that financialization led to higher correlation between commodities.

Although there have been many studies on understanding commodity price co-movements, the focus in recent years has been on identifying macroeconomic determinants of commodity prices. The discussion of *excess* co-movement that had initially begun the debate on co-movement has taken a back seat. The aim of this chapter of the dissertation will be to bring *excess* co-movement back into the picture. I will do so by adding a measure of financialization into the empirical analysis, this will provide us a more direct way to examine the role of financialization in the recent rise in comovement of commodity prices.

4.3 Data Sources

I use the following datasets for the empirical analysis:

1. Commodity spot prices: monthly prices for 42 commodities that include energy, metals, livestock, and agricultural commodities. The dataset is available through International Financial Statistics, IMF. Detailed description of the data is provided in Appendix 4.1.[64]

2. Measures of financialization: ideally we want a measure to quantify the process of financialization of the commodity futures market. However, due to the lack of good data we cannot accurately differentiate positions of different kinds of trader positions (discussed in detail in Chapter 3). Instead I use ***Total Open Interest*** as a proxy of financialization of the commodities market. Open interest is the total number of contracts that are open, and is a measure of the inflow of money into the futures market. To get an estimate of the total inflow of money into the futures market, I add up open interest across 23 commodities[65] and take the monthly average.

However, open interest across commodities is not of the same scale, futures contract represent different dollar values across commodities. To solve this weakness, I sum up the dollar values of open interest across the 23 commodity markets.

[64] A majority of the variables are spot prices, except for soybeans, soybean oil, soybean meal, and sugar. However, this should not be problematic as spot and futures prices are known to move together, with the futures prices leading spot prices (see Chapter 1 for more detailed discussion).

[65] CBOT, KCBOT, and MW wheat, corn, soybeans, soybean oil, soybean meal, oats, cotton, cocoa, sugar, coffee, live cattle, feeder cattle, crude oil, heating oil, natural gas.

$$OID_t = \sum_{i=1}^{n} OI_{i,t} \; P_{i,t}$$

Where, OID_t is the total open interest in terms of dollars in the commodities futures market at time t

$OI_{i,t}$ is the open interest of commodity i at time period t;

$P_{i,t}$ is the closing price of nearby futures contract[66] of commodity i at time period t;

This will provide us with an additional measure of financialization: ***Open Interest in Dollars***. The futures price data is from Pinnacle Data.[67]

3. Macroeconomic variables: as discussed before comovement of commodity prices may be due to common shocks from macroeconomics factors. To account for these, I include the following macroeconomic variables in the model.

Industrial Production Index for OECD and emerging markets, IFS, IMF: Demand side pressures from emerging markets have been identified as a factor that has led to recent rise in commodity prices. To account for this, I include the industrial production index (IP) of the following emerging markets: India, China, Russia, and Brazil. The 2008 commodity price spike also coincided with the collapse of the US sub-prime market and the global economic downturn that followed. I include IP of OECD countries in the model to account for the overall decrease in demand from OECD countries.

Federal Funds Rate, US Federal Reserve: There are three ways in which interest rates are expected impact commodity prices. First, low real interest rate lowers the cost of holding inventories. A high demand for inventories implies high total demand for commodities. Second, low interest rate increases the incentive to leave oil/minerals in

[66] Nearby futures contact is the contract with the closest settlement date, and it is by far the most heavily traded contract, so it is considered most important for price determination.

[67] https://www.pinnacledata.com/

the ground for the future than extract it today. This implies a lower supply of commodities thus higher prices. Finally, low interest rates means the cost of borrowing money is low and there is incentive for speculators to get out of the safe but low yield government bonds and get into to commodities futures market. (Calvo 2008, Frankel 2006)

US Nominal Broad Exchange Rate, US Federal Reserve: Since a majority of commodities are traded in the international market in US dollars, if the USD depreciates, then the price of the commodity in local currency will be lower and demand higher (Akram 2008). I will use the US nominal broad exchange rate index which is a weighted average of the foreign exchange values of the USD against the currencies of a large group of major US trading partners.

US Inflation, urban, all items less food and energy, Bureau of Labor Statistics: Inflation can raise the overall level of commodity prices. To ensure that the measure of inflation is not contaminated by rise in prices of food and energy, I use the change in core CPI.

Crude Oil Price (WTI), International Financial Statistics, IMF: The link between energy and food prices, through transportation and fertilizer costs, is well established. Soaring oil prices have also increased interest in biofuels, which has further strengthened the link between food and fuel. Crude oil prices thus, can be considered an important macroeconomic determinant of commodity prices. However, crude oil prices themselves may be influenced by financialization, therefore I show results for models both with and without crude oil prices.

4.4 Empirical Strategy

As the objective of this chapter is to study the cross-sectional correlation between prices of different commodities over time, panel data techniques that make use of cross-sectional information would be better than using commodity specific equations. However, including 42 commodities and macroeconomic variables along with their lags will quickly erode the degrees of freedom. Non-parametric dimension-reduction tools like factor analysis and principal component analysis have been used to reduce a large set of possibly correlated variables to a small number of uncorrelated factors or components that still contain most of the information of the data. I use a 2-step factor-augmented VAR (FAVAR) method of Bernanke, Boivin and Eliasz (2005).[68] The first step of the method is to extract underlying factors of commodity price movements using principal component analysis. In the second step, the extracted factor is included in a vector autoregressive (VAR) model along with relevant macroeconomic variables.

Under the factor model, commodity prices are decomposed into a small number of common factors, and idiosyncratic error terms that are commodity specific.

$$P_{it} = \lambda_i F_t + e_{it} \qquad 4.1$$

Where;
P_{it} = price of commodity i at time t
F_t = r X 1 vector of common factors
λ_i = vector of factor loadings for commodity i
e_{it} = idiosyncratic error term

Issues have been raised related to stationarity of the factor structure and consistency of the extracted factors. When e_{it} is stationary estimates of F and λ have been shown to be consistent. However, if e_{it} is I(1), the estimates are not consistent because the regression of P on F is spurious. We can get around this problem by using Panel Analysis of Nonstationary and Idiosyncratic Components (PANIC) method developed by Bai and Ng (2004) and extract consistent common and idiosyncratic

[68] Bernanke et al. (2005) use principal components analysis to extract a small number of unobservable factors that summarize the information about the economic environment contained in a large number of variables.

factors even when e_{it} is I(1). This is achieved by applying the method of principal components on first-differenced data. Taking first difference of equation 1 above yields:

$$\Delta P_{it} = \Delta F_t \lambda_i + \Delta e_{it} \qquad 4.2$$

Applying the method of principal components we get an estimate of ΔF_t, from which we can reconstruct the factor(s) in levels (F_t).

After exacting the common factor(s) using the PANIC method, the second step of the FAVAR method is to include the factor in a VAR model along with macroeconomic variables that are known to affect a given commodity. However, VAR technique requires stationarity of variables. If the variables are not stationary, test for cointegration must be carried out to check if the variables are cointegrated. If results indicate that the variables are not cointegrated then FAVAR on first-differenced data might be appropriate. However, if the variables are cointegrated, then the FAVAR model will be mis-specified, and a Factor Augmented Vector Error Correction (FAVEC) model should be used instead. FAVEC model is a natural generalization of the FAVAR model. Banerjee and Marcellino (2008) show that in case of cointegration, FAVEC improves on the results from FAVAR.

4.5 Empirical Results

Key results of the empirical analysis are: i) Pearson's correlation coefficient and cluster analysis show a significant rise in comovement between commodity prices in recent years; ii) the underlying common factor(s) and open interest were moving in the opposite direction until 2002, however since then they have been moving in the same direction, and during 2008-11, they show very strong correlation; iii) the extracted common factor(s) are I(1); and iv) both the proxies of financialization -- total open interest and total open interest in dollars-- are significant in explaining the common factor(s), after accounting for other macroeconomic factors.

The first step in the empirical analysis is to provide evidence that in fact comovement between commodities has increased in recent years. A general rise over time in Pearson's correlation coefficient among commodities is the simplest method to do so. Figure 4B (appendix 4.2) shows correlation coefficient for select commodities (including grain, energy and soft commodities, livestock, and metals) for two time-periods 1995-2005 and 2006-2012. Except for a few cases, correlation is higher in the second time-period among most commodities. Even correlation between commodities that are seemingly unrelated such as copper and grains, have risen in the second-time period.

Cluster analysis provides another method to analyze comovement among commodities. I use a single-linkage, agglomerative hierarchical clustering method. Under this method, each commodity is initially in its own cluster; then the pair of clusters that have the smallest distance among them are merged into one. The distance (dissimilarity measure) between two commodities is defined as (1-correlation coefficient). The distance between two clusters is defined as the smallest distance from any commodity of one cluster to any commodity of the other cluster. Starting from singleton clusters, each step merges two clusters with the smallest distance; and finally after a number of steps, we end up with a single cluster containing all commodities.

The result of cluster analysis can be shown by a dendrogram. In Figure 4C (appendix 4.2), the first dendrogram shows gasoline and crude oil (WTI) have the smallest distance (or dissimilarity measure), and so they are the first to be clustered together. In the next step, natural gas is added to the gasoline-crude oil cluster; while corn and sorghum is clustered together and so on. At the end of the process all the 42 commodities are grouped together. The second dendrogram is similarly constructed for the 2006-2012 time period. A comparison of the two dendrograms reveals that the dissimilarity measure between commodities has reduced substantially in the second period. Another way of looking at it is, if we take a cut-off point of say 0.2 dissimilarity measure (or correlation coefficient of at least 0.8) then in the first period we can identify 5 clusters; whereas in the second period, a majority of the commodities (27 out of 42) are grouped together in the same cluster. Both the correlation matrices and cluster analysis reveal that comovement among commodities has increased in recent years. In the next step, I examine the role of financialization in explaining this rise in comovement.

Before, moving on to the PANIC method, I carry out unit root tests to understand stationarity properties of commodity prices. DFGLS and Dickey-Fuller Unit root tests show that except iron ore, all other commodities are I(1). Iron ore is excluded from the rest of the empirical analysis. As Principal Component Analysis (PCA) is not scale-invariant, I standardize the data (demean and divide by variance) such that the mean of the series is 0 and variance is 1. Then, I first-difference the data and perform PCA to estimate the common factors and factor loadings.

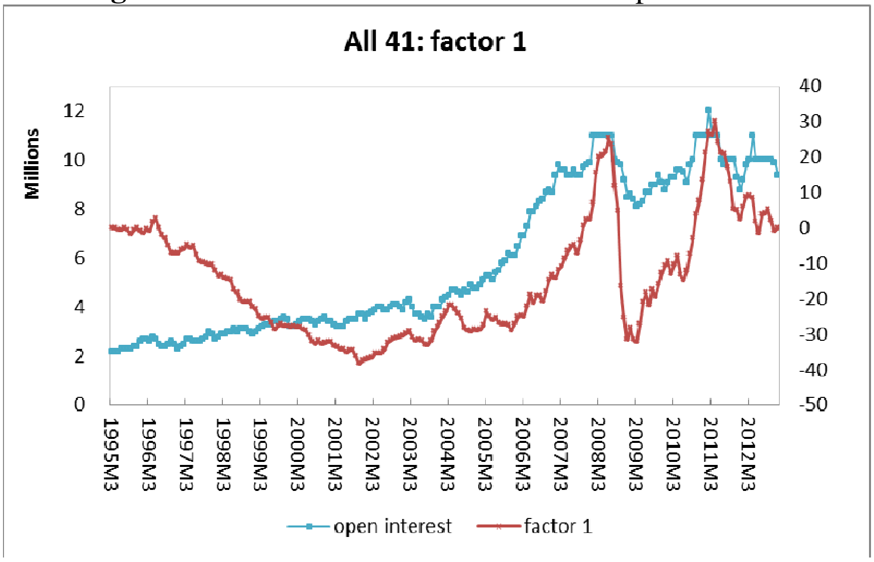
I carry out PANIC on the i) the entire set of 41 commodities, and the following groups of commodities: ii) grains & oil seeds, iii) energy & metals, iv) other soft commodities, and v) commodities that are part of S&P GSCI and DJ-UBS commodity index. Commodities included in each group are listed in Table 4A (appendix 4.1). The purpose of applying the PANIC method on different groups of commodities is so that we can identify shocks that might be specific to a particular commodity group. The common factor might be overestimated if we ignore these group-specific comovements. (Vansteenkiste 2009)

Components with eigenvalues > 1 are listed in Table 4B.1 (appendix 4.3). For the first group, containing all commodities, the first factor is the most important as it explains 22 percent of the variance in prices. The first factor of grains & oil seeds, energy & metals, other softs, and indexed commodities explain 34.49 percent, 46.08 percent, 19.56 percent, and 30.24 percent of the variance in prices respectively (see Table 4C.1 in the appendix). Table 4B.2 summarizes the variance explained by factor 1 for each of the 41 commodities. As can be observed, the retained factor 1 explains more of the variance in some commodities and less in others; for soybean oil and aluminum it explains 28 and 22.4 percent of the variance respectively, while for rice it only explains 5 percent of the variance. Similarly results for the group-specific factors are summarized in Table 4C.2 (in the appendix).

As the extracted factors are in first-difference, I reconstruct the factors in levels using the relationship $f_{t+1} = \Delta f_{t+1} + f_t$ and assuming $f_1 = 0$. Figure 4.1 below graphs reconstructed Factor 1 for all commodities along with Total Open Interest. As can be seen, the two series appear to be moving in the opposite direction until early 2002; Factor 1 was declining while open interest was slowly increasing. Since 2002, the two series move in the same direction, and with very strong correlation between 2008 and 2011. Similar trends in correlation can be observed between Total Open Interest and extracted group-specific factors (Figure 4D in appendix 4.2).

To understand the time series properties of the extracted factors, I carry out unit root tests. I also perform unit root tests on the macroeconomic variables and the two proxies of financialization: total open interest and total open interest in dollars. Results show that all the series are I(1) (see Tables 4D and 4E in Appendix 4.3). Given all the variables are I(1), the next step in the analysis is to use a FAVEC model to examine if macroeconomic variables and proxies of financialization can explain developments in the extracted factor(s).

Figure 0.1: Trends in Factor 1 and Total Open Interest



To estimate the optimum lag length for the FAVEC model, I estimate a VAR model using maximum lag given by Ng-Perron criterion. For all models, Akaike Information Criterion (AIC), Hanna-Quin information criterion (HQIC), and Schwarz information criterion (SBIC) show 14, 2 and 1 lags respectively. I proceed with 2 lags and carry out Johansen's cointegration test using both trace statistics and maximum eigenvalue test. Table 4F (appendix 4.3) details the results. For factor 1, with Total Open Interest as proxy for financialization, trace test shows that we cannot reject the null hypothesis that rank ≤ 2; while eigenvalue test shows that we cannot reject the null hypothesis that rank = 2. As results from both tests are consistent, I proceed with rank = 2. I also carry out tests for the group-specific factors. In some cases, results from trace and eigenvalue tests give inconsistent results. For example, for grains factor with Total Open Interest as proxy, trace test cannot reject the null hypothesis that rank ≤ 2; while eigenvalue test cannot reject the null hypothesis that rank = 1. In such cases, I proceed with results given by eigenvalue test as the null hypothesis of the eigenvalue test has a sharper alternative hypothesis.[69]

The VEC model assumes that residuals approximate white noise. I examine this assumption by performing Lagrange Multiplier (LM) test for serial correlation and Jarque-Bera normality tests. Unfortunately, with the 2 lags model, residuals show evidence of serial correlation and excess skewness and kurtosis. I repeat the exercise with 14 lags (given by AIC) and in this case residuals are not serially correlated. Table 4G (appendix 4.3) summarizes the results for the normality tests with 14 lags model. For factor 1, the residuals are skewed for 3 variables in each model: US exchange rage, IP of OECD and Russia for the first model, and exchange rate, IP of India and Russia for the second model. The residuals are kurtotic for exchange rate and IP of Russia for both models. Results for the group-specific factors are detailed in Table 4G.[70] Skewness is considered a more important assumption than kurtosis for normality of residuals.[71] Given these results I proceed with the rest of the empirical analysis using 14 lags.

Table 4H (appendix 4.3) summarizes results of unrestricted VEC model for Factor 1. I carry out four models including a proxy for financialization, with and without crude oil prices. For Factor 1, the first cointegrating equation in each model establishes relationship between Factor 1 and proxies of financialization, total open interest and total open interest in dollars. The proxies are significant and have the expected negative sign in all four models. This implies that Factor 1 and the proxies of financialization are cointegrated and move in the same direction.

For factor 1, IP of OECD is not significant for M1, M2, and M3; while IP of China is not significant for M4. I restrict these coefficients to be 0 and re-estimate the

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[69] Enders (2010), p. 392.

[70] crude oil is excluded from the energy factor model.

[71] Normality test is more sensitive to deviations from normality due to skewness than kurtosis because the variance of skewness is smaller than the variance of kurtosis (Juselius 2006, p.75).

model.[72] Similar restrictions are also placed for group-specific factor models. Table 4.1 below shows the results of restricted FAVEC model for Factor 1. Both proxies of financialization, total open interest and total open interest in dollars are significant in all cases. They also have the expected negative sign. These results appear to be robust. The industrial production indices of the emerging markets (India, China, Brazil, and Russia) are also significant for most cases, although IP of India has a positive sign while the sign for IP of Russia fluctuates. Crude oil is only significant in the M1, but it has a positive sign. The USD exchange rate is significant in all four models, and has the expected positive sign. Overall, the results factor 1 are provide evidence to support the thesis that financialization is a factor in explaining the recent comovement of commodity prices, after accounting for other macroeconomic variables.

Table 0.1: Restricted VECM Results for Factor 1

	M1	M2	M3	M4
exchange rate	1.013***	1.162***	0.987***	0.712***
IP OECD	--	--	--	0.337***
IP India	1.842***	2.167***	0.870***	0.920
IP China	-1.387***	-1.825***	-0.263**	--
IP Brazil	-1.553***	-2.847***	-1.424***	-1.46***
IP Russia	-0.858***	0.576**	0.846***	0.719***
Crude oil	1.198***	--	-0.081	--
Total OI	-1.E-5***	-5.9E-6***	--	--
Total OID	--	--	-2.E-8***	-2.1E-8***
constant	-0.493	-38.769	-220.66	-211.548

Factor 1 = 1. *** 1% significance, ** 5% significance, * 10% significance

Table 4J (appendix 4.3) summarizes results for group-specific factors. For the grains factor, total open interest is significant but has the positive sign in the model with crude oil (M1), and it is not significant in the model without crude oil (M2); while total open interest in dollars is significant and has the expected negative sign in both models (M3 and M4). For energy commodities, total open interest is significant and has the expected sign but total open interest in dollars is significant but has the

[72] chi-square tests reveal that these restrictions are not rejected.

positive sign. For softs and indexed commodities, proxies of financialization are significant and have the expected sign for 3 out of the 4 models (M1, M3 and M4 for softs and M1, M2 and M3 for indexed). Overall, the results for group-specific factors are not as strong and robust as they were for factor 1, although most of models (10/16) do show that the proxies explain the recent rise in comovement. One reason for the inconsistent results for group-specific factors is that commodities included in the groups are related; they are either complements or substitutes in demand or supply. For example, grains group consists of commodities including wheat, corn, oats, barley, oil seeds; similarly the energy group consists of crude oil, gasoline, natural gas, and a range of industrial metals. Commodity specific demand and supply factors may be more important in explaining comovement between these related commodities rather than macroeconomic factors, including financialization of the commodities futures market.

4.6 Conclusion

In this chapter, I explored one of the distinctive features of the 2008 commodity price developments -- the remarkably synchronized rise and fall of prices of unrelated commodities. Unlike related commodities, that are either complements or substitutes in production or consumption, comovement of prices of unrelated commodities cannot be explained by commodity specific demand and supply shocks. Only factors that simultaneously affect several commodity markets such as: demand from emerging markets, devaluation of the US dollar and financialization of the commodities futures market, can explain such comovement. I identify three ways in which financialization may cause co-movement between commodity prices: i) if commodity futures are bought and sold not based on fundamentals, but based on pre-set weights of a commodity index; ii) liquidity effects of commodity speculators trade in two or more commodity markets; and iii) transmission of shocks in energy markets to other commodities due to the higher weight of energy commodities in popular commodity indices.

For the empirical analysis, I extract common factors from 41 commodities and its sub-groups using the PANIC method of Bai and Ng (2004). The extracted common factor(s) were moving in the opposite direction as open interest until 2002, however since then they have been moving in the same direction, with very strong correlation during 2008-11. The extracted factor(s) are then included in a FAVEC model along with other macroeconomic factors including: industrial production indices of OECD and major emerging countries, inflation, USD exchange rate, and crude oil prices. Instead of assuming the *excess* comovement that is unexplained by macroeconomic factors is due to speculation, like previous studies, I also add a measure of financialization (total open interest and total open interest in dollars) in the FAVEC model. This is a stronger and more direct piece of evidence of the role of financialization in explaining comovement of commodity prices than previously provided in the literature.

Results show that both proxies of financialization are significant and have the expected sign for the common factor (Factor 1) extracted using all 41 commodities. This implies that financialization of the commodities futures markets explains the rise in comovement between unrelated commodity prices, after accounting for macroeconomic factors. Results for the group-specific factors are not as strong; the proxies of financialization are significant and have the expected sign for 10 out of the 16 models. One reason for the inconsistent results for group-specific factors is that commodities included in the groups are related, so commodity specific demand and supply factors may be more important than macroeconomic factors in explaining comovement between these commodities. Overall, my empirical analysis provides strong evidence to support the thesis that financialization of the commodities futures market has led to increasing comovement between unrelated commodity prices.

Appendix 4

Appendix 4.1: Data details and sources

Commodity Prices, International Financial Statistics, IMF, Monthly

Description taken from the IFS database

1.	**Aluminum**: LME, standard grade, spot price, 99.5% minimum purity, CIF UK ports, US$ per metric ton.
2.	**Bananas**: Central America and Ecuador, first class quality tropical pack, US importer's price FOB U.S. Ports, US$ per metric ton.
3.	**Barley**: Canada, no.1 Western Barley, spot price, Winnipeg Commodity Exchange, US$ per metric ton.
4.	**Beef**: Australia and New Zealand, frozen boneless, 85% visible lean cow meat, US import price FOB US port of entry, US cents per pound.
5.	**Cocoa Beans:** New York and London, International Cocoa Organization daily price, Average of the daily prices of the nearest three active future trading months. CIF US and European ports, US$ per metric ton.
6.	**Coconut Oil:** Philippines/Indonesia, US $ per metric ton.
7.	**Coffee (Brazil):** Unwashed Arabica, Santos No. 4, ex-dock, New York
8	**Coffee (Uganda):** Robusta, New York Cash Price, Cote d'Ivoire Grade II, and Uganda Standard. Prompt shipment, ex-dock, New York
9.	**Copper**: United Kingdom, grade A cathode, LME spot price, CIF European ports, US$ per metric ton.
10	**Corn (Maize):** United States. No.2 Yellow, FOB Gulf of Mexico, US$ per metric ton.
11.	**Cotton**: Cotton Outlook, Liverpool Index A, Middling 1-3/32 inch staple, CIF Liverpool, US cents per pound.
12.	**Crude Oil WTI:** United States, West Texas Intermediate (WTI), 40 API, spot, FOB midland Texas, US$ per barrel.
13.	**Gasoline**: regular unleaded, Petroleum Product Assessments, US cents per gallon
14.	**Groundnuts:** Any origin, 40 to 50 count per ounce, in-shell Argentina, US $ per ton.
15.	**Hides**: United States, Heavy native steers, over 53 pounds, wholesale dealer's price, Chicago, fob Shipping Point, US cents per pound.
16.	**Iron Ore**: Brazil, Caraja fines, 67.55 percent FE content, contract price to Europe, FOB Ponta da Madeira. US cents per dry metric ton unit.
17.	**Jute**: Raw Bangladesh, FOB Chittagong/Chalna, US $ per ton.
18.	**Lamb**: New Zealand, frozen, wholesale price at Smithfield Market London. US cents per pound.
19.	**Lead**: United Kingdom, 99.97% pure, LME spot price, CIF European Ports, US$ per metric ton.
20.	**Linseed Oil**: Any Origin, ex-tank Rotterdam, US $ per ton.
21.	**Natural Gas**: United States, Natural Gas Spot Price, Henry Hub, Louisiana, US$ per Thousands of Cubic Meters.
22.	**Nickel**: United Kingdom, LME melting grade, spot, CIF North European Ports, US$ per ton.
23.	**Olive Oil**: United Kingdom, extra virgin less than 1% free fatty acid, ex-tanker price U.K., US$ per metric ton.
24.	**Oranges**: France, miscellaneous oranges CIF French import price, US$ per metric ton.
25.	**Palm oil**: Malaysia, Crude Palm Oil Futures (first contract forward) 4-5 percent FFA, US$ per metric ton
26.	**Pepper**: Malaysia, Black, average US wholesale price, bagged, carlots, FOB New York. US cents per pound.
27.	**Poultry (chicken)**: United States, Whole bird spot price, Ready-to-cook, whole, iced, Georgia docks, US cents per pound.
28.	**Rice**: Thailand, 5 percent broken milled white rice, Thailand nominal price quote, FOB Bangkok, US$ per ton.
29.	**Rubber**: Malaysia, No.1 Smoked Sheet, FOB Malaysia/Singapore ports, US cents per pound
30.	**Shrimp**: United States, No.1 shell-on headless, 26-30 count per pound, Mexican, New York port, US cents per pound.
31.	**Sorghum**: United States, No 2 Yellow, FOB Gulf of Mexico ports, US $ per ton.
32.	**Soybeans**: United States, Chicago Soybean futures contract (first contract forward) No. 2 yellow and par, US$ per metric ton.

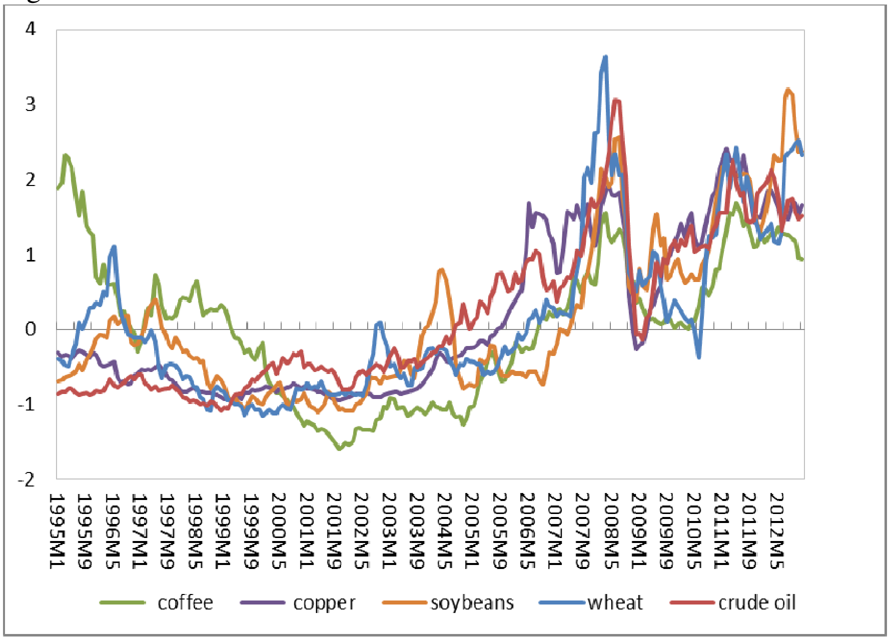
33.	**Soybean Meal**: United States, Chicago Soybean Meal Futures (first contract forward) Minimum 48 percent protein, US$ per metric ton.
34.	**Soybean Oil**: United States, Chicago Soybean Oil Futures (first contract forward) exchange approved grades, US$ per metric ton.
35.	**Sugar**: United States import price, contract no.14 nearest futures position, US cents per pound.
36.	**Sunflower oil**: United Kingdom, US export price from Gulf of Mexico, US$ per metric ton.
37.	**Swine Meat (pork)**: United States (Iowa), 51-52% lean hogs, US cents per pound.
38.	**Tea:** Mombasa, Kenya, Auction Price for best PF1, Kenyan tea. US cents per kilogram.
39.	**Tin**: Any origin, United Kingdom LME spot price, standard grade, spot, CIF European ports. US$ per metric ton.
40.	**Wheat**: United States, No.1 Hard Red Winter, ordinary protein, FOB Gulf of Mexico, US$ per metric ton
41.	**Wool 48's**: Austraila-New Zealand, coarse wool 23 micron, Australian Wool Exchange spot quote, US cents per kilogram.
42.	**Zinc**: United Kingdom, LME, high grade 98% pure, spot, CIF UK ports, US$ per metric ton.

Table 4A: Commodity sub-groups

Grains & oil seeds	barley, coconut oil, groundnuts, linseed oil, corn, olive oil, palm oil, rice, sorghum, soybeans, wheat, soybean meal, soybean oil, sugar, sunflower oil
Energy & metals	crude oil (WTI), gasoline, natural gas, aluminum, coppers, lead, nickel, zinc
Soft commodities	Cocoas, coffee Brazil, coffee Uganda, cotton, jute, sugar, teas, bananas, oranges, pepper
Indexed	wheat, corn, soybeans, coffee, sugar, cocoa, cotton, live cattle, feeder cattle, crude oil, heating oil, gasoline, natural gas, zinc, nickel, aluminum, copper, lead

Appendix 4.2: Figures

Figure 4A: Price Trends in Select Commodities



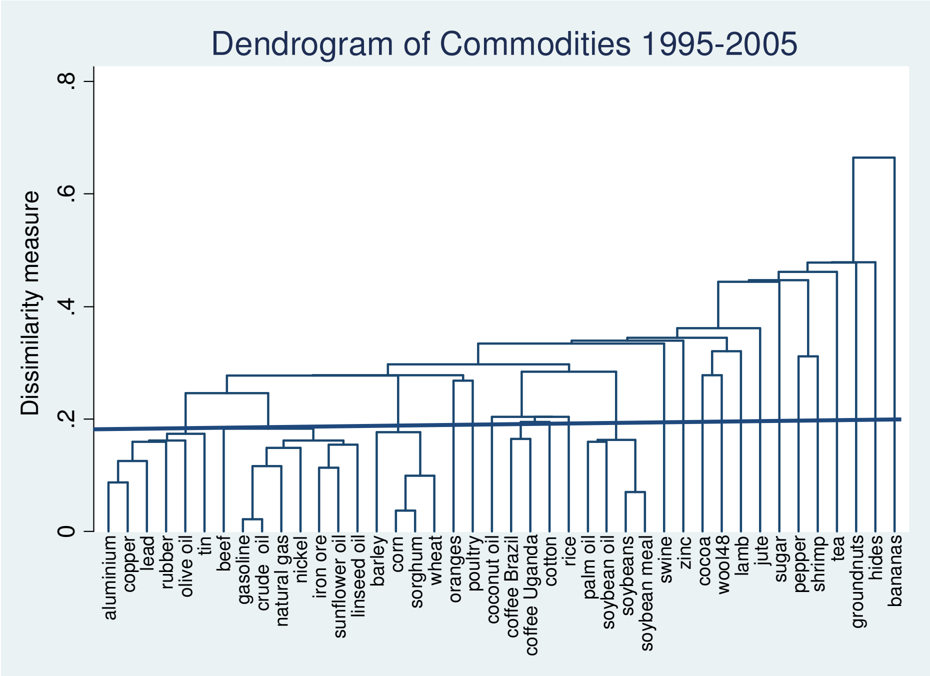
Standardized by demeaning and dividing by standard deviation of each series
Source: IFS, commodity prices

Figure 4B: correlation matrix

	wheat	corn	soybeans	soy. oil	sugar	cocoa	coffee	cotton	copper	crude oil
wheat	1									
corn	0.8742	1								
	0.7713									
soybeans	0.6441	0.6991	1							
	0.8142	0.9144								
soy. oil	0.5888	0.6062	0.8375	1						
	0.8497	0.8943	0.9306							
sugar	0.4835	0.4407	0.2481	0.4308	1					
	0.2087	0.5768	0.4659	0.5271						
cocoa	0.3751	0.2519	0.373	0.5191	0.3802	1				
	0.2583	0.4366	0.5721	0.56	0.5646					
coffee	0.3498	0.4221	0.4435	0.4625	0.3617	0.0903	1			
	0.5075	0.7877	0.6276	0.7137	0.8736	0.4629				
cotton	0.5792	0.6181	0.5835	0.6514	0.5566	0.1328	0.7067	1		
	0.4353	0.6324	0.5297	0.629	0.7986	0.5536	0.8521			
copper	0.4672	0.2561	0.4046	0.4564	0.0914	0.1171	0.3478	0.3375	1	
	0.5326	0.5941	0.4918	0.6643	0.5469	0.2849	0.63	0.6467		
crude oil	0.0393	-0.195	0.0354	-0.0206	-0.3646	0.0563	-0.2876	-0.3171	0.6636	1
	0.6958	0.6857	0.7079	0.8461	0.375	0.3583	0.5463	0.4705	0.735	

Pearson's correlation coefficient: first row 1995-2005, second row 2006-2012
Source: author's own calculations

Figure 4C: Dendrograms



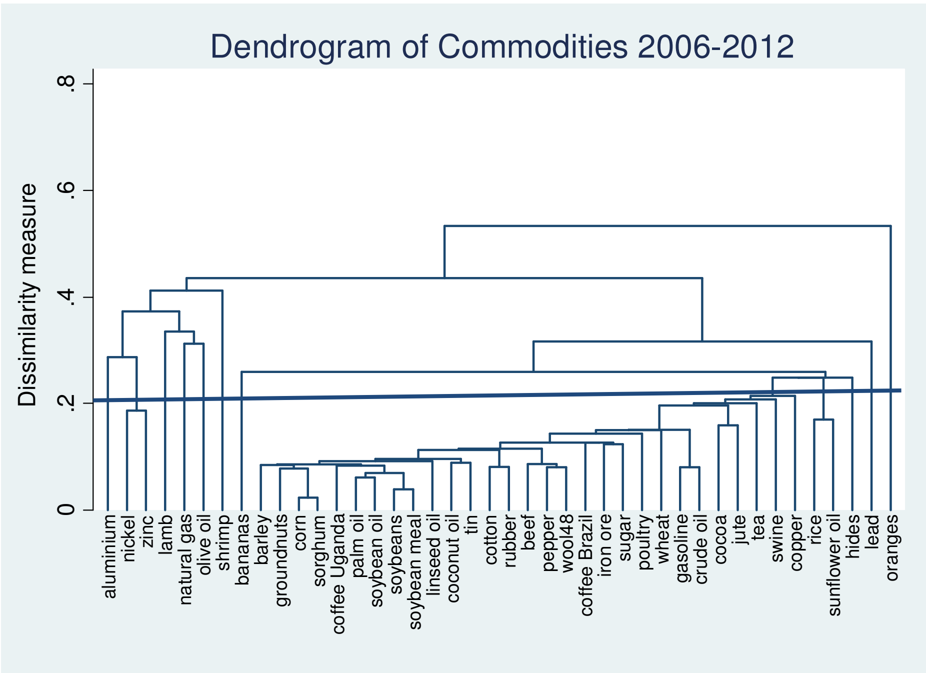
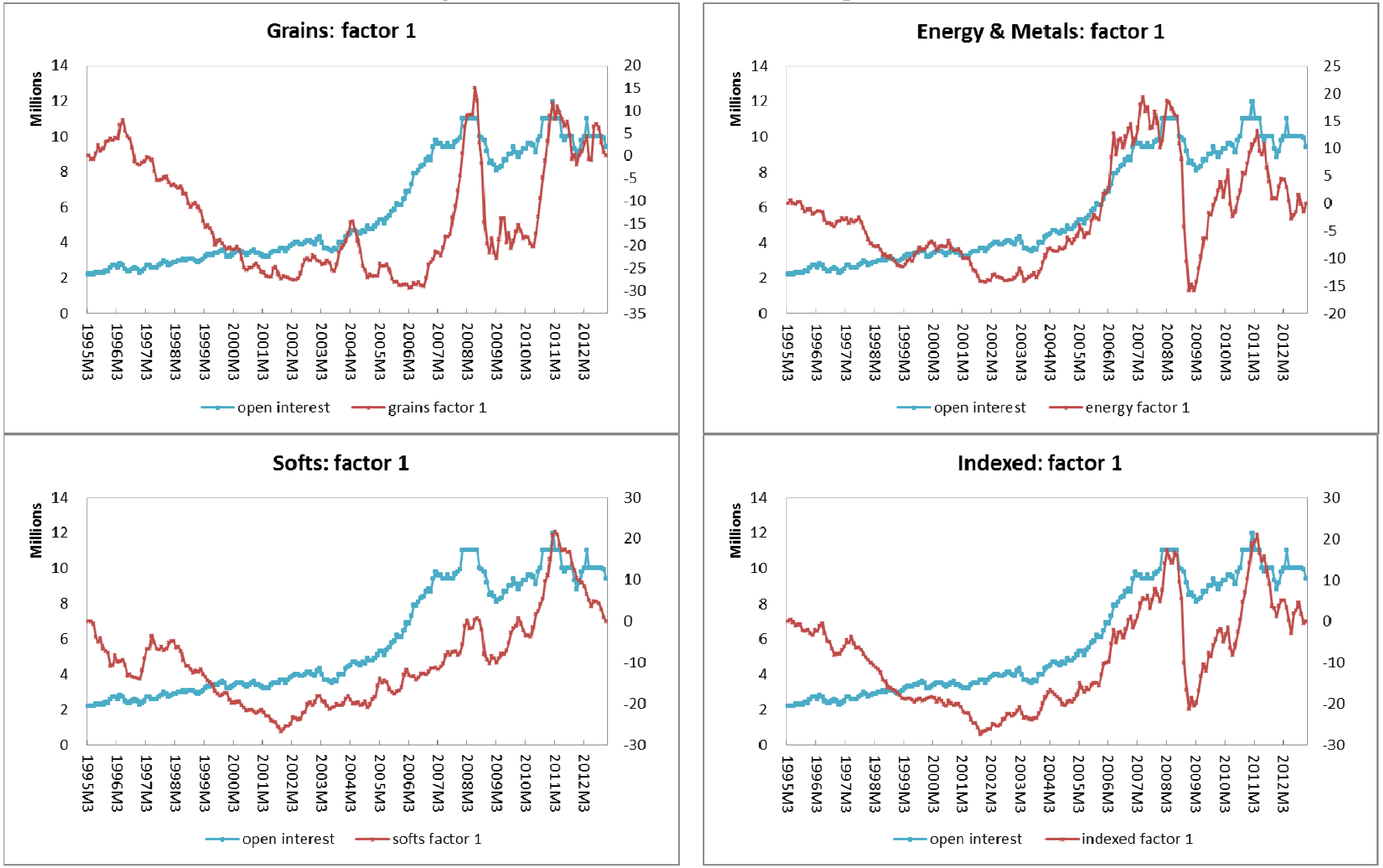


Figure 4D: Extracted Factors and Total Open Interest



Appendix 4.3: Tables

Table 4B: Results of PCA on All Commodities

Table 4B.1: Components and Eigenvalues

	Eigenvalues	Cumulative variance explained
Component 1	**9.0521**	**0.2208**
Component 2	2.7390	0.2876
Component 3	2.1819	0.3408
Component 4	1.8119	0.385
Component 5	1.6467	0.4252
Component 6	1.4663	0.4609
Component 7	1.4190	0.4955
Component 8	1.3502	0.5285
Component 9	1.2807	0.5597
Component 10	1.2178	0.5894
Component 11	1.1788	0.6182
Component 12	1.0984	0.6449
Component 13	1.0754	0.6712
Component 14	1.0284	0.6963

Table 4B.2: Variance explained by factor 1

All commodities	Variance explained
Aluminum	0.2242
Banana	0.0346
Barley	0.2153
Beef	0.0963
Cocoa	0.1381
Coconut oil	0.2252
Coffee Brazil	0.1314
Coffee Uganda	0.1271
Copper	0.2361
Cotton	0.145
Gasoline	0.2073
Groundnuts	0.0914
Hides	0.049
Jute	0.0447
Lamb	0.106
Lead	0.1498
Linseed oil	0.1601
Corn	0.2244
Natural gas	0.0702
Nickel	0.1441
Olive oil	0.0702
Oranges	0.0629
Palm oil	0.2326
Pepper	0.0358
Crude oil (WTI)	0.2248
Rice	0.0562
Poultry	-0.0021
Rubber	0.2087
Shrimp	0.0041
Sorghum	0.1872
Soybeans	0.2415
Soybean meal	0.1853
Soybean oil	0.2799
Sugar	0.0839
Sunflower oil	0.1295
Swine	0.032
Tea	0.0543
Tin	0.2263
Wheat	0.1689
Wool48	0.1617
Zinc	0.1434

Table 4C.1: Components and Eigenvalues for group-specific factors

	Eigenvalues				Cumulative variance explained			
	grains	Energy& metals	softs	indexed	grains	Energy& metals	softs	indexed
Component 1	5.1736	3.6866	1.9558	4.8379	0.3449	0.4608	0.1956	0.3024
Component 2	1.7030	1.3695	1.3023	1.8573	0.4584	0.632	0.3258	0.4185
Component 3	1.3220		1.1905	1.5556	0.5466		0.4449	0.5157
Component 4	1.1052		1.0893	1.1175	0.6202		0.5538	0.5855
Component 5	1.0732				0.6918			
Component 6								
Component 7								
Component 8								
Component 9								
Component 10								
Component 11								
Component 12								
Component 13								
Component 14								

Table 4C.2: Variance explained by factor 1

Grains		**Energy + Metals**		**Softs**		**Indexed**	
	variance		**variance**		**variance**		**variance**
Barley	0.0622	aluminum	0.4297	Cocoa	0.356	Aluminum	0.3436
Coconut oil	0.302	Gasoline	0.3537	Coffee Brazil	0.5434	Cocoa	0.2037
Groundnuts	0.1461	Copper	0.4579	Coffee Uganda	0.5198	Coffee Brazil	0.1959
Linseed oil	0.1924	Lead	0.3154	Cotton	0.3306	Coffee Uganda	0.1928
Corn	0.3496	Natural gas	0.0931	Jute	-0.106	Copper	0.3664
Olive oil	0.0528	Nickel	0.3182	Sugar	0.2826	Cotton	0.1933
Palm oil	0.332	Crude oil	0.3678	Tea	0.2053	Gasoline	0.3009
Rice	0.0506	Zinc	0.3687	Banana	0.158	Lead	0.2481
Sorghum	0.2876			Orange	0.1394	Corn	0.2681
Soybeans	0.3839			Pepper	0.144	Natural gas	0.0883
Wheat	0.2743					Nickel	0.2331
Soybean meal	0.3209					Crude oil	0.311
Soybean oil	0.3945					Soybeans	0.2815
Sugar	0.1309					Sugar	0.1054
Sunflower oil	0.1663					Wheat	0.225
						Zinc	0.2636

Table 4D: Clemente-Montanes-Reyes unit-root test with double mean shifts, IO model

	Break 1	Coefficient	Break 2	Coefficient	Test stat	Lags	Result
Factor 1	2006m8	2.3819**	2008m5	-1.5707*	-2.709	13	2 breaks, non-stationary
Grains	2007m7	2.7523**	2008m5	-2.2552**	-2.642	12	2 breaks, non-stationary
Energy	2005m10	3.0546**	2008m6	-1.7704**	-5.161	11	2 breaks, non-stationary
Softs	1998m3	-0.4639	2005m10	0.8603**	-3.289	3	1 break, non-stationary
Indexed	2005m10	1.7930**	2008m5	-0.9414*	-3.083	8	2 breaks, non-stationary
IP China	2004m5	0.8605**	2008m11	0.5772*	0.773	12	2 breaks, non-stationary
IP India	2003m3	2.791**	2005m10	2.623**	-3.023	13	2 breaks, non-stationary
IP Brazil	2003m7	1.9058**	2006m9	1.0071*	-3.622	0	2 beaks, non-stationary
IP Russia	1999m9	- 1.848*	2002m11	2.284**	-2.922	4	1 break, non-stationary
IP OECD	2003m7	2.422**	2008m5	-1.405	-3.020	10	1 break, non-stationary
Fed. funds	2000m10	-0.1094**	2007m8	-0.09291**	-5.491*	8	2 breaks, stationary
USD	2003m7	-0.70323	2007m1	-0.22677	-3.050	12	No break, non-stationary
Inflation	2003m10	0.02230	2008m2	-0.05061	-3.066	11	No break, non-stationary
Total OI	2003m8	169451.4**	2005m11	312777.97**	-4.207	13	2 breaks, non-stationary
Total OID	2006m8	1.64e+08**	2008m5	-3.88e+07**	-1.803	13	2 breaks, non-stationary

** 1% significance level, * 5% significance level. Critical value: -5.490, max-lag given by Ng-Perron, trim: 0.15, #m: month

Table 4E: DFGLS and Dickey Fuller Unit root tests for extracted factors

	Lags	DFGLS test	Dfuller w/ constant	Dfuller no constant	Dfuller w/ trend	Result
Factor 1 (level)	13	-1.292	-1.656	-1.079	-2.418	I(1)
Factor 1 (diff.)	12	-4.845**	-4.102**	-4.115**	-4.279*	
Grains (level)	11	-1.6635	-2.1589	-1.2352	-2.1907	I(1)
Grains (diff.)	11	-4.566**	-4.4489**	-4.46073**	-4.676**	
Energy (level)	13	-1.827	-1.806	-1.720	-2.409	I(1)
Energy (diff.)	12	-4.106**	-3.798*	-3.808**	-3.796*	
Softs (level)	11	-1.28342	-1.4314	-1.11884	-2.2051	I(1)
Softs (diff.)	7	-4.9513**	-5.0363**	-5.04113**	-5.068**	
Indexed (level)	13	-1.31078	-1.5209	-1.12074	-2.433	I(1)
Indexed (diff.)	12	-4.50525	-4.5677**	-4.58114	-4.669**	
IP OECD (level)	14	-3.038*	0.533	-2.563	-3.026	I(1)
IP OECD (diff.)	14	-1.521	-5.495**	-5.618**	-5.822**	
IP China (level)	14	-1.469	-0.542	-1.958	-2.216	I(1)
IP China (diff.)	14	-2.535	-4.830**	-4.819**	-4.806**	
IP India (level)	13	-1.092	2.363*	1.103	-1.762	I(1)
IP India (diff.)	12	-1.072	-1.880	-3.083*	-3.687*	
IP Brazil (level)	14	-1.724	-1.920	-0.508	-2.950	I(1)
IP Brazil (diff.)	14	-3.055*	-4.295**	-4.796**	-4.782**	
IP Russia (level)	12	-1.725	-0.041	-1.814	-2.451	Non-stationary
IP Russia (diff.)	11	-1.770	-2.770**	-2.771	-2.949	
Inflation (level)	13	-2.489	-0.500	-2.761	-2.726	I(1)
Inflation (diff.)	14	-1.543	-6.103**	-6.086**	-6.079**	
Nom. exchange rate (level)	2	-0.637	-0.122	-1.661	-2.247	I(1)
Nom. exchange rate (diff.)	9	-2.161	3.940**	-3.926**	-4.356**	
Total OI (level)	13	-1.66109	-0.56631	1.003016	-2.13189	I(1)
Total OI (diff.)	12	-2.8812*	-3.8247**	-3.5193**	-3.8152*	
Total OID (level)	13	-1.6157	-0.20705	0.734472	-2.30445	I(1)
Total OID (diff.)	12	-3.6932**	-4.7596**	-4.6157**	-4.879**	
Fed funds rate (level)	9	-3.097*	-1.465	-1.902	-3.177	I(1)
Fed funds rate (diff.)	14	-3.389*	-3.401**	-3.495**	-3.489*	

Table 4F: Johansen's Cointegration Test: Trace and Max Eigenvalue Tests

	All 41		Grains		Energy		Softs		Indexed	
Total Open Interest										
Rank	Trace stat	Max test	Trace stat	Max test	Trace stat	Max test	Trace stat	Max test	Trace stat	Max test
0	398.13	185.89	405.94	186.60	374.21	194.45	405.64	187.41	404.63	188.23
1	212.243	59.491	219.342	55.84**	179.760	62.125	218.23	57.732	216.40	66.37
2	152.7**	43.9**	163.5**	47.49	117.6**	44.65**	160**	42.8**	150.0**	43.1**
Total Open Interest in Dollars										
0	406.19	189.78	410.69	187.59	346.71	194.89	404.61	188.19	393.93	194.71
1	216.41	57.46	223.1	54.7**	151.82**	49.7**	216.42	51.3**	199.2**	50.1**
2	158.9**	48.13**	168.4	51.07			165**	47.1		
3			117.3**							

Table 4G: Normality Tests of the Residuals from VECM

	Skewness					Kurtosis				
	All 41	Grains	Energy	Softs	Indexed	All 41	Grains	Energy	Softs	Indexed
	Total Open Interest									
Factor 1	-0.024 (0.891)	0.229 (0.187)	-0.250 (0.150)	0.021 (0.903)	-0.228 (0.188)	2.830 (0.623)	3.194 (0.575)	4.064 (0.002)	3.991 (0.003)	2.748 (0.466)
inflation	-0.076 (0.662)	-0.106 (0.540)	-0.208 (0.229)	0.268 (0.111)	-0.168 (0.331)	3.011 (0.976)	3.366 (0.290)	3.155 (0.655)	3.158 (0.640)	2.782 (0.529)
USD	-0.542 (0.002)	-0.337 (0.051)	-0.364 (0.036)	0.218 (0.196)	-0.457 (0.008)	4.167 (0.001)	3.457 (0.187)	4.079 (0.002)	4.095 (0.001)	4.343 (0.000)
IP OECD	-0.459 (0.008)	-0.467 (0.007)	-0.088 (0.611)	-0.562 (0.001)	-0.311 (0.073)	3.530 (0.126)	3.948 (0.006)	2.913 (0.801)	3.882 (0.009)	3.226 (0.514)
IP India	0.048 (0.780)	-0.095 (0.584)	0.200 (0.248)	0.478 (0.005)	0.093 (0.593)	3.228 (0.510)	3.953 (0.006)	3.062 (0.858)	7.039 (0.000)	3.098 (0.777)
IP China	-0.273 (0.115)	-0.379 (0.029)	-0.300 (0.083)	-0.675 (0.000)	-0.284 (0.101)	3.201 (0.562)	3.387 (0.265)	3.691 (0.046)	4.027 (0.002)	3.494 (0.154)
IP Brazil	0.070 (0.684)	0.066 (0.705)	-0.012 (0.944)	-0.149 (0.376)	0.088 (0.611)	2.949 (0.883)	3.217 (0.532)	2.841 (0.646)	4.978 (0.000)	3.275 (0.427)
IP Russia	0.539 (0.002)	0.536 (0.002)	1.101 (0.000)	1.431 (0.000)	0.874 (0.000)	6.988 (0.000)	6.702 (0.000)	11.020 (0.000)	12.831 (0.000)	9.374 (0.000)
Crude oil	0.030 (0.862)	0.030 (0.864)	--	-0.198 (0.239)	-0.071 (0.682)	2.841 (0.647)	2.942 (0.866)	--	3.722 (0.032)	3.058 (0.866)
Total OI	-0.157 (0.365)	-0.190 (0.273)	-0.250 (0.148)	0.086 (0.610)	-0.308 (0.075)	3.419 (0.227)	3.895 (0.010)	3.842 (0.015)	5.002 (0.000)	3.259 (0.455)
	Total Open Interest in Dollars									
Factor 1	-0.072 (0.679)	0.087 (0.617)	-0.361 (0.037)	0.234 (0.177)	-0.234 (0.177)	2.879 (0.728)	4.259 (0.000)	4.458 (0.000)	2.741 (0.455)	3.458 (0.186)
inflation	-0.171 (0.322)	-0.113 (0.513)	-0.357 (0.039)	-0.363 (0.036)	-0.353 (0.042)	2.807 (0.577)	3.399 (0.249)	3.262 (0.449)	3.479 (0.167)	2.868 (0.703)
USD	-0.495 (0.004)	-0.297 (0.086)	-0.309 (0.074)	-0.325 (0.061)	-0.323 (0.062)	4.433 (0.000)	3.800 (0.021)	4.180 (0.001)	4.357 (0.000)	4.258 (0.000)
IP OECD	-0.339 (0.051)	-0.299 (0.084)	-0.407 (0.019)	-0.175 (0.311)	-0.458 (0.008)	3.552 (0.111)	3.131 (0.706)	3.231 (0.504)	3.060 (0.863)	3.544 (0.116)
IP India	0.492 (0.005)	0.476 (0.006)	0.069 (0.692)	0.104 (0.549)	0.226 (0.192)	3.364 (0.293)	4.198 (0.001)	3.450 (0.194)	4.055 (0.002)	3.239 (0.491)
IP China	-0.042 (0.810)	-0.515 (0.003)	-0.110 (0.524)	-0.233 (0.179)	-0.386 (0.026)	3.156 (0.652)	4.420 (0.000)	3.577 (0.096)	3.247 (0.476)	3.848 (0.014)

IP Brazil	0.048 (0.783)	-0.055 (0.751)	-0.084 (0.627)	-0.069 (0.691)	-0.041 (0.812)	3.044 (0.899)	3.233 (0.502)	2.920 (0.817)	3.400 (0.248)	3.321 (0.354)
IP Russia	0.591 (0.001)	0.344 (0.047)	0.888 (0.000)	0.543 (0.002)	1.080 (0.000)	6.140 (0.000)	4.513 (0.000)	9.739 (0.000)	5.957 (0.000)	11.226 (0.000)
Crude oil	0.011 (0.947)	0.157 (0.364)	--	-0.072 (0.677)	0.235 (0.174)	3.125 (0.718)	2.688 (0.367)	--	3.173 (0.618)	3.603 (0.082)
Total OID	-0.100 (0.562)	-0.043 (0.803)	0.087 (0.616)	-0.058 (0.736)	-0.187 (0.280)	3.012 (0.972)	2.960 (0.907)	2.683 (0.360)	3.014 (0.967)	3.246 (0.477)

Table 4H: Unrestricted VECM for Factor 1

	M1		M2		M3		M4	
	ce_1	ce_2	ce_1	ce_2	ce_1	ce_2	ce_1	ce_2
Factor 1	1	--	1	2E-18	1	2.E-18	1	
inflation	--	1	--	1	--	1	--	1
USD	1.094***	-0.002	0.949***	-2.E-4	0.902***	0.002	0.761***	0.004**
IP OECD	-0.237	-0.004	0.989*	-0.02***	0.223	-0.018***	0.272*	-0.020***
IP India	1.727***	0.006	3.828***	-0.03***	1.003***	0.001	1.027***	-0.004
IP China	-1.325***	-0.009***	-2.57***	0.013*	-0.253*	-0.011***	-0.108	-0.007*
IP Brazil	-1.412***	0.008	-5.523***	0.062***	-1.680***	0.024***	-1.579***	0.024***
IP Russia	-0.906***	0.007***	1.345***	-0.02***	0.960***	-0.011***	0.810***	-0.012***
Crude oil	1.271***	-0.016***	--	--	-0.142*	-0.001	--	--
Total OI	-1.E-5***	8.E-8***	-1.3E-5***	8.6E-8**	--	--	--	--
Total OID	--	--	--	--	-2.E-8***	8.E-11***	-2.1E-8***	9.7E-11***
constant	6.687	-0.954	-19.196	0.018	--	-2.211	--	-2.346

lags: 14 (AIC). *** 1% significance, ** 5% significance, * 10% significance
OI: open interest, IF: investment inflow

Table 4I: Unrestricted VECM for Grains and Soft Commodities

	Grains					Softs					
	M1	M2		M3	M4	M1		M2		M3	M4
	ce_1	ce_1	ce_2		ce_1	ce_1	ce_2	ce_1	ce_2	ce_1	ce_1
Factor 1	1	1		1	1	1	--	1	4.3E-19	1	1
inflation	334.5***	-7E-15	1	43.02***	58.496***	--	1		1	-28.396**	6.091
USD	-0.140	0.806***	-0.001	0.586***	0.627***	1.15**	0.002	0.219	0.001	0.554***	0.420***
IP OECD	-0.885	0.903*	-0.013**	0.089*	-0.118	0.853	-1.E-4	2.380**	0.002	0.034	0.169
IP India	4.11***	3.397***	-0.017*	0.707***	0.782***	6.32***	0.015***	7.553***	0.021***	-0.306	0.606***
IP China	-4.96***	-2.596***	0.010	-0.410***	-0.524***	-4.06***	-0.009**	-4.835***	-0.014***	0.527***	-0.335**
IP Brazil	0.826	-5.121***	0.042***	-0.518***	-0.594***	-9.74***	-0.016**	-9.211***	-0.021***	-1.075***	-1.37***
IP Russia	2.266***	1.578***	-0.017***	0.196***	0.309***	2.27***	0.005	2.556***	0.007	0.577***	1.006***
Crude oil	-4.66***	--		0.156***		1.45***	0.002	--	--	0.565***	--
Total OI	2.E-5***	-8.5E-6***	3.4E-8***	--	--	-2.E-5***	-5.E-8	-2.E-5***	-6.0E-8*	--	--
Total OID	--	--	--	-2.E-8***	-1.3E-8***	--	--	--	--	-1.E-8***	-9E-9***
constant	-346.698	-20.91	-0.217	--	-68.945	155.45	-0.048	12.25	-0.337	15.568	-1292

Table 4J: Unrestricted VECM for Energy and Indexed Commodities

	Energy			Indexed					
	M1		M4	M1		M2		M3	M4
	ce_1	ce_2	ce_1	ce_1	ce_2	ce_1	ce_2	ce_1	ce_1
Factor 1	1	--	1	1	--	1	-4.34E-19	1	1
inflation	-1.E-16	1	-943.3***	--	1		1	-77.6***	-153.86***
USD	0.249**	-0.01***	5.755***	2.220**	0.002	-9.066***	-0.050***	0.486***	0.98***
IP OECD	-0.203	0.005	2.700	-5.73***	-0.02***	11.751	0.048	1.006***	0.929
IP India	1.403***	0.010	4.954	-3.003	-0.005	19.027*	0.079	0.725*	0.908
IP China	-0.310	0.002	-2.876	1.494	-0.003	-0.163	0.005	0.497	0.118
IP Brazil	-1.397***	-0.009	-18.15***	6.318**	0.025	-26.62*	-0.102	-2.49***	-3.099***
IP Russia	0.180	-0.013***	14.57***	-8.45***	-0.02***	-3.945	-0.037	1.672***	2.218***
Crude oil	--	--	--	7.52***	0.007***			-0.60***	--
Total OI	-9.E-6***	-1.E-7***	--	-3.E-5***	-2.E-8**	-1.3E-4***	-6.0E-7***	--	--
Total OID	--	--	6.E-8*				--	-1.E-8***	-8.9E-9**
constant	42.902	1.754	-461.400	428.251	0.316	1730	9.234	-54.632	-64.14

Table 4K: Restricted VECM Results

	Grains		Softs		Indexed	
	M1	M3	M1	M3	M1	M3
inflation	217.1***	43.02***	--	-12.67	--	-66.7***
USD	--	0.59***	0.58***	0.52***	1.45***	0.47**
IP OECD	--	0.09*	--	--	-2.55***	1.13***
IP India	3.314***	0.71***	0.669**	--	--	1.35***
IP China	-3.77***	-0.41***	-0.78***	0.28***	--	--
IP Brazil	--	-0.52***	-0.80***	-1.22***	1.394	-3.11***
IP Russia	1.33***	0.19***	0.192*	0.71***	-3.63***	2.16***
Crude oil	-2.87***	0.16***	0.632***	0.414***	3.86***	-0.93***
Total OI	9.E-6***		-6.E-6***		-2.E-5***	
Total OID		-2.E-8***		-1.E-8***		-9.E-9***
constant	-256.6	-77.68	-25.43	8.48	193.05	-76.26
	M2	M4	M2	M4	M2	M3
inflation	217.1***	53.714***	--	--	--	-577.48***
USD	1.200***	0.575***	--	0.481***	-144.8***	4.608***
IP OECD	--	--	-2.851***	--	--	--
IP India	1.959***	0.738***	-5.807***	0.656***	412.9***	--
IP China	-1.881***	-0.445***	1.174	-0.471***	--	--
IP Brazil	-3.500***	-0.584***	15.67***	-1.19***	-399.6**	-3.552
IP Russia	1.302***	0.278***	-4.012***	1.065***	--	8.341***
Total OI	-1.89E-6		1.1E-5***		-2.4E-3***	
Total OID		-1.3E-8***		-7.9E-9***		4.2E-8***
constant	-37.63	-68.803	-413.6	-101.15	--	-625.59

	Energy	
	M2	M3
inflation	--	-282.2***
USD	0.14**	2.03***
IP OECD	--	--
IP India	1.24***	--
IP China	--	--
IP Brazil	-1.61***	-2.58***
IP Russia	--	3.19***
Total OI	-9.E-6***	
Total OID		2.E-8***
constant	74.81	-170.1

Factor 1 = 1. *** 1% significance, ** 5% significance, * 10% significance

CHAPTER 5
CONCLUSION

In mid-2008, prices of a range of commodities reached unexpected heights. In June 2008 the food price index of the FAO reached 185, a 90 percent increase from January 2002.[73] This development was striking because commodity prices had been slowly declining for the prior three decades. Another distinctive feature of the 2008 price developments was that it affected a wide range of commodities including grains, oil seeds, soft commodities, energy, and metals. These price developments coincided with a vast inflow of money into the commodities futures market, along with the emergence of new classes of traders, trading strategies, and financial instruments. I refer to this phenomenon as financialization of commodities futures market. A majority of this new liquidity entered the futures market through commodity index funds. In 2002, commodity index investment was negligible, by 2008 it was estimated to be over USD 200 billion, and in 2012 it had reached USD 400 billion (BIS). Large institutional investors like pension funds, university endowments were especially active in this kind of passive investment strategies, accounting for over 42 percent of the total notional value (CFTC 2008). In this dissertation, I have explored the links between these two developments in the commodities market.

My research approach consists of two inter-related parts: First, I establish that there exists a relationship between spot and futures prices, so that developments in the futures market affect the prices we see in the spot market (Chapter 1). Then I show that financialization has affected both the magnitude (Chapter 3) and comovement (Chapter 4) of commodity prices. In this chapter, I summarize the major conclusions of the dissertation, and provide some policy implications and directions for future

[73] In January 2002, the FAO food price index was at 97.

research.

In Chapter 2, I study the long-run relationship between spot and futures prices, in particular the nature of lead-lag dynamics between the two markets that may explain the process of price determination. I conduct empirical analysis for 19 commodities, consisting of agriculture, energy, livestock, and metals from 1991-2012. I use the cointegration framework accounting for up to two structural breaks that have been mostly ignored in the previous literature. Results show that spot and futures prices are cointegrated for 16 of the 19 commodities analyzed. For 11 of these commodities, futures markets are more influential than spot markets for price determination. These results suggest that market participants perceive futures prices as containing valuable information regarding supply-demand fundamentals, and look to the futures market to form expectations regarding spot prices. However, given this critical "price discovery" role of futures market, my research suggests that if futures market experience speculative bubbles, it will most likely be transmitted to the spot market.

In Chapter 3, I analyze commodity markets individually to understand the effect of financialization of the commodities market on prices. Unlike a majority of papers that study correlation between trading positions of different categories of traders and prices, I focus on the general inflow of money in each commodity futures market. I do this for three important reasons: i) the inability of publicly available data to accurately identify trader positions, ii) it allows me to study the broader aspect of financialization instead of focusing on a specific category of traders, and iii) to test the hypothesis that rapid inflow of liquidity increased the relative demand for long position, which led to an upward pressure on prices. I use the cointegration framework accounting for up to two structural breaks, to understand the relations between open interest and prices for 16 commodities for a time period of 15 years (1995-2012). Results show that prices and open interest for 14 of the 16l commodities analyzed share a long-run cointegrating relationship. More importantly for most commodities, if there is a deviation from the long run relationship, both open interest and prices adjust to maintain the relationship. It is reasonable to expect the adjustment parameter of open interest to be significant -- as prices rise more traders enter the market to gain from the rise in prices, so the overall liquidity in the market rises. But these results suggest that as liquidity rises, prices are pushed further up, leading to a bubble-like feedback mechanism. As futures prices act as a benchmark for spot prices, this development in the futures market is transmitted to the spot market, leading to a rise in spot prices. In conclusion, this paper provides strong empirical evidence to support the thesis that the 2008 rise in commodity prices were partly driven by the financialization of the commodities futures market.

In Chapter 4, I take a broader approach and explored one of the distinctive features of the 2008 commodity price developments -- the remarkably synchronized rise and fall of prices of unrelated commodities. My empirical approach is based on the notion that only factors that affect several commodity markets simultaneously, can explain synchronized movement of unrelated commodity prices. First, I extract common factors from 41 commodities and its sub-groups, using the PANIC method. The extracted common factor(s) were moving in the opposite direction as open interest until 2002, however since then they have been moving in the same direction, and during 2008-11, they show very strong correlation. The extracted factor(s) are then included in a FAVEC model along with macroeconomic factors and a proxy of financialization. Results for the common factor from extracted from the 41 commodities are quite robust; both proxies of financialization are significant and have the expected negative sign. They provide evidence to support the thesis that financialization of the commodities futures market has led to increasing comovement between unrelated commodity prices. However, results for the group-specific factors are not as strong; the proxies of financialization are significant and have the expected sign for 10 out of the 16 models. One reason for the inconsistent results for group-specific factors may be that commodities included in the groups are related, so commodity specific demand and supply factors may be more important than macroeconomic factors in explaining comovement between these commodities.

The overall results of my dissertation can be summarized as follows:

i) Spot and futures prices of commodities move together in the long run and market participants perceive futures prices to contain valuable information regarding supply-demand fundamentals; they look to the futures market to form expectations regarding spot prices.

ii) There was a tremendous rise of liquidity in commodities futures markets leading up to the 2008 price spike. This rise in liquidity increased demand for long positions, creating an upward pressure on prices.

iii) The new variety of traders and trading strategies also led to synchronization of prices of commodities that are unrelated. Although results are not as strong for group-specific factors, overall results show that financialization is a significant factor after accounting for other macroeconomic factors.

Together these three chapters of this dissertation provide strong evidence to support the thesis that financialization of the commodities futures market is a factor in explaining the rise in magnitude and comovement of commodity prices in recent years. This does not mean that fundamentals did not have a role to play in causing these price developments. Demand for oil and minerals from the emerging markets, effects of biofuels, and other macroeconomic effects may have been important. However, I argue that the level of rise in prices cannot be explained by these fundamentals alone. These findings have direct implications for food security and development in general. As mentioned at the outset of this paper, according to the USDA the 2008 price spike was responsible for increasing malnutrition for 80 million people worldwide and slowing down the global progress in reducing hunger. These results thus highlight the need to minimize distortions on prices due to financialization of commodities futures markets.

Directions for Future Research

In this dissertation, I presented recent developments in the commodities futures markets vis-à-vis financialization. However, the nature of financialization is changing rapidly as market participants find new trading strategies and instruments. Long-only, passive, index trading used to be the primary way new investors exposed themselves to commodity futures markets. However, in recent years second and third generation commodity indices called “enhanced”, “dynamic”, or “active” indices (such as the S&P GSCI dynamic roll index) that use different rolling strategies and market exposure based on state of the particular market (contango or backwardation), have overtaken the market. Moreover, by 2008 the relative importance of index trading had decreased as ETFs and ETNs grew in popularity and increasingly controlled a large share of the market. In the future, as the process of financialization proceeds, we should expect new financial instruments and trading strategies. One important direction for future research is to keep up with these new developments in the commodities futures market. As the financial sector comes up to new investment products and new strategies to invest, we need to understand the changing nature of financialization, and the various ways in which it may distort the market.

Besides financialization of the commodities futures market, finance has crept into commodity markets in other ways that are not covered in this dissertation, but are equally important. For example, in recent years production and distribution of commodities have also been financialized. Murphy et al. (2012) provide a detailed discussion of how the four largest grain traders: Archer Daniels Midland (ADM), Bunge, Cargill, and Louis Drefyus, (collectively referred to as ABCDs) have all established investment divisions offering external investors a range of financial services and products including commodity index funds, asset management services, insurance. In Chapter 3, I briefly discussed Cargill and its hedge fund Black River Asset Management to explain how the line between hedgers and speculators are blurred by these developments. Given that these grain trading companies have access to food suppliers and information regarding supply factors in agricultural markets, Murphy et al. (2012) go on further to compare their activities to insider trading. Questions have also emerged about whether these grain traders are manipulating the markets for their own financial gain. For example Cargill was among the first to speculate on falling wheat prices in 2008, which led to significant profits (Murphy et al. 2012 and Isakson 2014). These aspects of financialization have received very little attention in the literature; the focus has primarily been on the activities of commodity index traders. Future work in this area is required to comprehend the changing nature of commodity markets and they affect prices.

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