Commodity Index Investing: Investigating the Relationship between Commodity Index Investment Flows and Futures Prices Using a Non-linear Granger Causality Approach

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A Thesis

in

The John Molson School of Business

Presented in Partial Fulfillment of the Requirements
for the Degree of Master of Science in Administration at
Concordia University
Montreal, Quebec, Canada

May 2013

CONCORDIA UNIVERSITY

School of Graduate Studies

This is to certify that the thesis prepared

By: Filip Rusescu

Entitled: Commodity Index Investing: Investigating the Relationship between Commodity Index Investment Flows and Futures Prices Using a Non-linear Granger Causality Approach

and submitted in partial fulfillment of the requirements for the degree of

Master of Science in Administration

complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Abstract

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Filip Rusescu

The appearance in the late 1990s of commodity index investing funds and the increasing popularity of commodities as an asset class has led numerous market participants and academics to blame index investing for creating an artificial demand for commodities and thus to inflate commodity prices. While the issue has been widely discussed and attracted a lot of attention from academics, previous research focused on correlation analysis and linear Granger causality tests to investigate whether commodity index investing had a significant impact on commodity prices. While linear Granger causality tests have been widely used in empirical finance and econometrics and are standard tools in an econometrician's toolbox, most recent research has focused on developing non-linear, non parametric tests. In this study I take a new approach to testing the hypothesis that commodity index investing Granger caused commodity futures prices to increase by using the test proposed by Diks and Panchenko (2006) which uses a non-linear non-parametric framework. I perform both the linear Granger causality and the Diks and Panchenko tests for 12 agricultural markets for which index commodity investing data is available from the CFTC, for the period 2006 to 2012. Overall, the empirical results provide limited evidence to support the hypothesis that index commodity investing caused a spike in commodity prices but highlight the importance of considering non-linear effects in empirical studies with financial time series.

Acknowledgements

First of all, I would like to express my deepest gratitude to my thesis supervisor, Dr. Latha Shanker, who has given me invaluable guidance, support and advice throughout the thesis research and writing process and who has dedicated numerous hours to helping me understand, research, overcome obstacles and ultimately finalize my thesis.

I would also like to express my most sincere appreciation and gratitude to my thesis committee members, Dr. Fassil Nebebe and Dr. Rahul Ravi for their helpful suggestions and comments during the thesis writing process as well as for the knowledge they transmitted to me in their classes.

Last, but not least, I would like to thank my parents who have always been very supportive and provided me good advice.

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I Introduction

The first modern organized futures exchange started as early as 1710 with a rice contract at the Dojima Rice Exchange in Japan (West, (2000)). Futures contracts are often seen as an evolution of the forward contract in which two parties agree on the price, quantity and delivery date of a commodity or other product. The additional security of trading on an exchange with standardized contracts and with a clearinghouse which acts as an intermediary to minimize the risk of counterparty default attracted many commodity producers and users. Another advantage of a futures contract comes from its liquidity, as numerous financial third parties, often labelled as speculators, provide the necessary volume and immediacy to respond to a commodity producer’s or end user’s needs. In 1865 the first standardized futures contracts were introduced on the Chicago Board of Trade only 17 years after its creation. Over time, futures contracts became increasingly popular and are now represented in numerous markets including financial products, currencies etc.

In 2012, approximately 1.3 billion agricultural futures and options contracts exchanged hands. Agricultural futures markets are under the scrutiny of regulators and politicians, and their participants have often been accused of price manipulation, excessive speculation and blamed for creating instability in commodity prices, as well as social instability and hunger in certain parts of the world.

While financial intermediaries have been present in commodity futures markets since the beginning, commodity index investing is a relatively new phenomenon. Although the first commodity price index appeared in 1957 in the US, the use of commodity price indices as an investment class came much later, as the Prudent Man rule prevented pension plans and other trustees (Federal Deposit Insurance Corporation) from investing in risky or speculative assets such as commodities. As the Uniform Prudent Investor Act was adopted in 1992 (American Law Institute's Third Restatement of the Law of Trusts (Restatement of the Law Third, 1992)) fiduciaries were allowed to invest in such asset classes, reflecting modern portfolio theory and the concepts of total portfolio risk and return. As such, investing in futures contracts was no longer expressly prohibited as long as it allowed fiduciaries to hedge or minimize their overall portfolio risk. Masters and White (2008a) argue that pension funds and other investors, who had invested heavily in equity markets in the 1990s and who, in the aftermath of the tech bubble burst, the 9/11 attacks and the following mini-recession were shifting their asset allocations away from equities and often into “alternative” asset classes were being marketed commodities index investments as providing equity-like returns while being uncorrelated with equities thus reducing overall portfolio risk. Whether Wall Street banks convinced pension funds to invest in commodity markets or pension funds by themselves decided to invest heavily in commodities as an alternative asset class is subject to debate. What is certain however is that commodity assets under management increased from under $10 billion at the beginning of the 2000’s to over $400 billion in 2012 according to data compiled by Barclays. Over the same period, commodity prices increased significantly, which led numerous market participants to claim that index investing was creating a bubble in commodity prices.

In the US, the Commodity Exchange act, which was passed in 1936 and amended several times, regulates the trading of commodity futures. The 1936 act established speculative position limits in order to prevent excessive speculative trading activity that could destabilize commodity markets and create price bubbles. In 1974 the US Congress amended the act and created the U.S. Commodity Futures Trading Commission (“CFTC”) which replaced the Commodity Exchange Authority as a regulator and whose mission is to “to protect market users and the public from fraud, manipulation, abusive practices and systemic risk related to derivatives that are subject to the Commodity Exchange Act, and to foster open, competitive, and financially sound markets." However, in 1991 the CFTC approved commercial exemptions to position limits for swap dealers, the rationale being that these dealers would not be able to manipulate the market, given that their transactions in the futures market were made purely to offset their over the counter swaps transactions. It has often been argued (Masters, others) that this eventually allowed speculators to circumvent position limits by entering into over the counter swaps with banks.

In the new millennium, commodity investing increased dramatically thanks in part to new products targeted at both institutional and retail investors which offered an easy , convenient, and hassle free way of participating in the commodities markets. New products included Exchange Traded Funds, Exchange Traded Notes, and commodity index swaps and options. From January 2002 to June 2008, the Standard & Poor's – Goldman Sachs Commodity Index and the Dow Jones – UBS Commodity Index, the two most popular commodity indices, increased 398% and 159% respectively, which led certain observers decry a commodity bubble. As the financial crisis of 2008 eventually burst the commodity bubble, many market participants, regulators and academics eventually looked into the problem, trying to determine whether commodity index investing was really the driving force behind the 2007-2008 spike in commodity prices.

Determining whether commodity index investors have an impact on commodity futures markets is important because commodity prices are at the bottom of the value creation chain and their correct functioning is a prerequisite for economic stability. If commodity index investors destabilize commodity futures markets, regulators should react quickly and impose position limits or implement other measures to limit the impact of index investing.

After discussing the various arguments for and against commodity index investing impacting returns in the commodities markets and conducting a literature review on the subject, I will discuss the theoretical framework and history behind causality testing and argue for the advantage of using a non-linear framework, more specifically the recently developed Diks and Panchenko test, which provides a more robust non-parametric, non-linear approach to causality resting.

While the notion of causality is rather large and discussions around the definition of causality have been central to philosophical debates since antiquity, in empirical research causality is typically looked at as the relationship between an event or series of events (the cause) which cause or produce another event or series of events (the effect). A key notion central to the concept of causality is that the cause occurs prior to the effect. In time series analysis, causality testing typically involves what is commonly referred to as Granger causality testing in which a time series is said to Granger cause another one if past values of the first time series improve the ability to predict the second time series. Although Granger causality does not prescribe the use of a linear model to test for its presence, in practice, almost all Granger causality testing is conducted through the use of linear regressions, in which a time series is regressed against past values of itself and against past values of itself and of the presumed causer series. If the second regression provides a significantly better prediction than the first regression then one concludes that the second time series is Granger causing the first. Note that all previous research that looked at the impact of commodity index funds on commodity futures and used Granger causality testing, did so using linear regressions. Although widespread, the problem with linear Granger causality testing is that it assumes a linear relationship between the two time series and if this is not the case, it can fail to detect a causal relationship or lead to concluding that a causal relationship exists when it actually does not. Note that there is nothing, at least in theory, that would justify the use of a linear model in testing for causal relationships between index investing and returns in commodity futures markets, simplicity aside. Actually, given the large price swings in commodity futures markets and the high volatility observed in general in these markets, linear models are clearly not suitable to describe relationships between investment flows and returns. Given the recent advances in non-linear methods, I advocate that such a method should be used for the purposes of investigating the impact of index investing on commodity futures markets. The advantage of a non-linear approach such as the test proposed by Diks and Panchenko (2006) used in this study is obvious: since it makes no assumption on the underlying relationship between the time series it does not suffer from any model restriction. The Diks and Panchenko test is a non-parametric test for Granger non-causality which was shown to have good size and power characteristics in Monte-Carlo simulations. To uncover the importance of considering a non-linear approach to causality testing, especially with financial time series, I compare the standard linear Granger causality test to the Diks and Panchenko test. I apply the following Granger causality tests to the weekly change in commodity index traders' positions as a percentage of total open interest and to the weekly returns time series for 12 agricultural futures markets. First, the Diks and Panchenko test is applied to the residuals of the Vector Autoregression ("VAR") models used with the linear test. Second, the Diks and Panchenko test is applied directly to the weekly change in commodity index traders' positions as a percentage of total open interest and to the weekly returns time series. Evidence of non-linear effects is found in both cases, which justifies the use of a non-linear approach to Granger causality testing in this situation.

The study is organized as follows: Chapter II reviews the literature and various arguments advanced by advocates and critics of the view that index investing inflated commodity prices and discusses new non-linear approaches to causality testing. Chapter III describes the theoretical framework used in this study. Chapter IV discusses the underlying data, methodology used and describes and interprets the results and Chapter V concludes.

II. Literature Review

2.1 The relationship between returns and traders' positions

The question of whether the positions of different categories of traders influence commodity market prices or if market prices cause investment inflows has been widely researched by academics and discussed by policymakers over the last few decades and continues to be an important subject of debate today. Most studies rely on the CFTC's Commitments of Traders ("COT") reports and its more recent improvements such the Disaggregated Commitments of Traders report and the Supplemental Commitments of Traders report to address this issue.

A number of authors have reported evidence of a consistent ability of large futures traders or certain groups or traders to make profitable trades (Houthakker (1957), Rockwell (1967), Leuthold et al. (1994)). However there is no general consensus that a particular category of traders can consistently make profitable trades and that just by looking at their positions one could have an advantage in forecasting future prices. Kahn (1986) finds that the grain futures market is efficient in the semi-strong form and that the use of publicly available information available in the COT reports does not generate abnormal returns. Hartzmark (1991) finds evidence supporting the view that traders' futures returns are random and that traders holding large positions do not possess the ability to consistently earn profits. Yet Wang (2001), using a trader position-based sentiment index derived from the COT reports in six agricultural futures markets finds that noncommercial traders' sentiment was an indicator of price continuation, while commercial traders' sentiment was an indicator of price reversals and small trader sentiment had no impact on market movements. Wang concludes that his results are consistent with the hedging pressure theory under which hedgers pay risk premiums to transfer risks in futures markets and that large speculators did not possess any superior forecasting ability. Buchanan (2001) also finds that the position of large speculators contains valuable information for predicting the direction and magnitude of spot price changes in the natural gas market. However Sanders, Boris and Manfredo (2004) use Granger causality tests based on the COT reports for the crude oil, unleaded gasoline, heating oil and natural gas futures markets to investigate the relationship between traders' positions and prices and find that positive futures returns Granger cause increases in the net long positions held by non-commercial traders and decreases in the net long positions of commercial traders'. On the other hand, they find no evidence that traders' net long positions had any predictive power in forecasting market returns.

2.2 Commodity Index Traders

If there is no general consensus that the positions of a particular category of traders had a significant impact on commodity prices, the debate was revived in 2007-2008 when commodity prices reached record levels, leading to a spike in food prices and resulting in social unrest in some countries and widespread criticism and heated debates over the role of speculators in driving up commodity prices. In particular, some policymakers, economists and market participants started to blame commodity index investors for driving up commodity prices, arguing that massive investment inflows into index funds effectively created an artificial demand shock which created a speculative bubble in commodity markets. The US Senate Permanent Subcommittee on Investigations (the “Subcommittee”) released, on June 24, 2009, after a year of investigations and hearings, a report which noted that “there is significant and persuasive evidence to conclude that these commodity index traders, in the aggregate, were one of the major causes of “unwarranted changes” – here, increases – in the price of wheat futures contracts relative to the price of wheat in the cash market.” The Subcommittee thus recommended the phasing out of the waivers of position limits for commodity index traders and to reapply the standard position limits designed to prevent excessive speculation in the wheat market. It also recommended that the CFTC analyze other agricultural commodity markets to see if commodity index traders caused futures prices to increase as compared to cash prices or caused a lack of convergence between the spot and futures markets and to reinstate position limits if necessary. Influential testimony from Masters (2008) and a subsequent paper (Masters and White, 2008) illustrate well the arguments made by a number of economists and policymakers in arguing that massive commodity index investment inflows led to an unwarranted price increase in these markets. Essentially, it is argued that large financial institutions such as pension funds, sovereign wealth funds, endowments and other institutional investors, who were being advised to consider commodities as an investable asset class because of historically low correlations with other asset classes such as equities or fixed income, decided all of a sudden to pour billions of dollars into commodities futures through the use of relatively new financial instruments that allowed investors to take a passive, long-only position in a basket of commodities. Studies such as Gorton and Rouwenhorst (2006) and Erb and Harvey (2006) provided support for institutional investors to consider investing in long-only commodity index funds. Masters and White (2008) argue however that large scale investing in commodity index funds through commodity index swaps and the ability of swap dealers to exceed position limits because of the exemption granted to them effectively created a new class of speculators – index speculators, who they argue, are far more damaging than traditional speculators: while a traditional speculator is a liquidity provider and studies the markets and supply and demand dynamics to make his bets, an index speculator usually only takes a long-only, long term position, and rolls his position forward regardless of supply and demand dynamics, thus pushing prices only higher instead of towards their fundamental values. While the Subcommittee's and Masters' arguments certainly cast a doubt on the effect of commodity index investing on commodity prices most of the evidence presented is anecdotal and relies on testimonies and opinions as well as correlations between commodity index investment inflows and commodity prices. Several academics have criticized Masters' methods and the Subcommittee's analysis and presented counter arguments and evidence supporting the opposite view – that is, that index investing was not the cause of the 2007-2008 run-up in commodity prices and what was observed could not be qualified as a bubble (Sanders, Irwin and Merrin (2009, 2010a), Sanders and Irwin (2011a), Sanders and Irwin (2011b), Irwin Sanders and Merrin (2009), Stoll and Whaley (2010), Buyuksahin and Harris (2009), Brunetti and Buyuksahin (2009)).

One popular argument of the "no-bubble" proponents is that prices increased in the 2006-2008 period even for commodities which were not represented in commodity indices. Irwin, Sanders and Merrin (2009) show for example that similar price increases occurred for fluid milk and rice futures, which are not included in commodity indices, and that prices increased even for commodities without futures markets – apples and edible beans. Sanders and Irwin (2010) test empirically if the relative size of index fund positions is correlated with subsequent returns across different markets. Using Fama-MacBeth and traditional cross sectional tests, they conclude that index fund positions across futures markets have no impact on relative price changes. Stoll and Whaley (2010) react to the Subcommittee's conclusion and conduct a number of tests including Granger causality tests on the 12 agricultural markets included in the CFTC's Commitments of Traders Commodity Index Trader Supplement ("CIT") report to investigate whether index fund investment flows cause price changes and vice versa. They find insufficient evidence of causality in either direction, with cotton being the only market in which investment flows Granger-caused futures returns. Counter intuitively, Kansas City wheat futures returns Granger-caused commodity index investment flows. Overall, the authors conclude that commodity index investment is not speculation and that commodity index rolls have little price impact, with index investment inflows and outflows not causing prices to change. Similarly, Buyuksahin and Harris (2009), using non-public data from the CFTC over the 2000-2008 period, employ linear Granger causality tests to test the relationship between crude oil prices and the positions of various types of traders. The authors do not find a systematic causality relationship from any positions of any category of trader to price changes but find that price changes led the net position and net position changes of speculators and commodity swap dealers, suggesting that they are, in general, trend followers. In the same vein, Brunetti and Buyuksahin (2009) use highly disaggregated non-public daily data from the CFTC to investigate whether speculators cause price movements and volatility in futures markets. Using a linear Granger-causality framework, the authors look at the NYMEX crude oil and natural gas futures, CBOT corn futures, CME Eurodollar futures and CBOT Mini-Dow futures contracts and find that in general speculative activity does not cause price movements but that it reduces volatility levels. Sanders and Irwin (2011) also test the relationship between commodity index traders' positions and returns for CBOT corn, CBOT soybeans, CBOT wheat and KCBT wheat futures, using linear Granger causality tests over the 2004-2009 period. The study contained non-publicly available data for the 2004-2005 period for commodity index positions, prior to the spike in commodity prices. Both linear Granger causality tests and long-horizon regressions failed to reject the null hypothesis that commodity index traders' positions do not impact futures prices. In a separate study (Sanders and Irwin 2011b), this time using the DCOT report, investigated whether positions held by swap dealers, a proxy for index fund investing, impacted returns or volatility across 12 agricultural futures markets and 2 energy futures markets. A system of bivariate Granger style causality tests failed to detect a causal relationship between commodity index traders' positions and returns while a tendency is found for index traders' positions to lead market volatility, however with a negative sign – that is – index positions lead to lower volatility. In a similarly oriented paper, Irwin and Sanders (2010) conduct a test of what they call the "Masters hypothesis" using CFTC Index Investment Data (IID) report, arguing that this report provides a better measurement of commodity index investment since index investments are measured before internal netting by swap dealers. However the IID report is only produced quarterly and the study covered the period from the first quarter of 2008 to the first quarter of 2010. Not surprisingly, cross-sectional regression estimates fail to support Masters' hypothesis, i.e. that commodity index investing has a significant impact on commodity prices. Since commodity index funds have been accused by some of causing non-convergence of futures and cash commodity prices, Irwin et al. (2011) conduct an event study to test the behavior of spreads between futures and cash prices for CBOT corn, wheat and soybeans and perform Granger causality tests to see if trader positions had an impact on spreads. They find no evidence that index fund rollovers or index fund positions caused spreads to increase. Capelle-Blancard and Coulibaly (2012) use a panel Granger causality testing approach developed by Kònya (2006), which is based on Seemingly Unrelated Regressions and Wald tests with market-specific bootstrap critical values and which allows testing of each individual market separately by taking into account the possible contemporaneous dependence across markets. Using weekly data from the CIT report the tests were applied to 12 commodity futures markets and failed to detect a causal relationship between commodity index funds' positions and commodity futures prices.

If most academic studies to date fail to detect a formal relationship between index fund positions and futures returns, some authors have nevertheless provided at least some form of evidence that some links exist in certain markets.

Gilbert (2009) examines whether the high commodity prices of 2006-2008 resulted from bubble like behaviour and if commodity index investing had an impact on futures prices. Looking specifically at the crude oil, aluminum, copper, nickel, wheat, corn and soybeans markets, he finds that index fund investing had a significant impact on returns in the crude oil, aluminum and copper markets. However, index fund investing was estimated using a quantum index derived from the CFTC's CIT report (agricultural futures) and subsequently Granger causality tests were performed for the seven markets previously mentioned. It seems indeed strange that the null hypothesis of non causality was not rejected in the case of the three agricultural commodity futures (which were part of the 12 agricultural futures on which the quantum index was based) but was rejected for the energy and metals futures. Moreover, the reverse hypothesis – that is that futures returns do not Granger-cause index investing, was rejected for the agricultural markets. In a subsequent paper, Gilbert (2010) studies the determinants of the run-up in food prices in 2006-2008 and shows that index fund investing was a significant factor. He sets up a model of the change in food prices as a function of the change in oil prices, the exchange rate and a futures investment index. The Granger causality test rejects the null of non causality only for the futures investment index. However Gilbert sets up another equation for the change in index fund investing as a function of the change in the dollar exchange rate, the current and lagged changes in Chinese industrial production and current and lagged changes in the S&P 500 and Hang-Seng stock market indices, the rationale being that investors were investing in commodity indices as a means of taking an exposure to the growth in the Chinese economy in this period and as a dollar hedge. Gilbert (2010) concludes that index investing was a channel rather than a fundamental cause of the increase in food prices over the period.

Singleton (2011) examines the impact of investor flows and financial market conditions on returns in crude-oil futures markets and finds that commodity index fund flows are positively correlated with future changes in commodity prices. His findings are similar to Tang and Xiong (2010) who find an increasing trend of financialization of commodities markets with increasing correlation among commodities and among commodities and other financial assets.

2.3 New approaches to causality testing

Since its introduction more than four decades ago Granger causality (Granger, 1969) has been widely used by academics and practitioners in time series data analysis in fields as different as economics, biology, medicine and meteorology. While Granger's formal definition of causality does not make any assumption on the underlying data generation process, in practice Granger causality testing is generally conducted using a linear framework, whose simplicity, adaptability and ease of use contributed to its popularity. Criticism of the linear approach to causality testing mainly revolves around the low power of such tests in detecting certain types of non linear causal relationships (Hiemstra and Jones, 1994). Although several nonlinear extensions to linear Granger causality have been explored (Liu and Bahadori, 2012), namely kernelized regression and other non-parametric approaches, semi-parametric approaches and latent variable models, empirical research has mostly focused on the non parametric approach. Baek and Brock (1992) proposed a general test for nonlinear Granger causality based on correlation integrals. The test had the ability to detect causal relationships that could not be detected using a linear approach. Hiemstra and Jones (1994) used a modified and improved version of the Baek and Brock test to uncover bidirectional nonlinear causality between the Dow Jones stock returns and percentage changes in New York Stock Exchange trading volume. The Hiemstra and Jones ("HJ") test has been used in a number of academic finance and economics papers, however Diks and Panchenko (2006) showed that the HJ test suffered from over rejection problems with increasing sample size. The authors propose a new test that avoids the over rejection problem of the HJ test and has good size and power characteristics. Although only developed in 2006, the Diks and Panchenko test has been used by a number of authors on economic and financial time series (Qiao et al. (2008), Hernandez and Torero (2010), Rosa and Vasciaveo (2012), Benhmad (2013)).

III Theoretical Framework

3.1 Causality in general

The notion of causality has been central to philosophical debates since antiquity and discussion around the definition of causality and its detection continue today. However, in econometrics and science in general, causality is often referred to and sought under a Granger causality framework. Granger, whose work on methods of analyzing economic time series was recognized by the Nobel prize in Economics in 2003, formalized a definition of causality in the context of economic time series and developed a framework for causality testing. Granger's (1969) definition of causality is very general in nature, yet the testable forms assume a linear model.

Using Granger's (1969) notation, assume A_t is a stationary stochastic process and $\bar{A}_t$ the set of past values $\{A_{t-j}, j = 1,2, \dots, \infty\}$. Let the optimum, unbiased, least squares predictor of A_t using the set of values B_t be $P_t(A|B)$, the predicted error series be $\varepsilon_t(A|B) = A_t - P_t(A|B)$ and $\sigma^2(A|B)$ be the variance of $\varepsilon_t(A|B)$.

For two stationary time series X_t and Y_t and with U_t representing all the information in the universe accumulated since time t-1 and $U_t - Y_t$ all this information except Y_t then if $\sigma^2(X|U) < \sigma^2(X|\overline{U - Y})$, Y_t is causing X_t.

This definition is very general and only says that Y_t is causing X_t if the addition of Y_t to the information universe results in a better prediction of X_t. Note that this does not imply that Y_t causes X_t in the more general meaning of the word causation – it just says that the addition of X_t to the information universe results in a better prediction. In reality, a third phenomenon could cause both Y_t and X_t or there might be several reasons for Y_t being a good predictor of X_t.

3.2 The linear model

In economics and finance there is often no reason to assume that the relationship between two time series is linear, yet the linear model provides a convenient, easy way of modeling and uncovering basic relationships which led to its widespread use.

Under the linear model, for two stationary time series X_t and Y_t with zero mean and ε_t and η_t two uncorrelated white noise series:

$$X_t = \sum_{j=1}^{m} a_j X_{t-j} + \sum_{j=1}^{m} b_j Y_{t-j} + \varepsilon_t$$

$$Y_t = \sum_{j=1}^{m} c_j Y_{t-j} + \sum_{j=1}^{m} d_j X_{t-j} + \eta_t \quad (3.1)$$

Y_t is Granger causing X_t if some $b_j \neq 0$ and X_t is Granger causing Y_t if some $d_j \neq 0$ and if both some $b_j \neq 0$ and some $d_j \neq 0$ then bidirectional causality or feedback exists between X_t and Y_t. To test for Granger causality under this framework, a standard joint F or χ^2 test for the coefficients b_j or d_j being jointly 0 is employed, with the null hypothesis of non Granger causality being rejected if the coefficients b_j or d_j are jointly significantly different from 0. Although in theory m could go to infinity, in practice only a limited number of lags are used with m less than the time series' length.

3.3 The nonlinear model

Despite its widespread use and sufficiency in a large number of real world situations, the linear model can fail to uncover certain causal relationships or lead to the wrong conclusions when the time series studied present significant nonlinear components. Granger (1989) admits that univariate and multivariate nonlinear models represent the proper way to model a real world that is "almost certainly nonlinear". Recent research in econometrics and finance has been focused on developing and applying nonlinear methods (Baek and Brock (1992), Hiemstra and Jones (1994), Bell et al. (1996), Chen et al. (2004), Diks and Panchenko (2006), Péguin-Feissolle et al. (2013)). The Diks and Panchenko test used here was proposed by Diks and Panchenko (2006) and came as a response to the more frequently used Hiemstra and Jones (1994) test which was shown to suffer from severe over rejection problems, with rejection probabilities of the null hypothesis of non causality tending to one as the sample size increased (Diks and Panchenko, 2005).

In general, non-parametric extensions of the linear Granger causality model rely on some functionals $\theta(.)$ of two conditional distributions $Y_t|Y_t^{ly}$ and $Y_t|(Y_t^{ly}, X_t^{lx})$ where Y_t^{ly} and X_t^{lx} are time series of finite lags l_y and l_x respectively. The null hypothesis being tested is:

$$H_0: \quad \theta\left(F\left(Y_t \middle| Y_t^{ly}\right)\right) = \theta\left(F\left(Y_t \middle| (Y_t^{ly}, X_t^{lx})\right)\right) \tag{3.2}$$

To use the notation used by Diks and Panchenko (2006) let $Z_t = Y_{t+1}$ and $W_t = (X_t^{lx}, Y_t^{ly}, Z_t)$. Testing for conditional independence is equivalent to making a statement about the invariant distribution of W_t. Dropping the time index and considering only the case in which $l_X = l_y = 1$ for brevity, then $W = (X, Y, Z)$ denotes a three variate random variable, distributed as $W_t = (X_t, Y_t, Y_{t+1})$.

Under the null hypothesis of non Granger causality, the conditional distribution of Z given $(X, Y) = (x, y)$ is the same as that of Z given $Y = y$ only so the joint probability density function $f_{X,Y,Z}(x, y, z)$ and its marginals must satisfy:

$$\frac{f_{X,Y,Z}(x,y,z)}{f_{X,Y}(x,y)} = \frac{f_{Y,Z}(y,z)}{f_Y(y)} \tag{3.3}$$

Or equivalently:

$$\frac{f_{X,Y,Z}(x,y,z)}{f_Y(y)} = \frac{f_{X,Y}(x,y)}{f_Y(y)} \frac{f_{Y,Z}(y,z)}{f_Y(y)} \tag{3.4}$$

By adding a positive weight function $g(x, y, z)$ Diks and Panchenko show that the null implies

$$q = E[(\frac{f_{X,Y,Z}(X,Y,Z)}{f_Y(Y)} - \frac{f_{X,Y}(X,Y)}{f_Y(y)} \frac{f_{Y,Z}(Y,Z)}{f_Y(Y)}) g(X, Y, Z)] = 0 \tag{3.5}$$

where the weight function $g(x, y, z)$ was chosen so that $g(x, y, z) = f_Y^2(y)$[1] , therefore the functional q becomes:

[1] Diks and Panchenko (2006) considered three functions for the weight function g, namely $g_1(x, y, z) = f_Y(y)$, $g_2(x, y, z) = f_Y^2(y)$ and $g_3(x, y, z) = f_Y(y)/f_{X,Y}(x, y)$. g_2 was chosen because of stability in empirical studies and the ability of its estimator to be represented as a U-statistic, which allowed for an asymptotic distribution to be derived analytically for weakly dependent data.

$$q = E[f_{X,Y,Z}(X,Y,Z)f_Y(Y) - f_{X,Y}(X,Y)f_{Y,Z}(Y,Z)] = 0 \quad (3.6)$$

A natural estimator of q based on indicator functions is:

$$T_n(\varepsilon) = \frac{(n-1)}{n(n-2)}\sum_i(\hat{f}_{X,Y,Z}(X_i,Y_i,Z_i)\hat{f}_Y(Y_i) - \hat{f}_{X,Y}(X_i,Y_i)\hat{f}_{Y,Z}(Y_i,Z_i)) \quad (3.7)$$

where $\hat{f}_W(W_i) = \frac{(2\varepsilon)^{-d_W}}{n-1}\sum_{j,j\neq i} I_{ij}^W$ is the local density estimator of a d_W variate random vector W at W_i and $I_{ij}^W = I(\|W_i - W_j\| < \varepsilon)$. In order to derive an asymptotic distribution of T_n a form of kernel density estimation was used, which is a non-parametric technique to estimate the probability density function of a random variable. The technique is conceptually similar to using a histogram but provides better results. It involves using a kernel which is a weighting function and a parameter or "bandwidth" or "smoothing constant". The kernel determines the shape of the smoothing function and the bandwidth the amount of smoothing applied.

Diks and Panchenko show that for a sequence of bandwidths depending on sample size as $\varepsilon_n = C_n^{-\beta}$ for any positive constant C and $\beta \in (\frac{1}{4},\frac{1}{3})$ the test statistic T_n satisfies:

$$\sqrt{n}\frac{T_n(\varepsilon_n)-q)}{S_n} \xrightarrow{d} N(0,1) \quad (3.8)$$

The authors provide practical guidelines for choosing the bandwidth which, in applications can be truncated by taking $\varepsilon_n = \max(C_n^{-\frac{2}{7}}, 1.5)$with $C \simeq 8$ for an application to unfiltered financial returns data assuming an underlying ARCH process of the form $X_t \sim N(0, c + aY_{t-1}^2)$ with coefficient $a = 4$.

IV Data, Methodology and Empirical Results

4.1 Data

This study uses the CFTC's supplemental COT report, often referred to as the "CIT" report for Commodity Index Traders report, since the report provides in a separate category the positions of commodity index traders in 12 physical commodity futures markets. As part of its ongoing reviews and efforts to provide the public with useful information relating to the futures and options markets, the CFTC released in 2006 a request for comments regarding the COT reports entitled "Comprehensive Review of the Commitments of Traders Reporting Program". As a result of the agency receiving 4,659 comments, the largest number of comments it ever received in its 31 year history, it decided to publish the CIT weekly report which was to show aggregate futures and options positions of Noncommercial, Commercial, and Index Traders in 12 selected agricultural futures markets. The rationale behind the release of this report was that the futures market composition changed over time and the traditional categories of Commercial and Noncommercial traders could no longer provide an accurate representation of the market participants who were actually producers, traders or users of the physical commodities. In addition, commodity index traders accounted for a significant portion of the market yet their activities were hidden by appearing in both the Commercial and Noncommercial categories. As such, the new commodity index trader category was formed by drawing from the Noncommercial category the positions of pension funds, managed funds and other investors seeking exposure to commodity prices as an asset class in a passive manner and from the Commercial category the positions of swap dealers who used futures contracts to hedge their over the counter exposures with investors such as pension funds. Although the CIT report only provides data going back to 2006 and is limited to 12 agricultural futures markets (CBOT wheat, corn, soybeans, soybean oil, KCBOT wheat, ICE cotton, cocoa, coffee and sugar, and CME lean hogs, live cattle and feeder cattle) it provides a good estimate of the activity of commodity index traders and is helpful in analyzing the more general question of whether commodity prices are affected by massive inflows from this category of traders. One limitation of the CIT is however that the index investors' positions derived from swap dealers are net positions, since swap dealers use internal netting and the ultimate counterparties are unknown. However, particularly in the case of agricultural commodities, most swap dealers positions are long-only futures positions as they mostly take short OTC swap positions against pension funds or other commodity index investors.

The period covered is from January 3rd, 2006 to December 31, 2012 which includes 366 weekly observations.

Price data for the 12 CIT agricultural commodity futures was obtained from Thompson Reuters Datastream. Since futures contracts expire, the price series used in this study are perpetual series of futures prices which means that prices are based on individual futures contracts with switching based on a pre determined methodology. The roll method used here was the rollover based on a weighted volume of 1st month and 2nd month. This means that the series starts at the nearest contract month and once that month is reached a volume weighting calculation is made between the near and next nearest contract months and is applied to prices until the near contract reaches expiration, at which point the next nearest contract becomes the nearest and its price is then used. This method avoids having a sharp change in the price series associated with a single switching point based on a relative point in time or on a volume criterion.

Table 1 presents open interest and commodity index traders' positions statistics for the 12 agricultural futures markets studied. Note that total open interest varied quite significantly over the study period, with recorded open interest highs being 2.1 to 3.3 times as high as the corresponding lows for a given contract over the study period. Note also that almost all commodity index traders' positions are long which is consistent with commodity index traders being mostly passive investors. It is interesting to note that the total share of commodity index traders in the market is not the same for all 12 agricultural futures markets studied: commodity index traders' net positions represented on average 38.4% of open interest for lean hogs futures but only 14.5% of open interest for cocoa. It is also interesting to observe that the share attributed to commodity index traders has been relatively volatile, with standard deviations of 5% on average.

Table 1: Descriptive Statistics on Open Interest and Commodity Index Traders' Positions (2006 – 2012) for Different Futures Contracts

Contract	Open Interest (in thousands)			Commodity Index Traders' Positions (in thousands)					Commodity Index Traders' Positions as a % of Open Interest			
	Average over Period	Period Min	Period Max	Average Over Period Long	Average Over Period Short	Average Over Period Net	Period Min Net	Period Max Net	Average over Period	Period Min	Period Max	Standard Devia-tion
Wheat - Chicago Board of Trade	511	313	723	213	25	188	127	230	37.3%	28.1%	51.0%	4.4%
Wheat - Kansas City Board of Trade	150	81	263	36	2	33	16	53	22.9%	12.3%	34.2%	5.1%
Corn - Chicago Board of Trade	1,733	997	2,574	422	45	376	224	504	22.2%	13.2%	32.7%	4.3%
Soybeans - Chicago Board of Trade	692	379	1,260	171	21	150	90	201	22.7%	9.7%	32.2%	4.7%
Soybean oil - Chicago Board of Trade	337	211	503	87	9	79	37	114	23.4%	14.2%	36.5%	3.8%
Lean Hogs - Chicago Mercantile Exchange	227	132	349	89	4	85	46	127	38.4%	27.0%	51.4%	5.5%
Live Cattle - Chicago Mercantile Exchange	339	219	490	120	3	117	61	157	35.1%	25.3%	47.0%	5.5%
Feeder Cattle - Chicago Mercantile Exchange	37	21	62	8	1	8	5	11	22.1%	12.1%	35.2%	5.0%
Cotton no. 2 - ICE futures U.S.	280	149	573	80	6	74	43	123	27.8%	10.9%	43.1%	6.9%
Cocoa - ICE futures U.S.	162	116	248	26	2	24	5	40	14.5%	4.2%	22.2%	4.1%
Sugar no. 11 - ICE futures U.S.	922	604	1,535	267	56	211	106	393	23.0%	10.0%	32.8%	5.3%
Coffee c - ICE futures U.S.	182	112	284	46	3	43	28	67	24.2%	15.2%	42.2%	5.1%

Table 2 provides basic price and returns statistics for the 12 agricultural futures markets considered here. As expected, prices fluctuated in a wide range over the study period and weekly return standard deviations were quite large, averaging 4.1%

Table 2: Descriptive Statistics on Futures Prices and Returns (2006-2012)

Contract	Price				Returns			
	Avg. Price over Period	Min. Price	Max. Price	St. Dev. Price	Avg. Weekly return	Min Weekly return	Max. Weekly return	St. Dev. Weekly return
Wheat - Chicago Board of Trade	632	329	1,223	174	0.2%	-17.6%	18.7%	5.2%
Wheat - Kansas City Board of Trade	673	372	1,261	179	0.2%	-16.4%	14.8%	4.7%
Corn - Chicago Board of Trade	477	209	831	166	0.3%	-16.5%	18.9%	4.9%
Soybeans - Chicago Board of Trade	1,095	537	1,768	291	0.3%	-14.6%	10.7%	3.9%
Soybean oil - Chicago Board of Trade	43	22	69	11	0.3%	-10.9%	16.1%	3.8%
Lean Hogs - Chicago Mercantile Exchange	72	45	103	12	0.1%	-16.1%	16.6%	4.0%
Live Cattle - Chicago Mercantile Exchange	99	75	133	14	0.1%	-8.1%	7.3%	2.1%
Feeder Cattle - Chicago Mercantile Exchange	116	87	161	19	0.1%	-7.9%	8.0%	2.1%
Cotton no. 2 - ICE futures U.S.	77	39	207	34	0.1%	-35.8%	16.2%	5.2%
Cocoa - ICE futures U.S.	2,418	1,403	3,633	566	0.1%	-16.7%	14.3%	4.4%
Sugar no. 11 - ICE futures U.S.	18	9	33	6	0.1%	-14.5%	14.9%	4.9%
Coffee c - ICE futures U.S.	154	95	306	50	0.1%	-13.3%	17.7%	4.1%

4.2 Methodology and Empirical Results

4.2.1 Specification

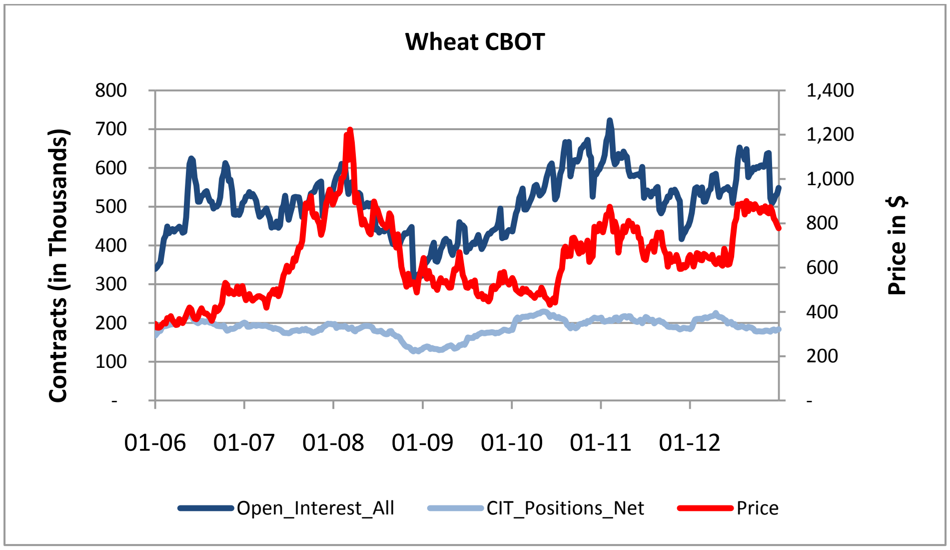
To investigate the relationship between index traders' positions and commodity futures prices, I argue that one should not look at index traders' positions in absolute value but rather relative to total open interest. Previous research efforts have focused on discovering the impact of commodity index traders' positions on prices. Or, for the purposes of causality testing, the time series need to be stationary which is almost never the case with price time series and only occasionally with traders' positions time series, so most researchers use returns and position changes. The problem is that by only looking at the change in positions and ignoring what is happening to total open interest, one could draw the wrong conclusions in terms of cause and effect. For example, assume that one finds that changes in commodity index traders' positions Granger cause returns. Let's also assume that over the same period, the total open interest of a particular futures contract increased more than the total positions of commodity index traders and that the changes in total open interest also Granger cause returns. The finding then that the changes in commodity index traders' positions Granger caused returns might be misleading because a third factor might have caused all investors to invest more resulting in a higher demand for futures contracts, a larger market (in terms of outstanding contracts) and higher prices. As such, I argue that one should look at the change in commodity index traders' positions relative to the total open interest and compare this change to returns.

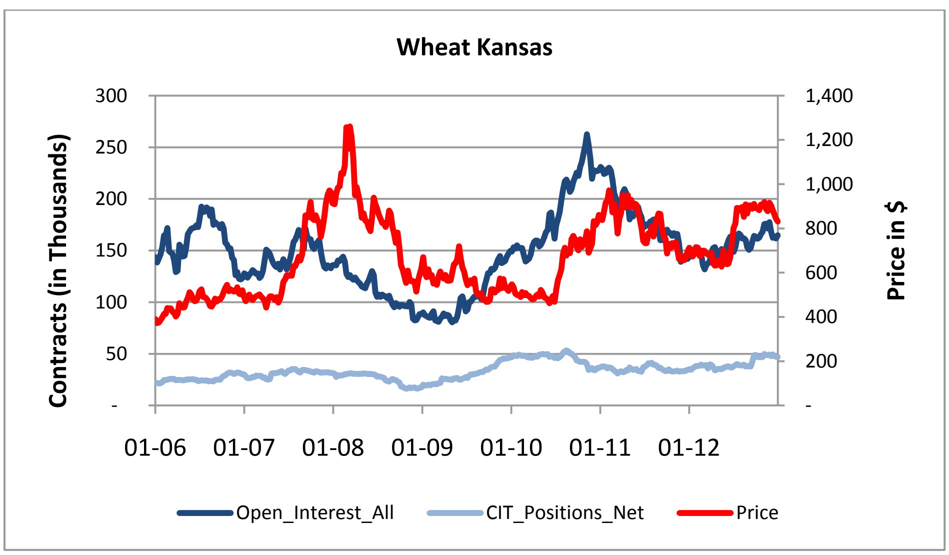
I also argue that for the purposes of this study, commodity index traders' positions should be taken as the net number of contracts (long less shorts) reported in the CIT report and not be multiplied by the contemporaneous futures prices to obtain a dollar value for commodity index investing (Stoll and Whaley, 2010), as this would create a feedback loop and would lead to spurious causality test results.

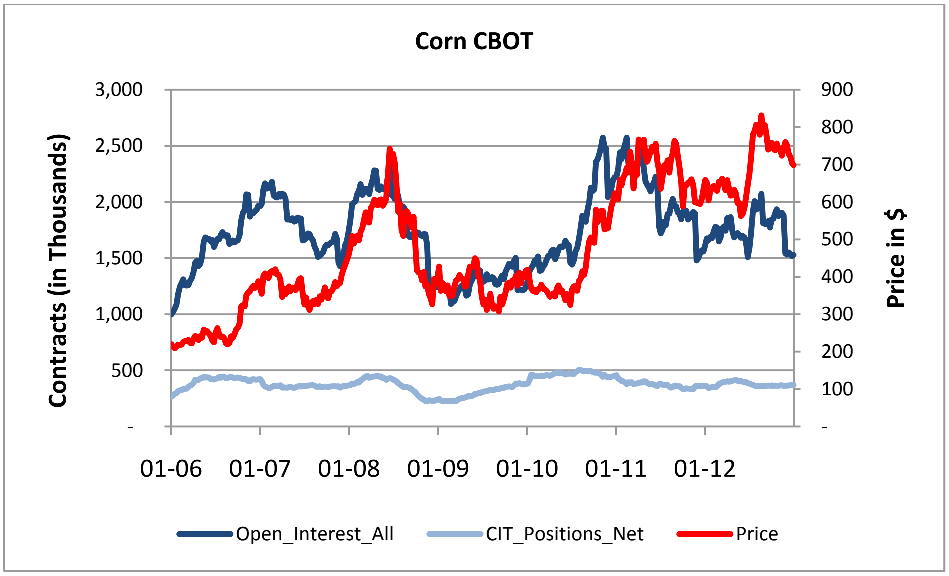
4.2.2 General observations

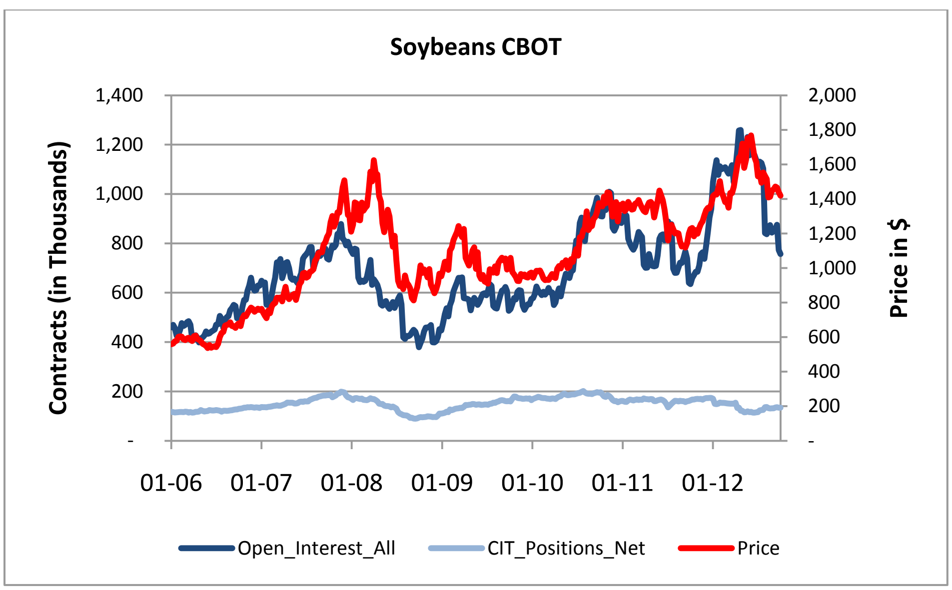
The following graphs show the evolution of commodity index traders' positions as well as of total open interest relative to prices. Note that both open interest and net commodity index trader's positions often tend to follow the same patterns as prices, which seems to indicate that some sort of relationship exists between these variables. In addition, it appears that both commodity index investors' positions and open interest follow the same overall trends, which is consistent with the theory that investors are herding or that other factors determine investment flows.

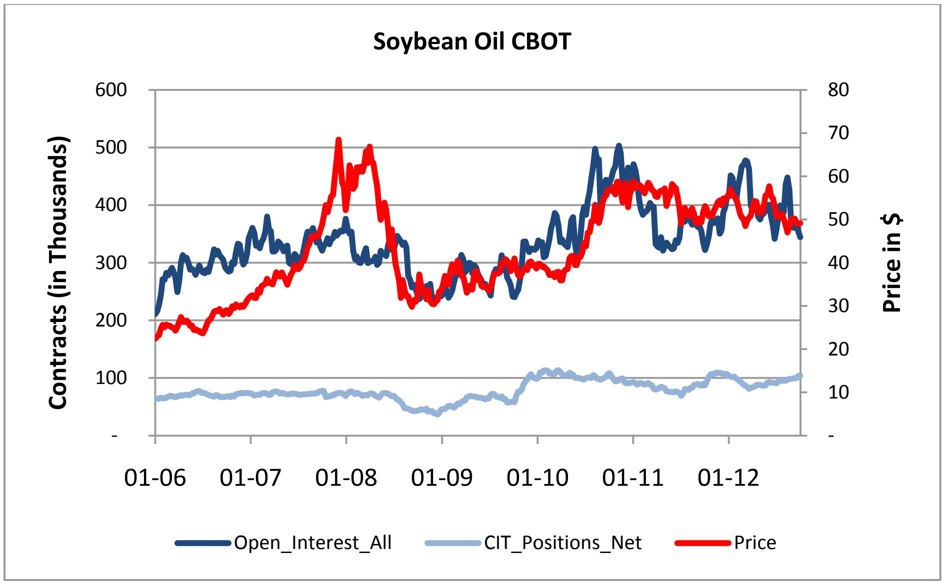
<u>Exhibit 1: Futures Prices versus Open Interest and Net Commodity Index Traders' positions on a Weekly Basis over the Period 2006-2012</u>



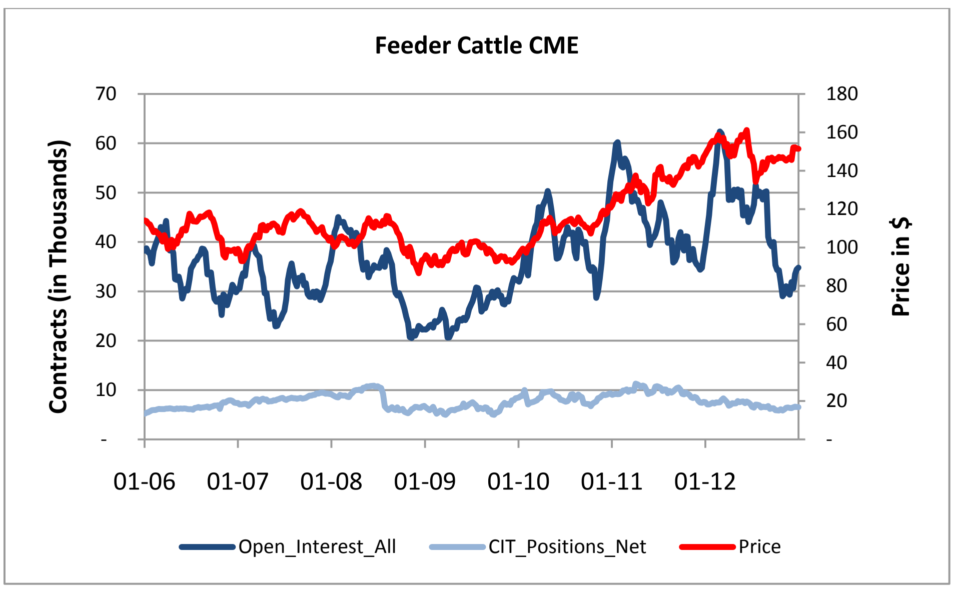



Corn CBOT
Contracts (in Thousands)
3,000
2,500
2,000
1,500
1,000
500
-
900
800
700
600
500
400
300
200
100
-
Price in $
01-06
01-07
01-08
01-09
01-10
01-11
01-12
Open_Interest_All
CIT_Positions_Net
Price

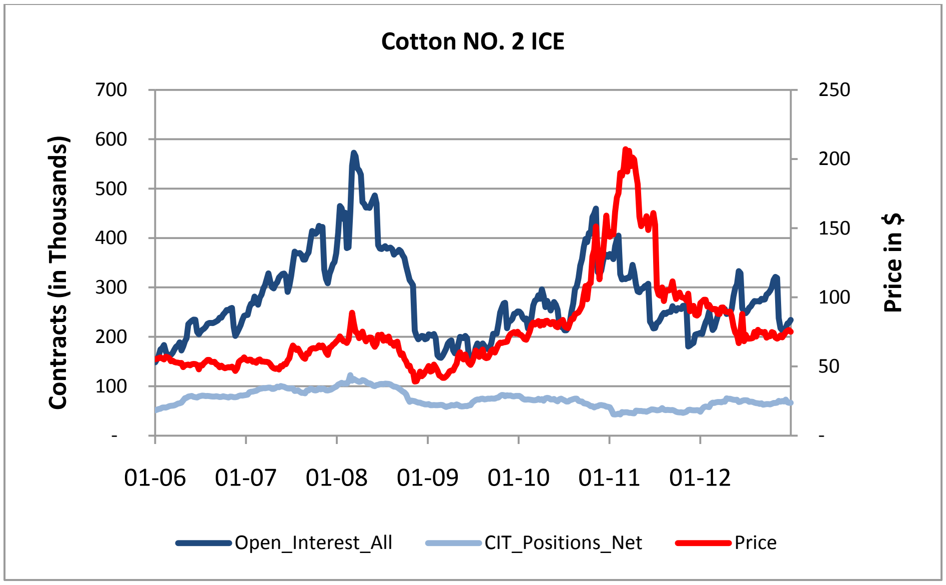

Soybeans CBOT
Contracts (in Thousands)
1,400
1,200
1,000
800
600
400
200
-
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
-
Price in $
01-06
01-07
01-08
01-09
01-10
01-11
01-12
Open_Interest_All
CIT_Positions_Net
Price



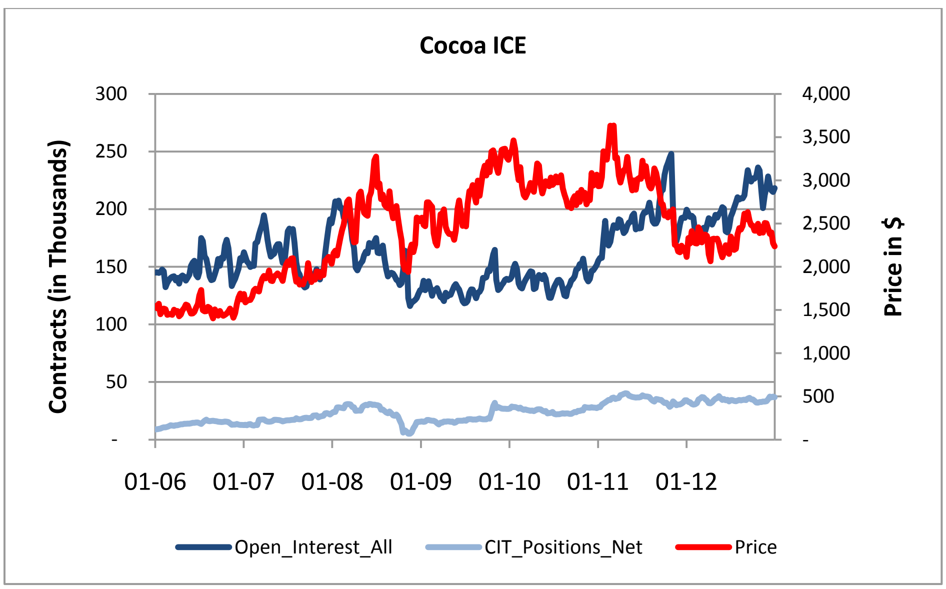
Soybean Oil CBOT
Contracts (in Thousands)
Price in $
600
500
400
300
200
100
-
80
70
60
50
40
30
20
10
-
01-06
01-07
01-08
01-09
01-10
01-11
01-12
Open_Interest_All
CIT_Positions_Net
Price



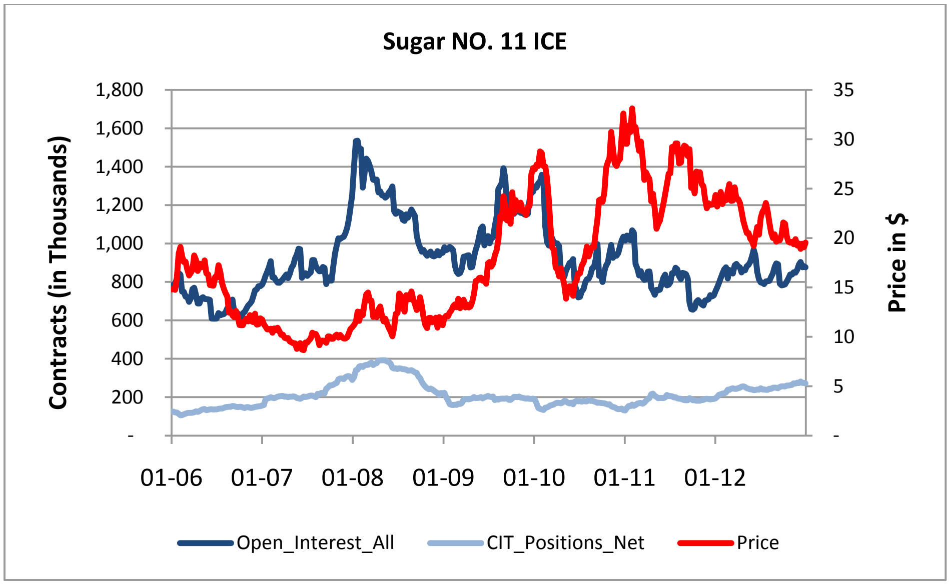
Feeder Cattle CME
Contracts (in Thousands)
Price in $
70
60
50
40
30
20
10
-
180
160
140
120
100
80
60
40
20
-
01-06
01-07
01-08
01-09
01-10
01-11
01-12
Open_Interest_All
CIT_Positions_Net
Price

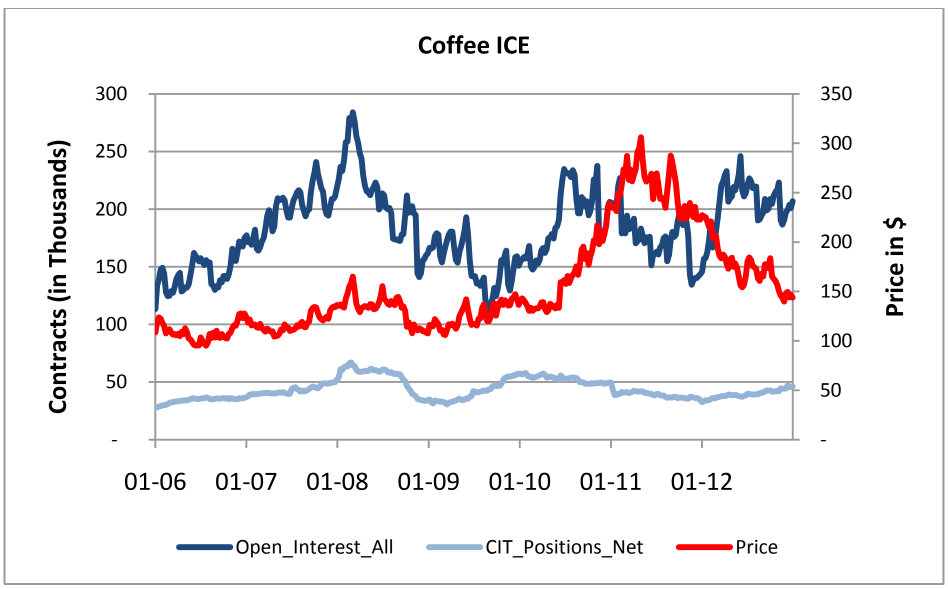


Cotton NO. 2 ICE
Contracts (in Thousands)
700
600
500
400
300
200
100
-
250
200
150
100
50
-
Price in $
01-06
01-07
01-08
01-09
01-10
01-11
01-12
Open_Interest_All
CIT_Positions_Net
Price



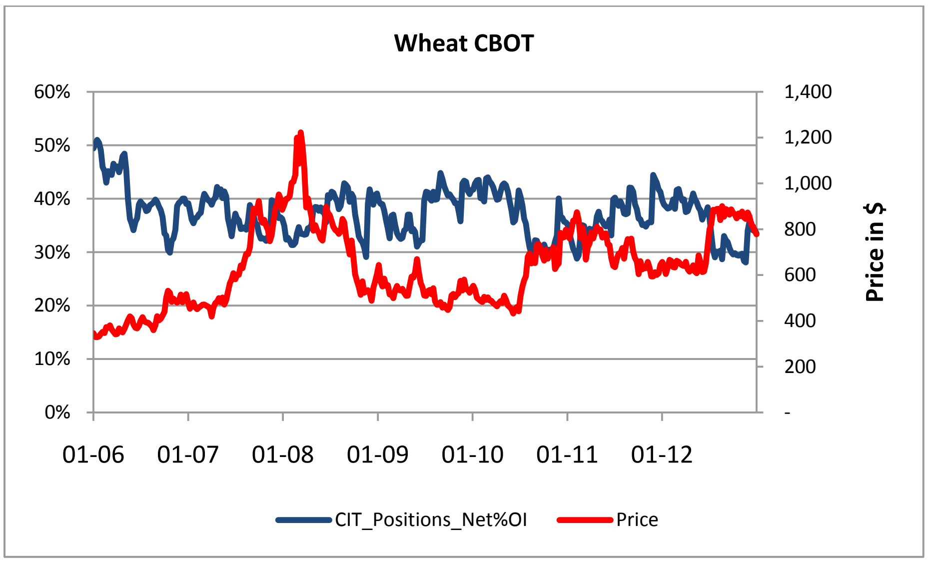
Cocoa ICE
Contracts (in Thousands)
300
250
200
150
100
50
-
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
Price in $
01-06
01-07
01-08
01-09
01-10
01-11
01-12
Open_Interest_All
CIT_Positions_Net
Price

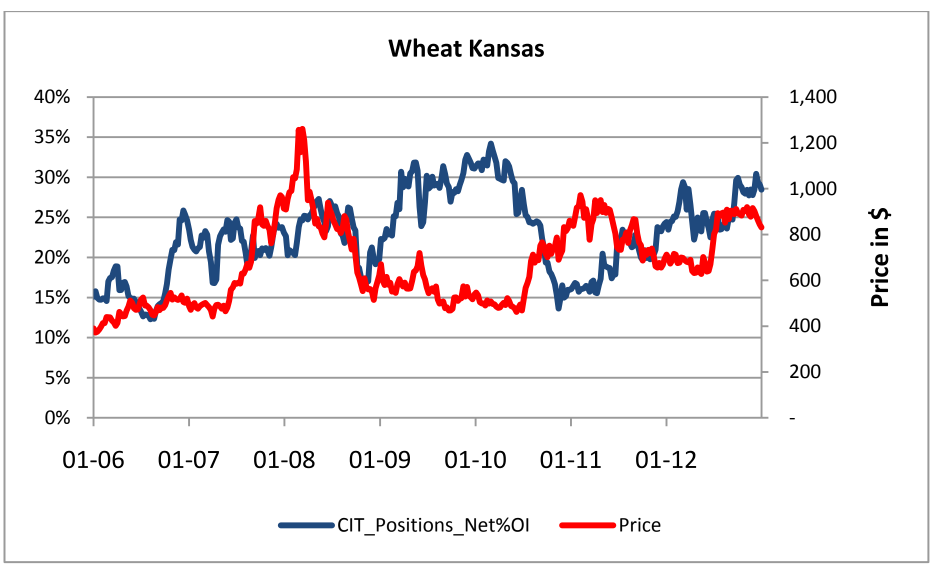

Sugar NO. 11 ICE
Contracts (in Thousands)
1,800
1,600
1,400
1,200
1,000
800
600
400
200
-
35
30
25
20
15
10
5
-
Price in $
01-06
01-07
01-08
01-09
01-10
01-11
01-12
Open_Interest_All
CIT_Positions_Net
Price

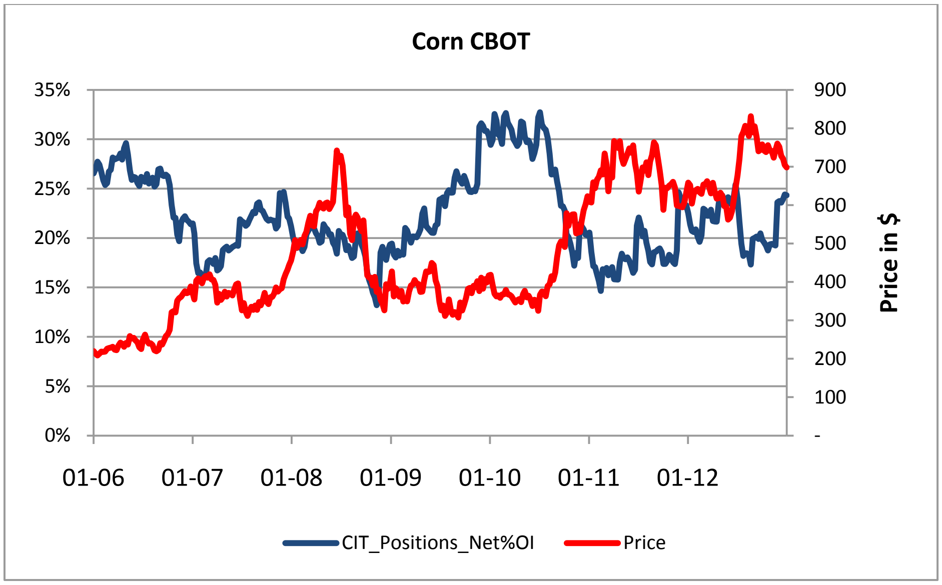

Coffee ICE
Contracts (in Thousands)
300
250
200
150
100
50
-
350
300
250
200
150
100
50
-
Price in $
01-06
01-07
01-08
01-09
01-10
01-11
01-12
Open_Interest_All
CIT_Positions_Net
Price

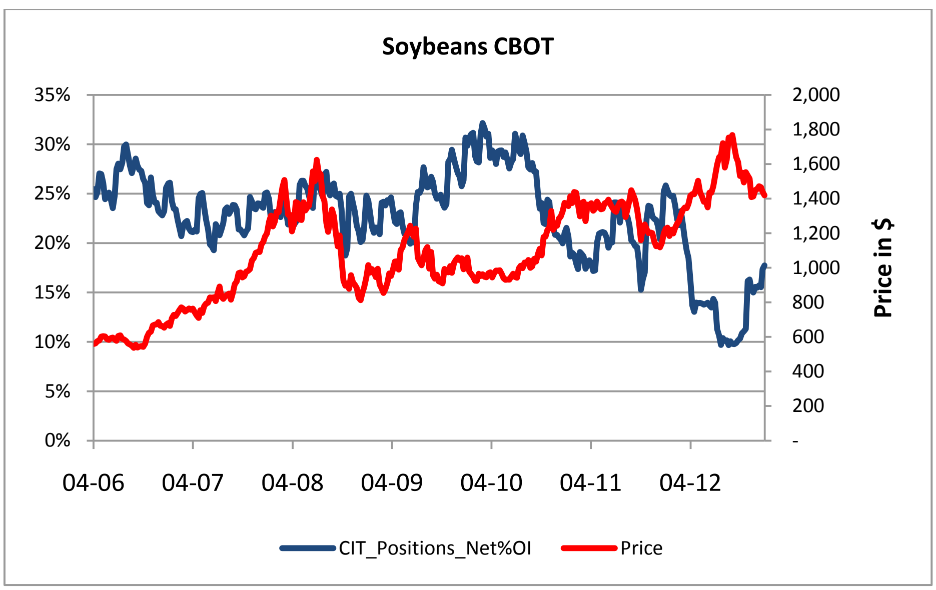
The following charts show futures prices compared to commodity index investment expressed as a percentage of total open interest. There is no clear indication that one influences the other even if at times, for shorter periods, some positive / negative correlation between the series can be discerned.

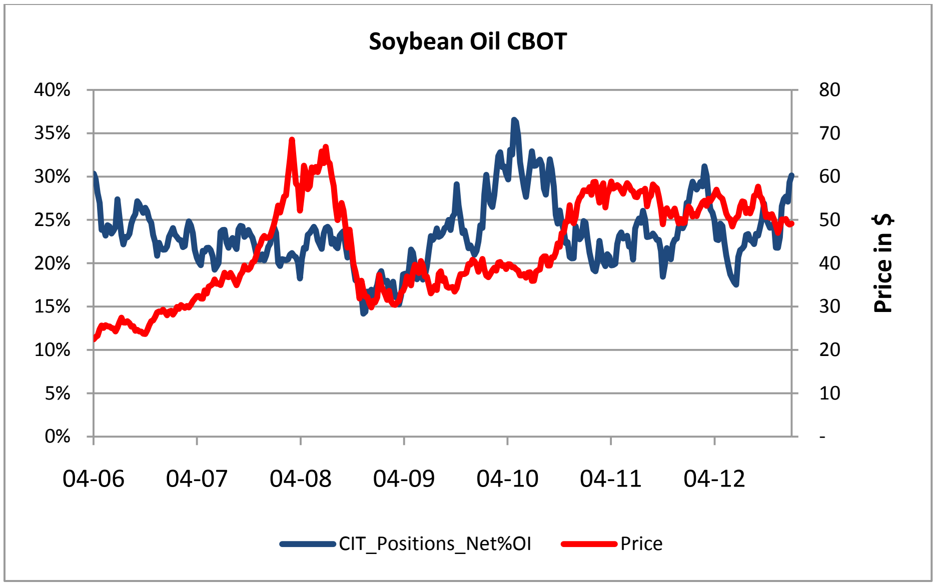
Exhibit 2: Commodity Index Traders' Positions as a Percentage of Open Interest Relative to Price on a Weekly Basis over the Period 2006-2012

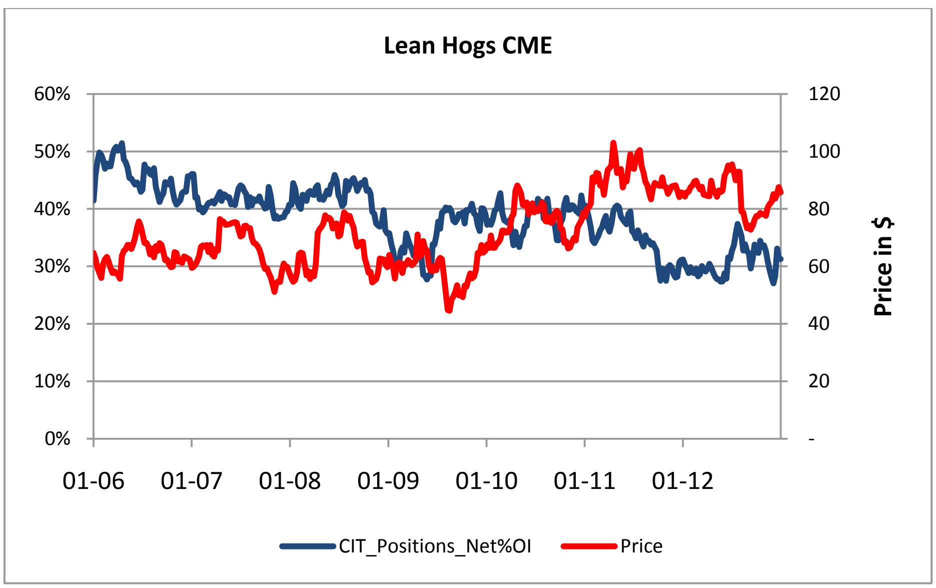


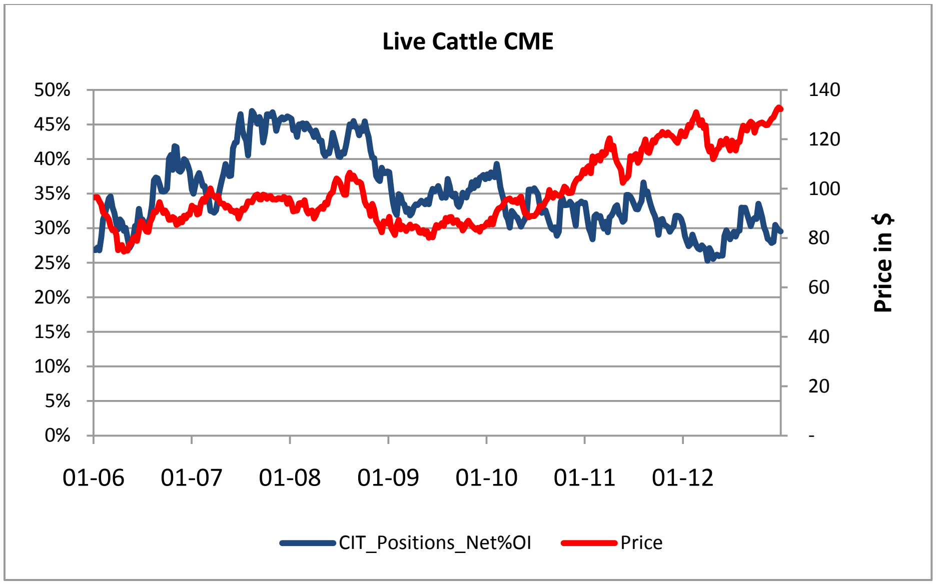


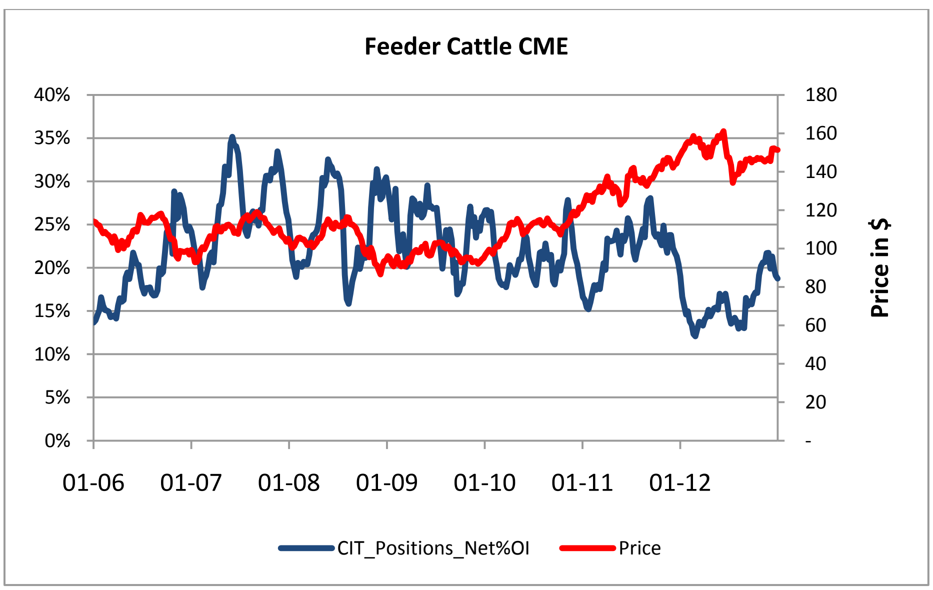

Corn CBOT
35%
30%
25%
20%
15%
10%
5%
0%
900
800
700
600
500
400
300
200
100
-
Price in $
01-06
01-07
01-08
01-09
01-10
01-11
01-12
CIT_Positions_Net%OI
Price

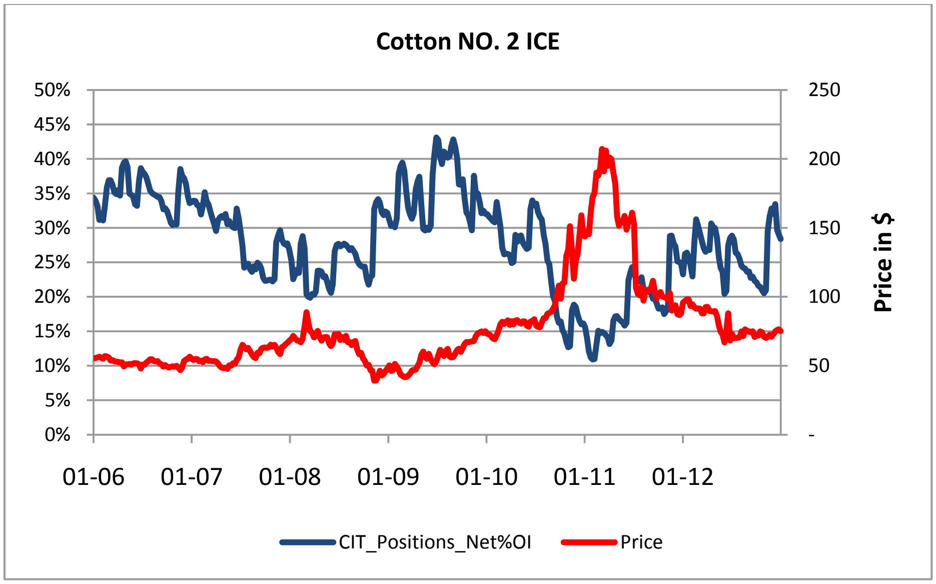

Soybeans CBOT
35%
30%
25%
20%
15%
10%
5%
0%
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
-
Price in $
04-06
04-07
04-08
04-09
04-10
04-11
04-12
CIT_Positions_Net%OI
Price

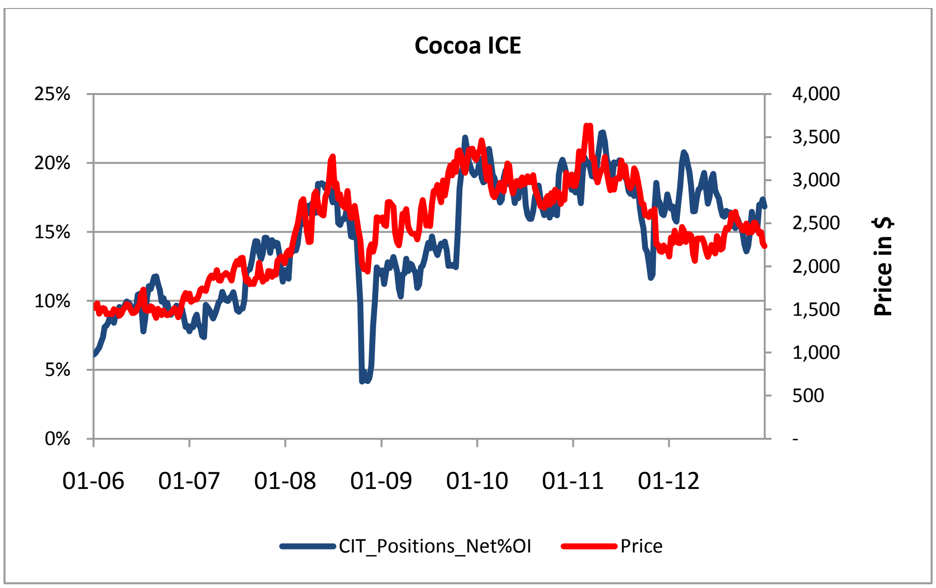

Soybean Oil CBOT
40%
35%
30%
25%
20%
15%
10%
5%
0%
80
70
60
50
40
30
20
10
-
Price in $
04-06
04-07
04-08
04-09
04-10
04-11
04-12
CIT_Positions_Net%OI
Price

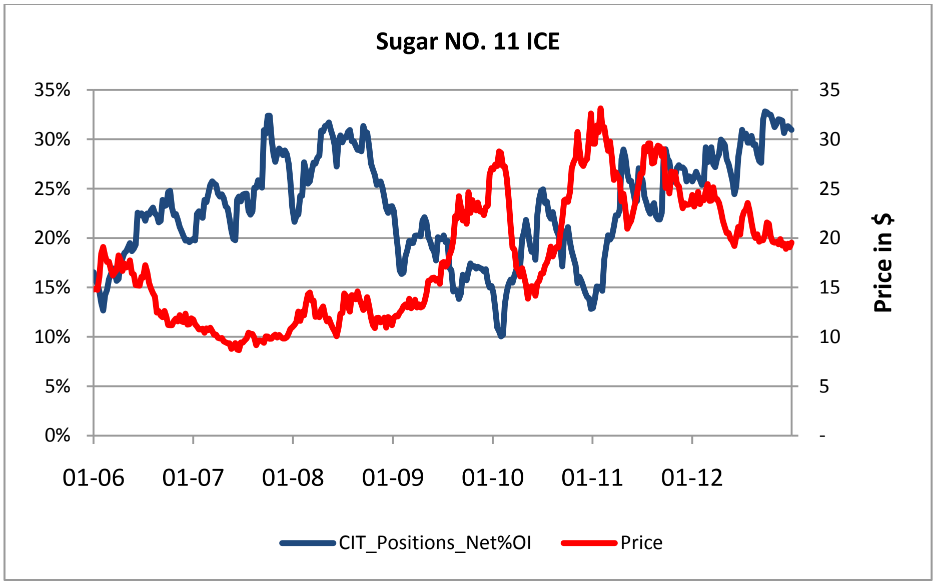

Lean Hogs CME
60%
50%
40%
30%
20%
10%
0%
120
100
80
60
40
20
-
Price in $
01-06
01-07
01-08
01-09
01-10
01-11
01-12
CIT_Positions_Net%OI
Price

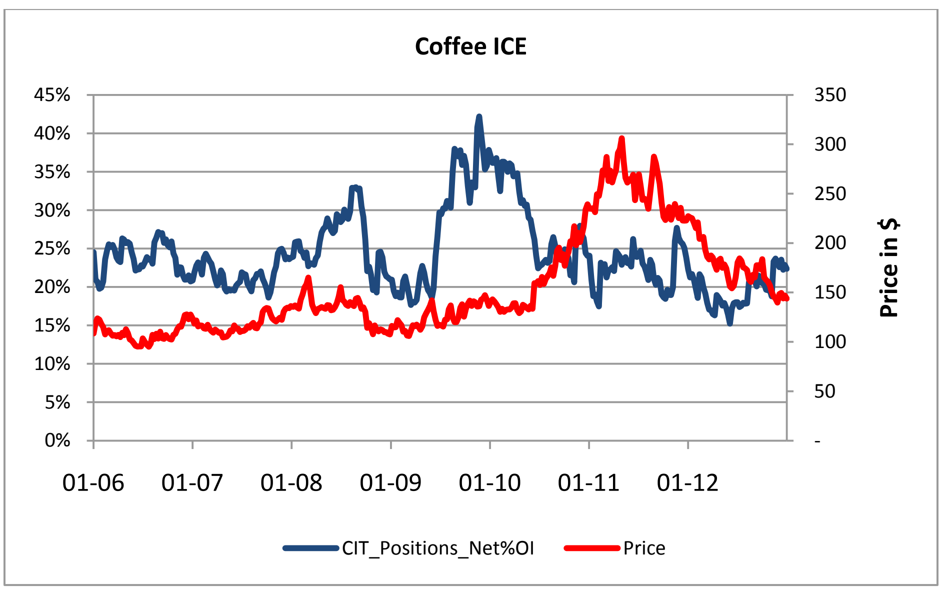

Live Cattle CME
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
140
120
100
80
60
40
20
-
Price in $
01-06
01-07
01-08
01-09
01-10
01-11
01-12
CIT_Positions_Net%OI
Price


Feeder Cattle CME
40%
35%
30%
25%
20%
15%
10%
5%
0%
180
160
140
120
100
80
60
40
20
-
Price in $
01-06
01-07
01-08
01-09
01-10
01-11
01-12
CIT_Positions_Net%OI
Price


Cotton NO. 2 ICE
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
250
200
150
100
50
-
Price in $
01-06
01-07
01-08
01-09
01-10
01-11
01-12
CIT_Positions_Net%OI
Price


Cocoa ICE
25%
20%
15%
10%
5%
0%
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
Price in $
01-06
01-07
01-08
01-09
01-10
01-11
01-12
CIT_Positions_Net%OI
Price


Sugar NO. 11 ICE
35%
30%
25%
20%
15%
10%
5%
0%
35
30
25
20
15
10
5
-
Price in $
01-06
01-07
01-08
01-09
01-10
01-11
01-12
CIT_Positions_Net%OI
Price


Coffee ICE
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
350
300
250
200
150
100
50
-
Price in $
01-06
01-07
01-08
01-09
01-10
01-11
01-12
CIT_Positions_Net%OI
Price

4.2.3 Causality Tests

To investigate whether commodity index investing was a determinant of the 2006-2008 spike in commodity prices I conduct three batteries of tests. First I apply the standard linear Granger causality test using a VAR approach, then I apply the Diks and Panchenko test to the residuals of the VAR equations (assuming only nonlinear effects are left) and finally I apply the Diks and Panchencko test to the raw time series, namely the weekly change in commodity index trader's positions as a percentage of total open interest and the weekly futures price returns.

Ideally, to find if index investing was a determinant of the increase in commodity futures prices, one should look at the raw time series, i.e. on one hand the percentage that commodity index traders' positions represent for a given futures contract's total open interest and on the other hand the price of the given futures contract. However, as Granger causality testing requires the underlying data to be stationary, two tests were performed, the Augmented Dickey-Fuller test in which the null hypothesis is that the time series has a unit root and the Kwiatkowski-Philips-Schmidt-Shin ("KPSS") test in which the null hypothesis is that the series is stationary. The tests were performed for each futures contract, for both the weekly commodity index traders' positions as a percentage of total open interest and for weekly prices as well as for the first differenced series, which are the change in the weekly commodity index traders' positions as a percentage of total open interest and the weekly change in prices. The results are presented in Table 3:

Table 3: Stationarity Tests – Weekly Commodity Index Traders' Positions as a Percentage of Open Interest (and weekly changes) and Weekly Futures Prices (and returns) – 2006-2012

	Augmented Dickey Fuller									**KPSS**			
	Null Hypothesis: Has unit root									Null Hypothesis: is stationary			
Commodity	CIT Positions % of OI		CIT Positions % of OI chg.		Price		Price Change			CIT Positions % of OI	CIT Positions % of OI chg.	Price	Price Change
	t-Stat.	Prob	t-Stat.	Prob	t-Stat.	Prob	t-Stat.	Prob		LM-Stat.	LM-Stat.	LM-Stat.	LM-Stat.
Wheat CBOT	-5.210	**0.000**	-17.121	**0.000**	-2.242	0.192	-19.205	**0.000**		0.364	0.086	**0.486**	0.097
Wheat KS	-2.415	0.138	-17.129	**0.000**	-2.120	0.237	-18.743	**0.000**		**0.494**	0.058	**0.513**	0.090
Corn CBOT	-2.987	**0.037**	-13.932	**0.000**	-1.498	0.534	-20.383	**0.000**		0.154	0.062	**1.516**	0.084
Soybeans	-2.384	0.147	-6.353	**0.000**	-1.854	0.354	-19.293	**0.000**		**0.772**	0.237	**1.375**	0.115
Soybean Oil	-3.856	**0.003**	-28.569	**0.000**	-2.020	0.278	-18.448	**0.000**		0.245	0.130	**0.983**	0.191
Lean Hogs	-2.423	0.136	-19.317	**0.000**	-2.066	0.259	-17.763	**0.000**		**1.685**	0.036	**1.391**	0.038
Live Cattle	-2.299	0.173	-5.401	**0.000**	-0.450	0.897	-20.117	**0.000**		**1.013**	0.248	**1.581**	0.169
Feeder Cattle	-3.673	**0.005**	-16.524	**0.000**	-0.545	0.879	-18.618	**0.000**		**0.584**	0.054	**1.447**	0.183
Cotton ICE	-3.368	**0.013**	-15.253	**0.000**	-1.585	0.489	-18.728	**0.000**		**0.737**	0.080	**1.002**	0.105
Cocoa ICE	-3.161	**0.023**	-14.730	**0.000**	-2.175	0.216	-18.761	**0.000**		**1.579**	0.061	**1.311**	0.250
Sugar	-2.527	0.110	-16.350	**0.000**	-1.470	0.548	-19.355	**0.000**		0.327	0.067	**1.542**	0.090
Coffee ICE	-3.078	**0.029**	-17.003	**0.000**	-1.488	0.539	-19.546	**0.000**		0.262	0.044	**1.434**	0.155

Note that all prices time series are not stationary and only half of the index traders' net positions as a percent of total open interest are stationary. After differencing, all series are stationary.

4.2.3.1 Causality Tests – Linear Tests and Diks and Panchenko Test applied to the VAR residuals

The linear Granger causality tests were performed to test the following null hypotheses:

1. The change in the weekly commodity index traders' positions as a percentage of total open interest does not Granger cause the weekly change in futures prices.

2. The weekly change in futures prices does not Granger cause the change in the weekly commodity index traders' positions as a percentage of total open interest

The following vector autoregressive (VAR) model was set up and block exogeneity Wald tests were conducted to test the null hypothesis each of the $\gamma_i = 0$ and of all $\nu_i = 0$:

$$R_t = \alpha + \sum_{t-1}^{t-l} \beta_i R_i + \sum_{t-1}^{t-l} \gamma_i V_i + \varepsilon$$

$$V_t = \alpha + \sum_{t-1}^{t-l} \mu_i V_i + \sum_{t-1}^{t-l} \nu_i R_i + \varepsilon \quad (4.1)$$

where R_t is the weekly logarithmic return and V_t is the change in the weekly commodity index traders' positions as a percentage of total open interest and l is the number of lags chosen.

The VAR model order was selected over lags 1 to 4 weeks using the Schwarz information criterion. Lagrange multiplier tests were conducted for residual autocorrelations and if detected, the VAR order was increased by the necessary number of lags to eliminate the autocorrelation.

In a second step, the Diks and Panchenko test was performed on the residuals of the first VAR model specification with the underlying model assuming the same number of lags as the original VAR model. The bandwidth was set at 1.5, based on sample size.

Table 4 presents the results of the linear Granger causality tests as well as the results of the Diks and Panchenko test applied to the residuals of the VAR equations from the linear Granger test.

Table 4: Results of the Linear Granger Causality and Diks and Panchenko Tests Applied to VAR Residuals

		Causal Relationship				Causal Relationship			
		Changes in CIT net positions as a % of total OI -> commodity price changes		Commodity price changes -> Changes in CIT net positios as a % of total OI		Changes in CIT net positions as a % of total OI -> commodity price changes		Commodity price changes -> Changes in CIT net positios as a % of total OI	
		Linear Granger				Diks & Panchenko (residuals)			
Commodity	Lags	Test Statistic	p-value	Test Statistic	p-value	Test Statistic	p-value	Test Statistic	p-value
Wheat CBOT	(1,1)	3.035	0.08*	1.134	0.29	1.112	0.13	2.225	0.01**
Wheat KS	(1,1)	0.267	0.61	0.536	0.46	0.409	0.34	-0.073	0.53
Corn CBOT	(1,1)	0.261	0.61	1.117	0.29	-0.030	0.51	0.804	0.21
Soybeans	(4,4)	7.266	0.12	11.267	0.02**	-0.698	0.76	-0.580	0.72
Soybean Oil	(4,4)	6.447	0.17	2.357	0.67	-0.260	0.60	-0.659	0.75
Lean Hogs	(3,3)	10.924	0.01**	6.396	0.09*	-0.549	0.71	0.191	0.42
Live Cattle	(1,1)	0.841	0.36	0.058	0.81	-1.128	0.87	1.265	0.10
Feeder Cattle	(1,1)	2.061	0.15	1.436	0.23	1.315	0.09*	0.150	0.44
Cotton ICE	(4,4)	14.583	0.01**	3.812	0.43	1.983	0.02**	-1.081	0.86
Cocoa ICE	(3,3)	3.831	0.28	6.041	0.11	0.915	0.18	1.050	0.15
Sugar	(1,1)	3.304	0.07*	0.707	0.40	1.501	0.07*	-2.782	1.00
Coffee ICE	(3,3)	9.867	0.02**	0.496	0.92	0.801	0.21	-0.242	0.60

According to the linear test, the hypothesis of non causality running from the weekly changes in commodity index traders' net positions as a percentage of total open interest to the weekly returns, can be rejected at the 5% level for 3 commodity futures contracts, namely lean hogs, cotton and coffee and at the 10% level for CBOT wheat and sugar as well. It is interesting to find that in the case of soybeans, causality runs in the opposite direction, i.e. price changes Granger cause changes in commodity index traders' positions as a percentage of total open interest. It is also interesting to note that in the case of lean hogs there is some weak evidence of price changes Granger causing changes in commodity index traders' positions as a percentage of total open interest.

The Diks and Panchenko test, as applied to the residuals of the underlying VAR models used in the previous linear tests provides some interesting results. First of all, in the case of CBOT wheat, contrary to the linear test, evidence is found for returns Granger causing changes in commodity index traders' positions, which suggests that the linear test failed to reject the hypothesis of non-causality because of non-linear effects. Given that the linear test found some weak evidence of commodity index traders' positions Granger causing returns (no additional nonlinear effects were found by the Diks and Panchenko test) this tends to suggest the relationship might be bidirectional.

Second, the Diks and Panchenko test as applied to the VAR residuals, confirms the causality relationship highlighted by the linear test for cotton and sugar, which again suggests that the linear test failed to uncover some nonlinear causal effects.

Given the fact that the causality test results presented here are not homogeneous across the family of commodities studied, it is hard to conclude overall that changes in commodity index traders' positions Granger cause commodity futures returns or vice versa. Furthermore the results are not consistent relative to the percentage of total open interest represented by index investors. For example, the live cattle contract has a relatively high percentage of commodity index traders' positions as a percentage of open interest (averages of 35.1%) yet, no causality relationship is detected in either direction.

4.2.3.2 Causality Tests - Diks and Panchenko tests (raw data)

In a third step, the Diks and Panchenko test is performed on the raw stationary series. As there is no lag selection criterion for the Diks and Panchenko test, the test was performed for lags of 1 up to 4 weeks. The bandwidth was set to 1.5 based on sample size.

Table 5: Results of the Diks and Panchenko Test Applied Directly to the Raw Data Series

		Causal Relationship			
		Changes in CIT net positions as a % of total OI -> commodity price changes		Commodity price changes -> Changes in CIT net positios as a % of total OI	
		Diks & Panchenko (raw data)			
Commodity	Lags	Test Statistic	p-value	Test Statistic	p-value
Wheat CBOT	1	1.281	0.100	2.085	0.02**
	2	0.484	0.314	1.548	0.06*
	3	-0.619	0.732	1.438	0.08*
	4	-1.138	0.872	1.451	0.07*
Wheat KS	1	0.521	0.301	-0.172	0.568
	2	0.233	0.408	-0.311	0.622
	3	0.027	0.489	-0.388	0.651
	4	-0.350	0.637	-0.855	0.804
Corn CBOT	1	0.086	0.466	1.012	0.157
	2	0.466	0.321	0.467	0.320
	3	-0.800	0.788	-0.521	0.699
	4	-0.807	0.790	-0.372	0.645
Soybeans	1	1.525	0.06*	0.965	0.167
	2	1.524	0.06*	0.789	0.215
	3	1.132	0.129	0.181	0.428
	4	0.113	0.455	-0.850	0.802
Soybean Oil	1	0.098	0.461	0.061	0.476
	2	-0.327	0.628	-0.648	0.741
	3	-0.642	0.740	-0.949	0.829
	4	-0.465	0.679	-0.557	0.711
Lean Hogs	1	-0.176	0.570	2.001	0.02**
	2	-0.231	0.591	1.425	0.08*
	3	-0.191	0.576	0.661	0.254
	4	0.286	0.388	0.448	0.327

		Causal Relationship			
		Changes in CIT net positions as a % of total OI -> commodity price changes		Commodity price changes -> Changes in CIT net positios as a % of total OI	
		Diks & Panchenko (raw data)			
Commodity	Lags	Test Statistic	p-value	Test Statistic	p-value
Live Cattle	1	-1.181	0.881	0.910	0.181
	2	-0.821	0.794	1.121	0.131
	3	-1.600	0.945	0.653	0.257
	4	-1.959	0.975	0.287	0.387
Feeder Cattle	1	1.224	0.111	0.563	0.287
	2	1.207	0.114	0.404	0.343
	3	0.065	0.474	-0.172	0.568
	4	0.236	0.407	-0.175	0.569
Cotton ICE	1	1.221	0.111	-0.278	0.610
	2	1.990	0.02**	-1.277	0.899
	3	2.134	0.02**	-1.312	0.905
	4	1.642	0.05*	-1.147	0.874
Cocoa ICE	1	1.725	0.04**	1.577	0.06*
	2	0.877	0.190	0.976	0.164
	3	1.005	0.158	0.593	0.277
	4	1.291	0.10*	0.895	0.185
Sugar	1	1.598	0.06*	-2.484	0.994
	2	1.899	0.03**	-0.315	0.624
	3	1.870	0.03**	1.099	0.136
	4	1.769	0.04**	1.023	0.153
Coffee ICE	1	0.240	0.405	0.406	0.342
	2	1.128	0.130	-0.185	0.574
	3	1.325	0.09*	-0.243	0.596
	4	1.290	0.10*	0.035	0.486

In theory, the test should report results consistent with the linear test results if the relationship is linear and report somewhat different results for the situations in which nonlinear effects were previously reported. The results are again interesting: the test finds strong evidence for causality running from commodity index trader's positions to returns in the case of cotton, cocoa and sugar and finds weak evidence for soybeans and coffee. Contrary to the linear test no such evidence is found for lean hogs and CBOT wheat. Also contrary to the linear test but consistent with the Diks and Panchenko test applied to the VAR residuals, the test finds evidence for returns Granger causing commodity index traders' positions changes as a percent of open interest for CBOT wheat. Again, this tends to suggest that the linear test failed to discover causality in a setting where the underlying relationship is of a non-linear nature.

Overall, the Diks and Panchenko test applied to the raw data series suggests that at least for some commodities, there is a relationship between commodities index investing and returns and vice versa. However, no relationship was found for Kansas wheat, corn, soybean oil, live cattle and feeder cattle. In addition, the cause and effect relationship intensities do not seem to be stronger or weaker for markets in which commodity index traders have a higher or lower participation, so it is hard to generally conclude that over the studied period commodity index investors were the driving force behind the spike in commodity futures prices.

V Conclusion

This study investigated whether commodity index investment flows had an impact on commodity futures prices in the 2006 – 2012 period and adopted a non-linear approach to causality testing. More precisely, three batteries of tests were applied to test the causal relationship between the weekly changes in the commodity index traders' positions as a percentage of total open interest and weekly returns for 12 agricultural futures markets. First, a linear Granger causality test was conducted and then the non-linear, non-parametric Diks and Panchenko test was applied to the VAR residuals of the first test and subsequently the Diks and Panchenko test was applied directly to the raw time series.

Overall, the evidence supporting the hypothesis that massive commodity index investing caused a spike in commodity futures prices is mixed. Although for certain markets the null hypothesis of non causality was rejected by the tests for other markets it could not be rejected and the relationship did not seem to be stronger with a strong presence of commodity index investing in a given market. In addition, the results of the tests suggest that in certain cases index investing is actually following price returns, and that in some cases the relationship is bidirectional.

It is interesting to note that the linear approach to Granger causality testing failed to uncover a causal relationship when the non-linear model did not or led to the conclusion that a causal relationship existed when the non-linear model failed to reject the null of non-causality. This is perhaps not surprising as it is expected that the linear model will not perform well when coping with non-linear effects, yet it is typical for researchers, especially in the fields of finance and economics to assume the most important effects are linear and neglect, by an abuse of language “non-linearities”. From this perspective, I argue that the use of linear Granger causality testing with financial time series for which the true causal relationship is unknown (if any) can lead at times to spurious results. This is not to say that the linear approach cannot be reliably used, however under certain circumstances, particularly where extremely volatile data such as traders’ positions and returns time series are present, the linear model can lead to unwarranted conclusions. I believe more work needs to be done to assess the reliability of the underlying models used in Granger causality testing in empirical finance and would like to orient future research in this area.

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