Zentrum für Entwicklungsforschung
Center for Development Research
University of Bonn

ZEF-Discussion Papers on Development Policy No. 176

Bernardina Algieri

A Roller Coaster Ride: an empirical investigation of the main drivers of wheat price

Bonn, February 2013

Bernardina Algieri, A Roller Coaster Ride: an empirical investigation of the main drivers of wheat price, ZEF - Discussion Papers on Development Policy No. 176, Center for Development Research, Bonn, February 2013, pp. 38.

ISSN: 1436-9931

Published by:
Zentrum für Entwicklungsforschung (ZEF)
Center for Development Research
Walter-Flex-Straße 3
D – 53113 Bonn
Germany
Phone: +49-228-73-1861
Fax: +49-228-73-1869
E-Mail: zef@uni-bonn.de
www.zef.de

The author:

Bernardina Algieri, University of Calabria and Center for Development Research (ZEF).
Contact: b.algieri@unical.it

Acknowledgements

I am grateful to the comments and suggestions offered by Prof. Joachim von Braun, Dr. Matthias Kalkuhl, and Prof. Antonio Aquino. I would like to thank the participants at the international Workshop on “Food price volatility and food security”, held in Bonn, at ZEF Centre, January, 31st –February, 1st, 2013 for their helpful comments and suggestions. Financial support from the Federal Ministry for Economic Cooperation and Development, BMZ (Scientific Research Program on “Volatility in food commodity markets and the poor”) is grateful acknowledged.

Abstract

Over the last decade, commodity prices have registered substantial booms and busts marked by extreme volatility. Wheat in particular, one of the main non-oil commodities, has registered a roller-coaster in price levels which seems to be inconsistent with supply and demand fundamentals. To acutely investigate the drivers of wheat prices and quantify their impact, a Vector Error Correction Model (VECM) has been used. The exogenous variables have been distinguished into four groups: market-specific factors, broad macroeconomic determinants, speculative components, and weather variables. The quadriangulation of the determinants will enable us to better understand the movements in wheat price and identify the specific role of each component. The results show a mix of short and long term factors that are contributing to wheat price movements, and their effect should be taken into account in designing proper policy intervention to mitigate the negative impact of price shocks.

Keywords: wheat price, fundamentals, speculation

JEL code: C22, E31, Q11

1. Introduction

In recent years, food commodity prices have increased unusually rapidly, and wheat prices in particular have registered marked upsurges interrupted only briefly by the global financial crisis. These trends can be particularly detrimental because they could amplify the incidence of poverty (IMF, 2011; von Braun and Tadesse, 2012), hamper economic growth in poor countries (Jacks et al., 2011), and generate worldwide protests and demonstrations, such as those registered in several sub-Saharan African regions. This occurs because people living in these areas spend a larger share of their income on food (about 50 per cent) than urban residents do in other parts of the world (about 30 and 15 per cent in middle and high income countries, respectively) (Portillo and Zanna, 2011). Given that Africans depend on a small number of staple crops, increases in cereal prices can be particularly destructive. More consumer money on food, in fact, means fewer purchases of services such as sanitation, health, and education (The Economist, May 26th 2011). In addition, the Middle East and North Africa regions are the world's largest importers of cereals, particularly wheat, exposing them to higher international prices. This can lead to substantial terms-of-trade shocks, which affect countries' internal and external balances, with higher non-accelerating inflation rates of unemployment and balance of payments deficits.

In this context, the present study tries to shed light on the main drivers of wheat prices by identifying the influence of the fundamental factors of supply and demand on the one side, and the behavior of investors in the financial markets on the other side. In light of the steep hikes in the price of several commodities, it becomes especially important to investigate the underlying factors that exert an influence on the wheat market.

Specifically, the study distinguishes wheat price drivers into market specific variables, broad macroeconomic variables, financial factors, and weather conditions. The empirical analysis is based on monthly data for the period 1980:1-2012:1 and the sub-period 1995:1-2012:1. The quadriangulation of the drivers will allow us to better understand commodity price patterns. This could help policy makers address proper interventions and manage any deleterious effect of quick price variations.

The paper provides several contributions to the existent literature. It explicitly examines the case of the wheat market, merging different strands of the literature. To my knowledge, the empirical analyses on the factors behind wheat spot price are quite scanty (Borenszten and Reinhart, 1994; Westcott and Hoffman, 1999). Some studies on wheat have more of a descriptive nature. For instance, Trostle (2008) and Mitchell (2008), carrying out a graphical inspection, suggest that wheat price bounced up due to a large demand for biofuels, high transportation costs, and severe drops in world supply. Other analyses consider demand and supply factors leaving out the role of financialisation or other broad macro-economic factors (Goodwin and Schroeder, 1991; Westcott and Hoffman, 1999). This study tries to extend the discussion on the wheat market by singling out specific factors behind price swings within a cointegration framework. A further novelty consists in comparing two long and short run relationships, before and after the “financialisation” of the commodity markets, to catch similarities and differences. A final important element of this study relates to the use of monthly data, allowing for a finer analysis of price dynamics. Most papers are based on annual or quarterly data (Westcott and Hoffman, 1999).

The rest of the study is organized as follows. Section 2 reviews the literature on the key factors influencing commodity price. Section 3 introduces the variables entering the model. Section 4 presents the VECM estimation and discusses the results. Section 5 concludes.

2. Literature review

The significant roller coaster in commodity prices over the recent years has triggered a vivacious discussion regarding the causes of these ups and downs.

Some observers argue that the run-ups in commodity prices reflect strong changes in economic fundamentals, with price fluctuations moderated by the participation of non-user speculators[1] and passive investors in commodity futures markets. Others points to the role of broader macroeconomic factors as main drivers pushing up prices. Finally, some other observers argue that commodity prices have been exuberant and divorced from market fundamentals. The first view can be dubbed the “fundamentalist” view, the second the “broad” macro view, and the third the “financialisation” view.

According to the market “fundamentalist” view (Irwin et al., 2009; Irwin and Sanders, 2010; Krugman, 2010a, 2011; Yellen, 2011; Dwyer et al., 2012, 2011), the price of any good or asset should be driven by demand and supply in the absence of “irrational exuberance.” In this context, any shock to demand and supply which leads to rising global demand and disruption to global supply causes relevant price swings. Negative shocks to agricultural commodities supply, which imply price surges, are mainly determined by adverse weather conditions and collapses in the stock-to-use ratios. Put differently, extreme weather conditions result in greater yield variability, with likely damage to existing cropping areas and consequent price changes. Additionally, when stocks are low relative to use, the market is less prone to cope with significant supply drops or demand excesses, and thus prices skyrocket (Williams and Wright, 1991; Gilbert and Morgan, 2011). Pre-existing stocks are thus a fundamental source of stability in commodity markets. According to a report on the pre-recession spike in food commodity prices by FAO (2009), stock levels have been decreasing, on average, by 3.4% per year since the mid-1990s, and the highest prices were registered during a period in which the stock-to-use ratios were at historical lows. Low stocks in food and other crops finish exacerbating weather disruptions. For instance, the

[1] A rational expectations model predicts that the existence of a futures market would reduce the fluctuation of spot prices for reasonable value of input parameters.

47% increase in wheat prices in 2010 was largely attributable to droughts in Russia and China and to floods in Canada and Australia.

With respect to demand, the process of income caught-up between developing and advanced countries has triggered demand growth for commodities, and hence the price of commodities. More than 90% of the augmented demand for agricultural commodities over recent years has, in fact, originated from developing countries, mainly from India and China (Heap, 2005; Fawley and Juvenal, 2011; Cevik and Sedik, 2011). In Krugman's words (2010b), rising commodity prices are a sign that "we are living in a finite world, in which the rapid growth of emerging economies is placing pressure on limited supplies of raw materials, pushing up their prices." However, it should be noted that, in real terms, the price of food commodities has increased by 75 percent from 2003 to 2008 (Erten and Ocampo, 2012). This pattern was a reversal of the strong downward trends experienced since the 1980s, but it is still too early to assess if the reversal implies a long term change (shift) in the trend (in its direction), a pronounced short-run blimp (movement) of food commodity prices around the long-run trend , or a commodity price super-cycle (Rogers, 2004; Heap, 2005; Jacks, 2012).

According to the "broad" macro view, other macroeconomic determinants, such as exchange rates, monetary policies, inflation, energy price, global economic activity, and the "thinness" of markets, could have affected price levels and their fluctuations via demand or supply channels. For instance, exchange rates can influence commodity prices through several conduits, such as international purchasing power and the effects on margins for producers with non-US dollar costs (Mussa, 1986; Gilbert, 1989; Borensztein and Reinhart, 1994; Roache, 2010). This means that dollar depreciation increases prices to US producers and consumers inside the dollar area. A change in the dollar exchange rate thus conditions prices measured in dollar terms, but its effect would fizzle out if prices were measured in terms of a weighted basket of currencies. Monetary policies, including interest rate manoeuvres, can as well impact on a number of demand and supply channels (Orden and Fackler, 1989; Frankel, 2008; Calvo, 2008; Bakucs et al., 2009), leading to greater movements in real commodity prices when changes in real interest rates become frequent. This occurs particularly when interest rates are low, and there is an incentive to hoard physical commodities as an investment vehicle, causing price to go up. Inflation is a common factor driving prices of different commodities. Further, oil prices have been mentioned as an additional shock to food price via demand channels (Mercer-Blackman et al., 2007, Thompson et al. 2009). This because a surge in oil price leads to an increase in demand for grains as biofuels, and this causes a consequent raise in food commodity prices[2].

[2] To reduce oil dependence as the main source of energy, several countries, including the US, have adopted new energy policies to promote the use of biofuel. The 2005 US energy bill mandated that 7.5 billion gallons of ethanol be used by 2012. The 2007 energy bill further raised the mandate to 36 billion by 2022. The mix of increasing ethanol subsidies and high oil prices determined a rapid growth of the ethanol industry, which consumes about one third of the US maize

Also, the “thinness” of markets, which is the combined share of imports and exports relative to the size of global consumption or production, significantly affects commodity price movements. It does this because in thinner markets, where domestic prices do not follow the international market, world market prices have to vary more to accommodate an external shock to traded quantities (OECD, 2008).

Some other observers have doubts that fundamental shocks are able to justify the whole price run-ups. Instead, they point to the “financialisation” of commodity markets and speculation as the main culprits of the drifts and fluctuations of commodity prices (Masters, 2008; Stewart, 2008; Hamilton, 2009; Gilbert and Morgan, 2011; Tang and Xiong, 2012). “Financialisation” refers to the large flows of capital into the commodity market, explicitly in the long-only commodity index fund (Acworth, 2005; Domanski and Heath, 2007; Miffre, 2011). Speculation involves buying, holding, and selling of stocks, bonds, commodities, or any valuable financial instrument to profit from fluctuations in its price, as opposed to buying for use, dividend or interest income, or hedging purposes by market participants (Robles, Torero, von Braun, 2009). Speculation thus may take the form of speculative stockholding, speculative purchase and sale of commodity futures, or other derivative contracts.

Along this line was the report by the US Senate’s Permanent Subcommittee on Investigations (USS/PSI 2009, p. 2) which argued that commodity traders and futures contract were disruptive forces, pushing prices away from fundamentals and inducing excessive price movements.

In this context, some believe that a speculative bubble is forming in commodities as a consequence of the highly accommodative stance of the US monetary policy, including the maintenance of the target federal funds rate at exceptionally low levels (Hamilton, 2009), and extremely high flows of investment funds into commodity futures. Loose monetary policy influences commodity prices by reducing the cost of holding inventories or by fomenting “carry trades” and other forms of speculative behavior. However, the “fundamentalist” view points to the fact that stocks of agricultural products have generally been falling over 2006-2008, thus undermining the hypothesis that speculators contributed to the spike in prices.

The financialisation hypothesis suggests that prior to the recession, the large gains in commodity prices were accompanied by a large flow of funds. According to Barclay’s, index fund investment in commodities augmented from $90 billion in 2006 to about $200 billion

production. The rise of the ethanol industry might have led prices of maize, and other close substitutes such as soybeans and wheat, to co-move with oil prices (Roberts and Schlenker, 2010; EPA, 2012).

by the end of 2007, to record a historical peak in July 2011 with $431 billion. In this context, the speculative buying of index funds on a large base created a "bubble," with the result that commodity future prices far exceeded fundamental values during the boom. However, the fundamentalists again argue against the speculation "theory," suggesting that commodities without any futures markets have experienced approximately as much fluctuations as commodities with a derivative market.

3. Variables and Data

In order to empirically examine the causes of price fluctuation, I consider wheat spot prices at monthly frequency for the whole sample 1980-2012 and the sub-period 1995-2012. The sub-sample starts in 1995 due to the unavailability of some financial data before that period. To identify the key drivers, I merged the different strands of the extant literature and distinguished the determinants of wheat price into four dimensions: market specific variables, broad macroeconomic variables, speculative components, and weather conditions. A detailed data description is reported in the Annex.

I focus on the spot market, rather than the futures market for two main reasons. First, it is important to understand the inter-connections between the two markets and assess how futures market trading activities affect the patterns of spot prices for their economic and welfare consequences. Second, the existing analyses are mainly focused on commodity futures markets and less on the cash markets.

Wheat spot prices are taken from the IMF International Financial Statistics, via Datastream. They are expressed in US dollars, averaged from daily quotations, and then prices have been deflated using the US consumer price index to have real values and finally indexed (2000=100).

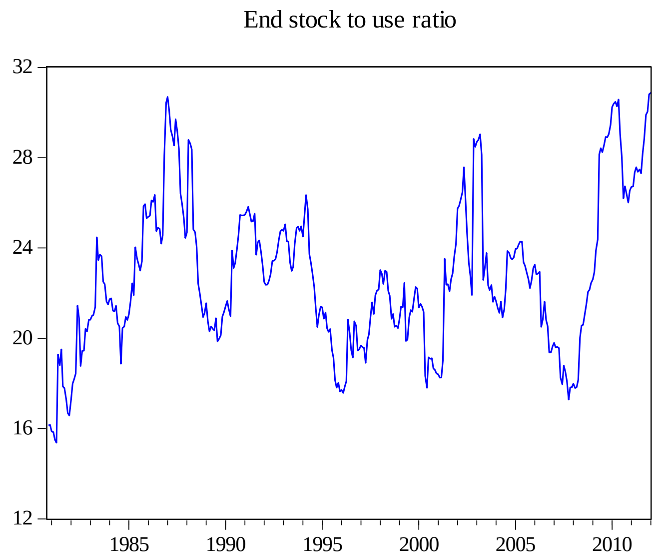
Market Specific Variables include inventory-to-consumption and the "thinness" of markets.

Inventory-to-consumption
(-)

Inventory stock levels have a crucial role in commodity pricing (Williams and Wright, 1991; Pindyck, 2001; Krugman, 2011). As in manufacturing industries, inventories are used to reduce costs of adjusting production over time in response to fluctuations in demand, and to shrink marketing costs by facilitating timely deliveries and preventing stock-outs. Producers can reduce their costs over time by selling out of inventory during high-demand periods, and replenishing inventories during low-demand periods. Since inventories can be used to ease production and marketing costs despite fluctuating demand conditions, they will have the effect of lowering the degree of short-run market price fluctuations. Therefore, one would expect that price levels and their fluctuations increase when inventories lessen.

While inventory holdings can change, production in any period does not need to be equal to consumption. As a result, the market-clearing price is determined not only by current production and consumption, but also by changes in inventory holdings.

I have considered stocks at the end of year as a proportion of the consumption for the previous year at an aggregate world level. This ratio is also referred to as the stock-to-use ratio. The inventory data are the predicted end-of-season global wheat inventories as they are published in the monthly USDA reports. Therefore, the inventories appraise the projected quantities of grain reserves carried from the ongoing marketing year to the new marketing year. The definition of the marketing year is based on the aggregate of local marketing years. The largest trader of wheat in the international market is the United States, where the marketing season starts at the beginning of June and ends at the end of May. The consumption data are the projected season's consumption levels. The source of data is the United States Department of Agriculture (USDA).



International Thinness of Markets
(+)/(-)

The "thinness" of markets refers to the share of the imports and exports of a specific commodity relative to the size of global consumption or production (OECD, 2008). This ratio describes to which extent agricultural products are internationally traded. Formally, it has considered the thinness of the wheat market as follows:

$$TH \equiv \left(\frac{EX_w + IM_w}{Cons_w} \right)$$

A low ratio means that market is "thin," while a high ratio implies "fatness" of the market. A thin market is a market characterized, hence, by low trading volume.

The thinness of a market could exert two opposite effects on price. Higher trading volume may lead to a higher demand for commodities; this could result in a price run up. Conversely, trade could help smooth production and consumption across space by moving goods from surplus to deficit regions, thus mitigating price movements. In this context more trade implies more stability and price drops, while lack of trade implies high movements and price increases (Jack et al. 2011). Increased trade integration would thus facilitate the stabilization of food prices and the reduction of prices for consumers (The Word Bank, 2012).

In regards to volatility, a thin market, characterized by low trading volumes, tends to show high fluctuations (illiquid), while fat markets display high trading volumes and high liquidity. It is often argued that agricultural markets are "thin" because the ratio of trade flows to global production/consumption is considered low as a consequence of protectionist measures or because most of commodity's production is consumed where it is produced, like in the case of rice (Timmer, 2009). This causes price swings that are larger than would be expected in more liquid or deeper markets. With reference to wheat, the thinness variable can be considered more directly as a proxy of trade policy since wheat is consumed independently from where it is produced, and the market dimension is more linked to the existence of restrictive or expansive trade policies.

When markets are thinner and prices in domestic markets do not follow those in international trade because of insulating policies or market imperfections, world market prices must change to better accommodate an external shock to traded quantities, if all else is equal. Trade thus would be an important buffer for localized fluctuations originating in the domestic market and could also be a power engine to level out supply movements around the globe.

Broad Macroeconomic Variables include global economic activity, interest rates, real exchange rates, oil price, and inflation.

Global Economic Activity
(+)

To measure the global economic activity, the monthly global industrial production index has been considered. The latter has been used because real world GDP is not available on a monthly basis but only at quarterly frequencies. Initially, it was thought to separately consider industrial production for advanced and emerging economies to analyze the impact of aggregate demand growth; however, these data are available only with annual frequency, and in any case world figures have the advantage of including emerging countries such as China and India. This is in line with the study by Frankel and Rose (2009).

Interest rate and yield curve
(-) & (+)/(-)

Real interest rates can influence commodity prices in several ways, as explained by Frankel (2006; 2012). For instance, a rise in interest rates reduces inventory demand since it increases the cost of carrying inventories. This, in turn, boosts commodity prices. In addition, another mechanism by which real interest rates impact commodity prices relates to financial speculation in commodity markets. Commodities can also be thought of as financial assets, thus when real interest rate are very low, investors are more prone to take open positions in the financial market for commodities, and this pushes their prices up. Conversely, an increase in interest rates encourages speculators to shift from spot commodity contracts to Treasury bills, and this curbs commodity prices. Following this line of thought, Calvo (2008) put forward that the increase in commodity prices mostly stems from the combination of low central bank interest rates, the growth of sovereign wealth funds and the consequent lower demand for liquid assets.

In order to account for monetary policy, the US money market rate (federal funds) deflated by the consumer price has been considered. The interest rate is thus expressed in real values.

In addition, to have an idea of the expected future path of the short term interest rates, the US interest rate spread has been included, constructed as the difference between the 10 year Treasury bonds and the federal funds. This spread or difference between long and short rates is often called the yield curve. It is felt to be an indicator of the stance of monetary policy and general financial conditions because it rises (falls) when short rates are relatively low (high). When it becomes negative (i.e., short rates are higher than long rates and the yield curve inverts), its record as an indicator of recession is particularly strong. Shortly, it is a leading indicator which signals changes in the direction of aggregate economic activity.

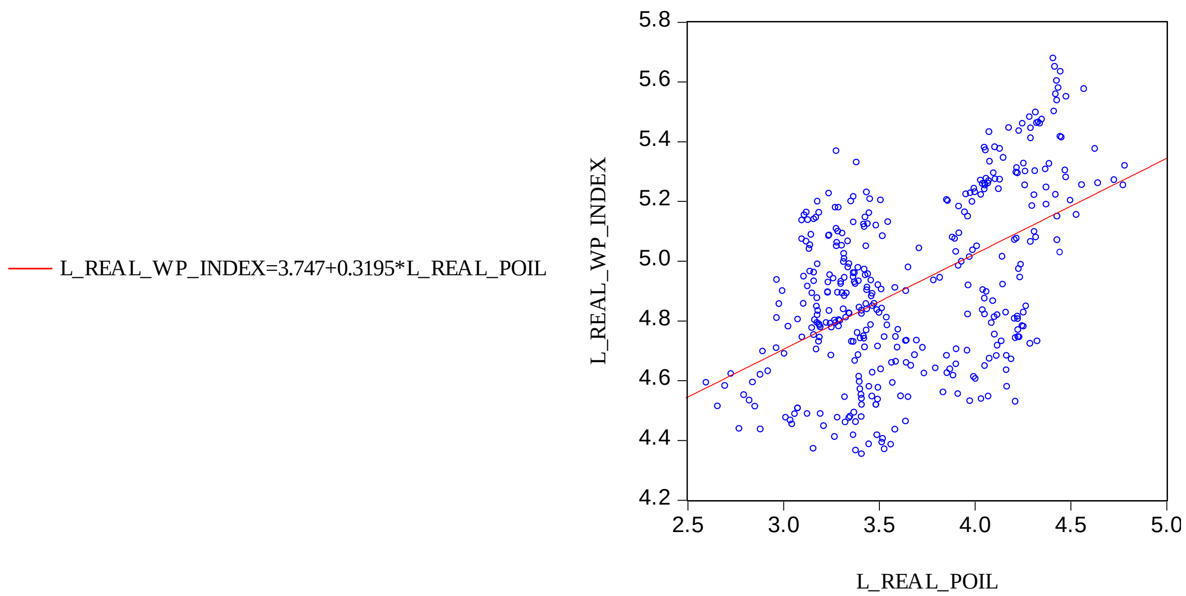
The expected relationship between yield spread and commodity prices is uncertain. If the presence of risk-premiums in Treasury bond markets represents rewards to investors for exposure to economy-wide macroeconomic risks, then we should expect a strong positive linkage between variation in commodity spot prices and measures of risk in Treasury bond markets. This indicates that higher yield spreads, which signal a declining risk tolerance in the Treasury bond market, mean higher commodity prices, which indicate an increasing risk tolerance in the commodity markets. This pattern is consistent with the thesis that the asset classes are being treated as substitutes in diversified portfolios.

If risk aversion is instead expressed in similar ways across the Treasury and commodity markets during the period, then rising Treasury yields are correlated with lower commodity prices. This pattern is consistent with the thesis that the asset classes are being treated as complements in diversified portfolios.

<u>Oil spot price</u>
(+)

The oil price is a critically important contributing factor in the increase in production costs for agricultural commodities and food (cost of processing, transportation, and distribution) and ultimately in the market prices for these goods. Additionally, an increase in oil price provides an incentive to produce biofuels and thus exerts a further pressure on food commodity prices. Therefore, wheat prices and oil prices are expected to be positively related.

Cushing, Oklahoma West Texas Intermediate (WTI) Spot Price FOB (Dollars per Barrel) has been collected from Datastream. To have real values, the average petroleum spot price has been deflated using the US CPI.
To have a first idea of the relationship between real wheat and oil prices, a simple OLS estimation has been performed. The results indicate that a 10% increase in real oil prices leads to about a 3% rise in wheat price.



<u>Real effective exchange rate</u>
(+)/ (-)

Trade in many agricultural commodities (as also for oil) is denominated in US$; this implies that movements in the dollar effective exchange rate affect the price of commodities as perceived by all countries outside the United States. Therefore, a change in the dollar exchange rate can modify the demand and supply for agricultural commodities and thus change their prices. A real exchange rate appreciation (depreciation) can be positively or negatively related to prices.

On the one hand, dollar depreciation tends to reduce the commodity price in domestic currencies for countries with floating exchange rates, such as the euro area, Japan, the Philippines, and South Korea. This leads to an increase in their commodity demand. Therefore, dollar depreciation has a positive impact on commodity demand and should contribute to raise prices. Conversely, a dollar appreciation makes exports less competitive and decreases the demand for commodities, causing dollar denominated international commodity prices to diminish. The effect is neutral for countries that have a currency pegged to the US dollar, like Oman, Saudi Arabia, Eritrea, and Hong Kong.

On the other hand, if uncertainty increases, both the demand for dollars and the demand for commodities increase, thus causing commodity prices to rise.

<u>Inflation</u>
(+)

Since commodities are considered to store value, their demand as financial assets or stocks increases with inflation. Inflation tends to affect commodity prices through the portfolio choices of financial investors; this occurs because holding commodities can hedge investment portfolios against inflation risks (Roache, 2010). The inflation rate is computed using changes in the US consumer price index.
To account for ***Financial Variables***, I include a measure of financialisation and speculation in the wheat market.

<u>Financialisation and Speculation</u>
(+)/(-)

Commodity markets have registered a progressive financialisation over time. This is clear if one looks at the evolution of the level in Open Interests which describes the total number of futures contracts long (purchased contracts outstanding) or short (sold contracts outstanding) for a given commodity in a delivery month or market that has been entered into and not yet liquidated by an offsetting transaction or fulfilled by delivery of the commodity[3]. Open interests are hence a widely used measure of the size of a commodity futures market. Specifically, Chart 1 sketches the disaggregated open interest for type of traders and nature of contract in wheat market; i.e., it considers the long and short open interests for commercial traders, non-commercial traders, and non-reportables.

Specifically, "commercial traders" are also known as hedgers. This type of futures trader holds position in the underlying commodity and attempts to offset risk exposure through future transactions. "Non-commercial traders" are called also speculators. They only hold positions in futures contracts and do not have any involvement in the physical commodity trade. Commercials and non-commercials are defined as reportable traders because they hold positions in futures and options at or above specific reporting levels set by the US Commodity Futures Trading Commission (CFTC). "Non-reportables" are small traders who do not meet the reporting thresholds set by the CFTC. Traders could take either long (buy) or short (sell) positions in commodity futures markets, depending on whether commodity prices are expected to appreciate or depreciate.

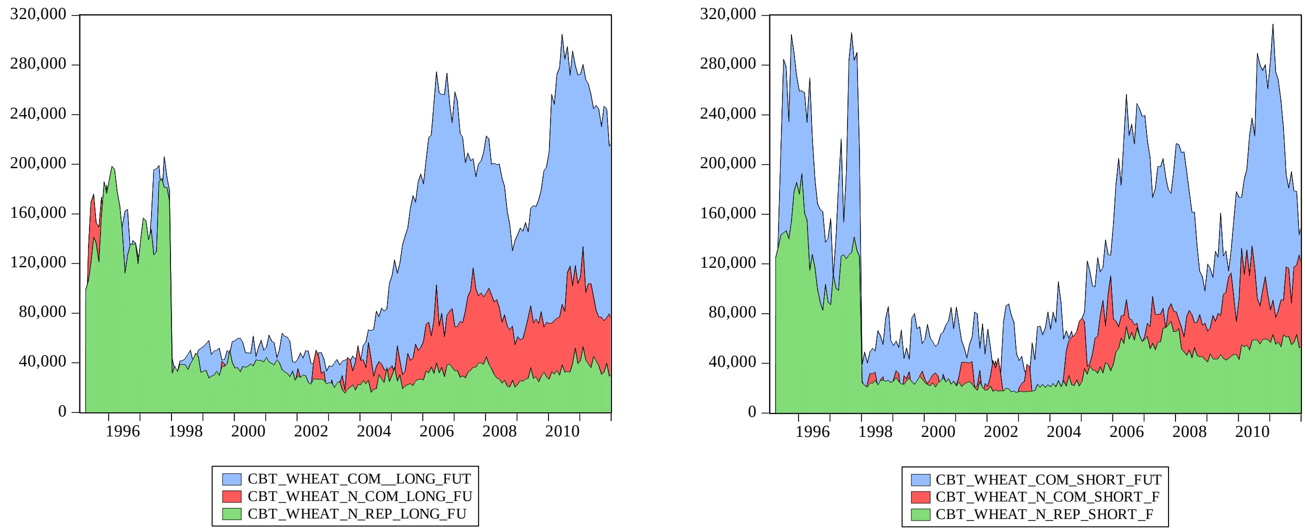
It is worth noticing that although wheat futures can be traded on the Kansas City Board of Trade (KCBT), and the Minneapolis Grain Exchange, I have used figures from the Chicago Board of Trade (CBT) because it is the world's oldest futures and options exchange and the largest commodity exchange in the world. Founded in 1848, it accounts for about half of the turnover in futures contracts in the US and the bulk of the world's grain futures trading.

As displayed chart 1, open interest recorded significant raises from 2003 onward, to register a drop during the financial crisis and a surge soon afterwards. The fact that the long and short positions of all types of investors in the wheat market have increased over time suggests a rise in the financialisation of commodity futures markets.

---

[3] In analytical terms, the market's total open interest is the sum of reporting and non-reporting positions: *TOT OI = [NCL+NCS+2*NCSP]+[CL+CS]+[NRL+NRS]*, where non-commercial open interest (NC) is distinguished in long (NCL), short (NCS) and spreading (NCSP); while for commercials (C) and non-reportables (NR) open interest is divided in long and short.

Chart 1 Role of commercials, non-commercials, and non-reportables in the wheat market (Chicago Board of Trade)



Source: Own Elaboration on Datastream.

In a well-functioning futures market, hedgers, who are willing to lessen their exposure to price risks, find counterparts. In the absence of any speculative activity, long hedgers have to find short hedgers with an equal and opposite position. Since long and short hedgers do not always trade simultaneously or in the same amount, there is space for speculators to satisfy the unmet hedging demand. Speculators thus reduce searching costs by taking the opposite positions when long and short hedgers do not perfect match each other (Büyükşahin and Harris, 2011). This follows Friedman's (1953) argumentation, according to which speculators stabilise prices by buying low and selling high so as to bring prices closer to fundamentals. Conversely, it often turns out that the speculative activity exceeds the level required to offset any unbalanced hedging, thus destabilising markets. According to De Long et al. (1990), in fact, rational speculators finish setting price trends and leading short term prices away from fundamentals by anticipating the buy/sell orders of trend followers.

In short, the financialisation of commodity markets has brought about an increase in speculation, which could have positive or negative effects on commodity markets, and consequently on prices.

Since the share of net long positions of non-commercial traders is frequently used as a variable to capture financial investor activity in commodity markets (IMF, 2006; Micu, 2005; Domanski and Heath 2007), an excessive speculation index has been constructed following Working (1953). This metrics is a good measure of speculative activities in futures markets, since it assesses the relative importance of speculative positions with respect to hedging positions and indeed as Working suggested, the level of speculation is meaningful only in comparison with the level of hedging in the market. The Working index has been used also by Sanders et al. (2010), Büyükşahin and Harris (2011) to examine the adequacy or excessiveness of speculative participation in the commodity futures markets. Formally, the excessive speculative index is given by:

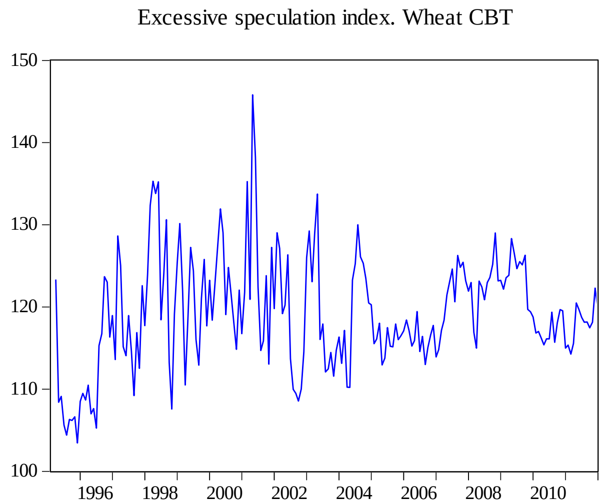
$$ESPI = \left[1 + \frac{NC\,OIShort}{(C\,OIShort + C\,OILong)}\right] \cdot 100 \quad \text{if} \quad C\,OIShort \geq C\,OILong$$

$$ESPI = \left[1 + \frac{NC\,OILong}{(C\,OIShort + C\,OILong)}\right] \cdot 100 \quad \text{if} \quad C\,OIShort \prec C\,OILong$$

where *NC OI Short* = open futures position of short speculators, *NC OI Long* = open futures position of long speculators, *C OI Short* = open futures position of short hedgers, and *C OI Long* = open futures position of long hedgers. In other terms, the nominator denotes the speculation positions short and long. The denominator is the total amount of futures open interest resulting from hedging activity.

Chart 2 reports the excessive speculation index in the wheat market and its descriptive statistics.

Chart 2



	Excessive speculation index				
Mean	119.2063	Std. Dev.	6.836168	Skewness	0.395802
Median	118.4291	Sum	24079.67	Kurtosis	3.710677
Maximum	145.8218	Sum Sq.	9393.373	Jarque-Bera	9.525128
Minimum	103.4452	Observations	202	Probability	0.008544

Finally, the model controls for **Global weather conditions**.

To account for weather conditions, the following two indicators have been considered:

i) The sea surface temperature anomalies (SST) for the El Niño region 3.4 (a central region of the Pacific). This index measures the deviations between the sea surface temperatures in the El Niño region 3.4 and its historical average, and it is calculated by the National Climatic Data Center US Department of Commerce and NOAA Satellite and Information Service using the extended reconstructed sea surface temperature.

ii) The Southern Oscillation Index anomalies (SOI), which measures the fluctuations in air pressure occurring between the western and eastern tropical Pacific during El Niño and La Niña episodes (i.e., the state of the Southern Oscillation). It is a standardised index based on the observed sea level pressure differences between Tahiti, French Polynesia and Darwin, Australia. In general, a negative phase of the SOI represents below-normal air pressure at Tahiti and above-normal air pressure at Darwin. SOI data are taken from the National Oceanic and Atmospheric Administration National Climatic Data Center.

Although the events described by these indices arise in the Pacific Ocean, they have strong effects on the world's weather and an important influence on the world's production and price of primary non-oil commodities (Brunner, 2002). The monitoring of both SOI and SST variables allow for a better understanding of global climatic fluctuations enabling us to nicely distinguish between atmosphere and ocean influences on yield and thus prices. In addition, their combination significantly improves the weather forecast, compared to the use of one of the two variables separately (Russell, et al. 2010).

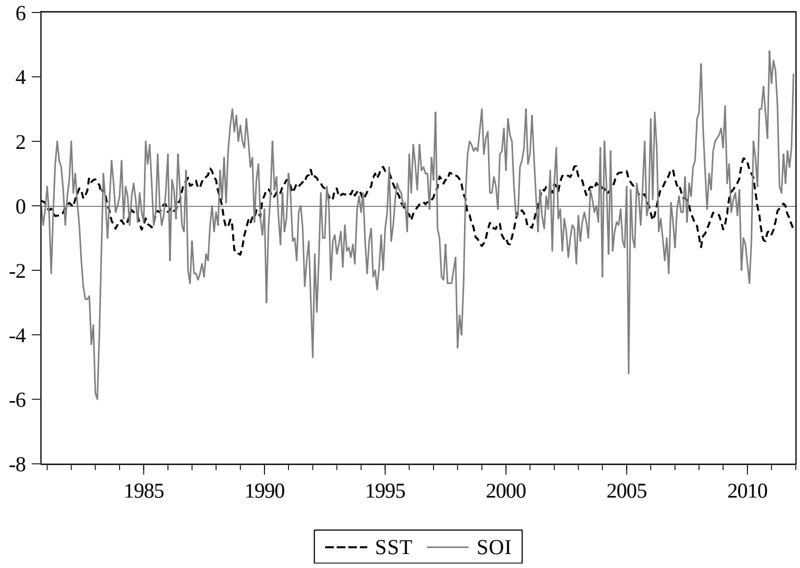
The dynamics of SST and SOI are reported in the following chart. As regards the SST index, positive anomalies (index values above zero) are related to abnormally warm ocean waters across the eastern tropical Pacific typical of an El Niño event, and negative anomalies are related to a cool phase typical of a La Niña episode. Conversely, prolonged periods of positive SOI values (values above zero) coincide with La Niña events during which water becomes cooler than normal; vice-versa, SOI values below zero mirror El Niño episodes during which water becomes warmer than normal. La Niña events are associated with increasing droughts throughout the mid-latitudes, where much of wheat and other relevant grains such as corn and soybeans are produced, thus suppressing their yield (Hurtado and Berri, 1998) and driving up prices. For this reason, La Niña episodes have historically been associated with global food crises. El Niño is associated with an increased likelihood of droughts in tropical land areas, which mainly affects crops such as sugar and palm oil.

It is worthwhile noticing that, the Sea Surface Temperature and the Southern Oscillation anomalies indices tend to vary with opposite signs, and that SOI has a higher variability than the SST index as computed by the coefficient of variation reported below.

	SOI	SST		SOI	SST
Mean	0.070400	0.163707	Std. Dev.	1.693240	0.632532
Median	0.100000	0.290000	Coef. of variation	24.052	3.8638
Maximum	4.800000	1.470000	Jarque-Bera	10.29199	15.87622
Minimum	-6.000000	-1.520000	Probability	0.005823	0.000357

Observations: 375

Chart 3 Weather proxy



4. Empirical Evidence

4.1 Preliminary Unit Root Test

Prior to testing for cointegration, the time series examined in section 3 have been trasformed in log form, and their properties have been carefully investigated. The transformation in log form has the advantage of interpreting the coefficients as elasticities. The grafical inspection of the data (see appendix) reveals that most of the series resemble random walk processes, some "trending" upward, and some "trending" downward with fluctuations, therefore the Augmented Dickey-Fuller (ADF) (1981) and the Philips Perron (P-P) (1988) tests have been conducted for each variable to formally test for the presence of *unit roots*. The critical values for the rejection of the null hypothesis of a unit root are those computed according to the MacKinnon criterion (1991). The lag length for the ADF test is based on the Schwarz Information criterion. The lag structure for the P-P is selected using the Bartlett Kernel with automatic Newey-West bandwidth. The two tests have been carried out with a constant plus a linear trend.

The ADF and P-P tests show that all the independent and dependent variables are integrated of order one I(1), i.e. the series become stationary after their first differenciation. This occurs because the computed values do not exceed the Mac Kinnon critical values. The only exceptions are for the US fed spread, the sst index which shows different results according to the two tests[4].

[4] Although Engle and Granger's (1987) original definition of cointegration refers to variables that are integrated of the same order, Enders (2009) argues that: "It is possible to find equilibrium relationships among groups of variables that are integrated of different orders." Asteriou and Hall (2007) also explains that in cases where a mix of I(0) and I(1) variables are present in the model, cointegrating relationships might exist. Similarly, Lütkepoh and Krätzig (2004) explain: "Occasionally it is convenient to consider systems with both I(1) and I(0) variables. Thereby the concept of cointegration is extended by calling any linear combination that is I(0) a cointegration relation, although this terminology is not in the spirit of the original definition because it can happen that a linear combination of I(0) variables is called a cointegration relation." Therefore, even in the presence of a set of variables which

However, it is acceptable to consider the series integrated of order one, because it is confirmed by a supplementary Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test (1992). The outcomes of the tests are reported in Table 1. The presence of non-stationarity implies that standard time-series methods are no longer suitable, and that, consequently, a cointegration analysis is required (Enders, 2009).

Table 1 Unit Root Tests

	ADF level		**ADF first difference**		**PP Level**		**PP first difference**	
	t-stat	**prob**	**t-stat**	**prob**	**t-stat**	**prob**	**t-stat**	**prob**
Ln real p	-2.992336	0.1357	-14.91106	0.0000	-2.757717	0.2142	-14.85588	0.0000
Ln real poil	-2.431287	0.3627	-14.53731	0.0000	-2.172822	0.5029	-14.02567	0.0000
Ln real fed fund	-1.068320	0.9316	-11.71861	0.0000	-0.941496	0.9489	-11.64171	0.0000
Ln rex	-2.354874	0.4028	-13.60509	0.0000	-2.339289	0.4111	-13.54361	0.0000
Ln end stock to use	-3.065811	0.1162	-18.98650	0.0000	-3.124239	0.1022	-18.98570	0.0000
sst	-4.110884	0.0066			-3.852657	0.0150	-12.36475	0.0000
soi	-5.795922	0.0000			-9.231864	0.0000		
Ln us cpi	-2.674356	0.2480	-11.59517	0.0000	-3.129232	0.1010	-10.55466	0.0000
Ln world ind prod	-1.775113	0.7150	-6.057624	0.0000	1.850015	0.9848	-44.35757	0.0000
Us fed spread	-4.483997	0.0018			-3.363331	0.0580	-13.33936	0.0000
Ln thinness	-2.636053	0.2645	-18.78330	0.0000	-2.900078	0.1637	-18.78232	0.0000
Ln speculation	-6.667659	0.0000			-6.765594	0.0000		

Note: test equation includes trend and intercept. Mac Kinnon crit-values. The sample goes from 1980 to 2012 with monthly observations. Only for speculation does the sample refer to the period 1995-2012.
Null hypothesis: there is a unit root.
Real p= real wheat price, real poil=real oil price, real fed fund=real federal fund, rex= real effective exchange rate, sst = sea surface temperature anomalies, soi= Southern oscillation index anomalies, us cpi= US inflation rate, world ind prod=world industrial production, US fed spread= US bond yield, thinness= thinness of the market, speculation= excessive speculation.

To have a broader indication on the variables of interest, the correlation matrix has been computed[5] (Table 2).

Table 2 Correlation Matrix

Correlation	ln real poil	ln real fed funds	ln rex	ln end-stock-to-use	SST	SOI	ln us cpi	ln world ind prod	us fed spread	ln thinness	ln speculat.
ln real poil	1.000000										
ln real fed funds	-0.230940	1.000000									
ln rex	0.020129	0.464242	1.000000								
ln end-stock-to-use	-0.065554	-0.513541	-0.099634	1.000000							
SST	-0.113990	-0.082467	-0.131752	0.312614	1.000000						
SOI	0.138456	-0.215968	-0.110052	-0.109167	-0.678119	1.000000					
ln us cpi	0.093971	-0.811466	-0.540060	0.201368	0.053524	0.241883	1.000000				
ln world ind prod	0.020336	-0.645609	-0.499580	0.076532	0.011486	0.252010	0.942967	1.000000			
us fed spread	-0.075433	-0.509713	-0.022470	0.600049	0.289031	-0.160499	0.253741	0.103674	1.000000		
ln thinness	-0.022559	0.498823	0.439119	-0.185072	-0.162278	-0.289031	-0.134466	-0.632596	-0.139455	1.000000	
ln specul.	0.038166	-0.078841	0.240894	0.145715	-0.104505	0.000639	0.167215	0.196903	0.024702	0.116950	1.000000

contains both I(1) and I(0) variables, cointegration analysis is applicable and the presence of a long-run linear combination denotes the existence of cointegrated variables. Hence, it is possible to find long-run equilibrium relationships among a set of I(0) and I(1) variables if their linear combination reveals a cointegrating relationship.

[5] On the basis of the variance inflation factor, the variable ln us cpi was excluded from the model because it is highly correlated with the world industrial production. Further, the inclusion of the inflation rate would have caused a clear problem of endogeneity.

Notes: the sample goes from 1980 to 2012 with monthly observations. Only for speculation does the sample refer to the period 1995-2012. Real p= real wheat price, real poil=real oil price, real fed fund=real federal fund, rex= real effective exchange rate, sst = sea surface temperature anomalies, soi= Southern oscillation index anomalies, us cpi= US inflation rate, world ind prod=world industrial production, US fed spread= US bond yield, thinness= thinness of the market, speculat.= excessive speculation.

4.2 Johansen and Juselius Analysis

The Johansen and Juselius methodology (1990), based on maximum likelihood estimation, permits us to simultaneously evaluate equations involving two or more variables and to determine whether the series are cointegrated; that is to say, that there is a long term relationship among variables. Furthermore, this technique controls for endogeneity, and enables us to assess and test for the presence of more than one cointegrating vector. Finally, this methodology performs better than other estimation methods by including additional lags, even when the errors are non-normal distributed or when the dynamics are unknown, and the model is over-parameterized (Gonzalo, 1994).

Consider a *p*-dimensional vector autoregressive model, which in error correction form is given by:

$$\Delta x_t = \Pi x_{t-p} + \sum_{i=1}^{p-1} \Gamma_i \Delta x_{t-i} + \Phi S_t + \xi_t , \quad (1)$$

where Δ is the difference operator and x_t=(k x 1) is the vector of non-stationary I(1) variables, explicitly:

$$x_t = \left[wheat\ price_t ; market \text{ specific variables}_t ; broad\ macro \text{ variables}_t ; weather_t ; speculation_t \right] \qquad (2)$$

and:

$$\Pi = \sum_{i=1}^{p} A_i - I \qquad (3) \qquad \text{I=a (k x k) identity matrix}$$

$$\Gamma_i = -\sum_{j=i+1}^{p} A_j \qquad (4) \qquad \text{A=a (k x k) matrix of parameters}$$

The variable *St* contains a constant term and a time trend, and ξ is a vector of Gaussian, zero mean disturbances. Γ_i are (k *x* k) dimensional matrices of autoregressive coefficients. The long-run matrix ∏ can be decomposed as the product of α and β, two (k x r) matrices each of rank *r*, such that ∏=αβ', where β' contains the r cointegrating vectors and α represents the adjustment parameters, which reflect the speed of adjustment of particular variables with respect to a disturbance in the equilibrium relationship. Therefore, equation (1) becomes:

$$\Delta x_t = \left(\alpha\beta^{'}\right) x_{t-p} + \sum_{i=1}^{p-1} \Gamma_i \Delta x_{t-i} + \Phi S_t + \xi_t \qquad (5)$$

The maximum likelihood approach makes it possible to test the hypothesis of r cointegrating relations among the elements of x_t,

$$H_0 : \Pi = \alpha\beta^{'} \qquad (6)$$

where the null of no cointegration relation (r=0) implies *∏=0*. If ∏ is of rank *k*, the vector process is stationary. If *rank (∏)=1* there is a cointegrating vector; for other cases in which *1<rank (∏)<k* there are multiple cointegrating vectors.

4.3 Empirical Results

A VAR system of variables has been constructed to test whether real wheat prices are cointegrated with specific market variables, broad macroeconomic factors, speculation, and weather events. To identify the proper model, the five possibilities considered by Johansen (1995) were tested, specifically: (1) the series have no deterministic trends and the cointegrating equations do not have intercepts, (2) the series have no deterministic trends and the cointegrating equations have intercepts, (3) the series have linear trends but the cointegrating equations only have intercepts, (4) both series and the cointegrating equations have linear trends, and (5) the series have quadratic trends and the cointegrating equations have linear trends. Following the Pantula test (Pantula, 1989), the third and the fifth model are the most appropriate for two samples. To identify the lag length, the Aikaike Information and the Schwarz Criteria have been implemented. The chosen lag structure is three (the smallest value) for the complete sample and five for the subsample, following the AIK criterion. A number of dummies have been included in the cointegration test to take into account periods of social and economic instability and structural breaks[6].

The results of Johansen's test for cointegration are displayed in Table 3, which reports the hypothesized number of cointegration equations in the first left column, the eigenvalue, the trace[7] statistics, the max eigenvalue statistics[8], and 5% critical values. The asterisks indicate the rejection of the hypothesis.

In detail, the first row of the trace statistic tests the hypothesis of no cointegration, the second row tests the hypothesis of one cointegrating relation, the third row tests the hypothesis of two cointegrating relations, and so on, all against the alternative hypothesis of full rank; i.e., all series in the model are stationary. For the longer sample, the λ_{trace} test and the λ_{max} statistic indicate the presence of one cointegrating equation at the 5% level. For the shorter sample, the λ_{trace} test indicates the presence of three cointegrating equations at the 5% level. The λ_{max} statistic does not confirm this result: the null hypotheses of no cointegrating vector (r=0) can be rejected at the 5%

[6] Specifically, outliers were detected by looking at the graphs of the residuals. Five dummies relative to 1998, 2007, 2008, 2010, 2011 were inserted in the short sample wheat price equation. The effects of including dummy variables to capture structural breaks in cointegration models have been analyzed in Kremers et al. (1992), and Campos et al. (1996).

[7] The trace statistic of r cointegration relations is a sequence of likelihood ratio tests, computed as $\lambda_{trace}(r) = -T \sum_{i=r+1}^{k} \ln(1-\hat{\lambda}_i)$, where λ_i is the estimated value of the characteristic roots (also called eigenvalue) obtained from the estimated long-run Π matrix, and T is the number of usable observations.

[8] The max eigenvalue statistic is calculated as $\lambda_{t\max}(r) = -T\ln(1-\hat{\lambda}_{r+1})$.

level, but the null of r=1 cannot be rejected. So, it can be concluded that there is one cointegrating vectors at the 0.05 level in the system.

Table 3 Johansen Cointegration Tests

Sample (adjusted). Included observations: 365 after adjustments Trend assumption: Quadratic deterministic trend

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical Value	Prob.**
None *	0.172202	233.6297	219.4016	0.0090
At most 1	0.110743	164.6500	179.5098	0.2206
At most 2	0.096942	121.8105	143.6691	0.4306
At most 3	0.076587	84.59191	111.7805	0.6913
At most 4	0.049592	55.50900	83.93712	0.8503

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5% Critical Value	Prob.**
None *	0.172202	68.97972	61.03407	0.0071
At most 1	0.110743	42.83950	54.96577	0.4688
At most 2	0.096942	37.21862	48.87720	0.4742
At most 3	0.076587	29.08291	42.77219	0.6531
At most 4	0.049592	18.56544	36.63019	0.9422

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Sample (adjusted). Included observations: 173 after adjustments. Trend assumption: Linear deterministic trend

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical Value	Prob.**
None *	0.362402	350.6322	285.1425	0.0000
At most 1 *	0.304058	272.7739	239.2354	0.0006
At most 2*	0.295918	210.0632	197.3709	0.0100
At most 3	0.247698	149.3645	159.5297	0.1561
At most 4	0.167292	100.1256	125.6154	0.5978

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5% Critical Value	Prob.**
None *	0.362402	77.85829	70.53513	0.0091
At most 1	0.304058	62.71069	64.50472	0.0736
At most 2*	0.295918	60.69876	58.43354	0.0294
At most 3	0.247698	49.23886	52.36261	0.1010
At most 4	0.167292	31.6714	46.23142	0.6786

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values. Estimations include significsnt dummies.

Although the results of trace tests and maximum eigenvalue tests point to different outcomes, we can conclude for one cointegrating vector since as Johansen and Juselius note, “one would, however, expect the power of this procedure [the trace test] to be low, since it does not use the information that the last three eigenvalues have been found not to differ significantly from zero. Thus one would expect the maximum eigenvalue test to produce more clear cut results” (1990:19).

To extract the cointegrating vectors, a VEC representation has been adopted. Convergence was reached after few iterations for the entire and small sample. The restricted cointegrating vectors and the speed of adjustment coefficients are reported in the following table.

Table 4 Vector Error Correction Estimations

Cointegrating vector β	**1981:1-2012:1**	**1995:1-2012:1**
ln real poil	0.231 (4.44)	0.294 (2.84)
ln real fed funds	-0.132 (-2.55)	-0.207 (-6.03)
ln rex	-0.771 (-3.12)	-0.726 (-9.77)
ln end-stock-to-use	-0.999 (-3.94)	-0.436 (-1.99)
sst	0.244 (3.50)	0.248 (4.54)
soi	0.166 (5.71)	0.104 (4.26)
ln world ind prod	3.29 (2.80)	1.807 (2.63)
us fed spread	0.045 (1.99)	0.021 (1.09)
ln thinness	-1.008 (-2.56)	0.340 (1.42)
ln speculation		0.715 (7.14)
constant	27.99	25.80
Speed of adjustment α		
dln real price index	-0.069 (-4.87)	-0.085 (-2.07)

Regressand: ln real wheat price index. t stat in brakets. Ln stands for logarithm.

4.4 Discussion of Results and implications

The cointegration analysis suggests that real wheat prices are cointegrated with market specific, broad economic variables, weather events, and speculation. In particular, the columns of β are interpreted as long-run equilibrium relationships between variables, and the matrix α determines the speed of adjustment towards this equilibrium.The estimated speed of adjustment coefficients carry the expected signs and are statistically significant different from zero. This means that cointegrating vectors converge towards their long-run equilibrium in the presence of a shock to the system. Expressly, 6.9% of the disequilibrium is eliminated in one month for the complete sample and 8.5% for the sub-sample; i.e., it takes 14.5 months (1/0.069) and 11.7 months (1/0.085) respectively to restore the equilibrium after a shock.

More specifically, table 4 provides suggestive evidence that higher oil prices lead to an increase in wheat prices due to both a greater use of petroleum-based inputs in the wheat market and the growth in wheat-based ethanol production. Put differently, on the supply side a rise in oil price exerts an upward pressure on input costs such as fertilizers, irrigation, and transportation costs, which lead to a decline in profitability and production, with a consequent shift of the supply curve to the left and a rise in wheat prices.

On the demand side, the higher crude oil price has induced a higher derived demand for wheat and other grains, such as maize or soybeans to be destined to biofuels production and has resulted in higher prices of these grains (Krugman, 2008). This result testifies that energy and agricultural prices have become increasingly interwoven. With rising oil prices, and with the US government and the European Union subsidizing agriculture-based energy, farmers have massively shifted their cultivation toward crops for biofuel. In detail, a 10% increase in international oil prices brings about an approximatley 2.3% rise in wheat price for the longer sample and a 2.9% increase for the shorter sample, other things being equal. This result is in line with the studies by Tang and Xiong (2012) and Chen et al. (2010), which find an increasing correlation between agricultural commodities and oil price.

In addition, wheat prices appear to be sensitive to fluctuations in the real exchange rate. This intensity is almost the same for the two samples before and after the financialisation of the wheat market. Specifically, the elasticity of about -0.7 suggests that a real dollar depreciation translates to a rise in wheat prices as they are denominated in US$. The coefficients of the real exchange rate fall in the range of 0 and -1 as predicted by the economic theory (Gilbert, 1989; Borensztein and Reinhart, 1994).

The real federal fed fund variable is negatively linked to the real wheat price, thus confirming the presence of the monetary policy effect. A loose monetary stance of 1% in fact implies that the price level increases by about 0.1% and 0.2%. When the real interest rate is high, as it was in the 1980s, money flows out of commodities and prices shrink. This confirms the studies by Dornbusch (1976), Frankel (2008), Svensson (2008), Anzuini et al. (2012) that emphasize the high responsiveness of agriculture prices to monetary policy changes. The spread variable has a positive sign, signaling that the future expectations on tightened monetary policies do not have a depressing effect on wheat prices and that the Treasury bond market and the commodity market for wheat are treated as substitutes asset classes in diversified portfolios. Put differently, when the long term rate is larger than the short term interest rate this signals an increase in the financial and macroeconomic risk linked to Treasury bonds. This causes investors to shift from the bond market to the commodity market, which in turn raises commodity prices. An increase in the spread by 10% increases prices by about 0.5%; this value decreases to 0.2% in the short sample, although it becomes insignificant.

The stocks-to-use ratio is used to capture the effects of market supply and demand factors on price determination (Westcott and Hoffman, 1999). The variable shows a negative relationship with the wheat price. A faster growth in use than in ending stocks would in fact imply that demand growth outpaces supply growth. This would put an upward pressure on prices. Specifically, a reduction in the stocks-to-use ratio by 1% triggers a real price surge by 0.9% and 0.4% for the longer and shorter sample. This means that the combined effects of market supply and demand factors matter in determining prices, and a rise in the stocks-to-use ratio translates to an almost proportional drop in its price in the longer sample and to a more contained effect in the shorter sample.

As expected, bad weather conditions negatively affect wheat prices. Specifically, the sea surface temperature anomalies have a larger impact than the fluctuations in air pressure occurring between the western and eastern tropical Pacific during El Niño and La Niña episodes[9]. However, since the variability of SOI is larger than SST, the effect of SOI could be more detrimental for wheat production and prices.

An increase of industrial production by 1% produces a significant rise in price by about 3% and 2%. This implies, in accordance with the studies by Svensson (2008) and Wolf (2008), that global demand is an important determinant of commodity prices.

The thinness of the market, while negative and significant for the sample 1980:1-2012:1, turns out to not be significant for the sample 1995:1-2012:1. This implies that trade restricting policies could exert a detrimental effect as they tend to push wheat prices further up.

Finally, the speculation variable that is included only in the shorter sample indicates that the financialisation of markets has contributed to push prices up. In fact, in traded markets, when futures traders seek exposure to commodities without holding the underlying commodity and speculate on future price movements of the commodity, they finish amplifying the price fluctuations on cash market. This implies that speculative behaviour in the wheat futures market affects the associated spot market. In particular, a 1% increase in financial speculation boosts cash prices by about 0.7%.

In a nutshell, the estimated coefficients testify that market specific variables, broad macroeconomic variables, speculative components, and weather conditions have a significant effect on real wheat price, and thus the existing theories complement rather than contradict one another. The key to understand this finding is that commodities have different aspects: they are both consumption goods and financial assets for investments. Specifically, the positive effect of world demand on wheat commodity prices reflects the aspect of wheat as a consumption good. The positive impact of open interest and yield curve on wheat price mirrors the second aspect.

[9] The Sea Surface Temperature has been multiplied by -1 so as to have the same sign as the Southern Oscillation index.

Besides, an increasing demand is a dominant factor in driving up wheat prices, together with inventories for the longer sample; excessive speculation turned out to be significant and a relevant factor behind price swings for the shorter sample. Real price pressures are trimmed down by restrictive monetary policies, a real dollar appreciation, and to some extent, by expansive trade policies.

The short-run dynamics are reported in Table 5. It is clear that in the short period (first three months), the variable end-*stock-to-use* does not have any significant influence on changes in real wheat price for both samples, while other variables do affect wheat price to a different extent, depending on their lags. This is likely due to the fact that in the short run prices do not respond immediately to changes in end-stock-to-use ratio for the presence of menu costs.

The properties of the residuals of the estimated model have been carefully analysed (Tables 7-11, Annex). A battery of unit root tests on the residuals, estimated from the cointegrating regression, reveal that resisuals are stationary. The system residual Lagrange-Multiplier test for autocorrelation shows that the null of no residual correlation up to lag 10 cannot be rejected. The VEC residual heteroskedasticity test provides evidence of absence of hetheroskedasticity in the data. The Doornik-Hansen test gives evidence that residuals are not multivariate normal. This deviation from normality, however, does not render the co-integration tests invalid. Similar deviations from normality were observed by Johansen and Juselius (1990) and Islam and Ahmed (1999). Finally, the estimated model is also "dynamic stable" as confirmed from chart 5, showing that all the inverse roots of AR characteristic polynomial lie in the unit circle.

To complete the analysis and provide more information on the dynamic nature of the interaction between wheat prices and its drivers, first the impulse response function representations based on the Cholesky decomposition method (Charts 4 and 5) have been carried out. This approach has the additional benefit of illustrating the short and long-run dynamic responses of wheat prices with respect to the four dimentions of determinants. Charts 4 and 5 indicate that the short run wheat price patterns in response to a shock are rich and the impact of the shock is long lived.

Second, the variance decomposition based on Monte Carlo repetitions has been performed. This approach allows us to better disentangle the relative importance of each of the determinants of the real wheat prices. The variance decomposition indicates the percentage of real wheat price explained by its own shocks and the shocks to the other variables in the system. The results show that the thinness of the market accounts for 10.5% of the variation of the wheat price at most, the oil price for about 8% percent, speculation for about 4%, the real exchange rate and income for about 3.5% percent, end stock to use for about 1%, weather events for about 2%, and the monetary policy for about 0.6%, within 10 months. Up to 4-month real wheat price shocks explain well over 80% of its variations, and up to 10-month real wheat price shocks explain 65% of its variations. This confirms that there is a long-run relationship between the variables, and that all the determinants together have a certain power to predict real wheat prices.

5. Conclusions

The roller coaster ride in commodity prices over the last decade has generated considerable interest among academicians, policy makers, and investors for its effects on the real economy, and thus on economic growth, food security, and investment decisions. In this context, the present study has tried to shed light on the key factors of price movements of one of the major food grains throughout the world, wheat. The analysis has been carried out for the period 1980-2012 and the sub-period 1995-2012, using monthly data.

The results of the study indicate that all the theories on the drivers of commodity price do not necessarily contradict, but rather complement each other. In fact, the results show that there has been a complex of factors that together have caused quick price increases in the wheat markets, including speculation in futures markets, macroeconomic fundamentals, market specific variables, and weather conditions. This would require a complex response at the international level.

It emerges that loose monetary policy reflected in low real interest rates, strong economic activity proxied by industrial production, and speculative pressure push wheat prices up. An increase in the stock-to-use ratio and a real appreciation has a curbing or dampening effect on wheat prices. The thinness of the market turns out to be significant in the long run for the entire sample and in the short run for the small sample, with an upward pressure on prices when trade shrinks. This would suggest that policy makers should give more consideration to the impact of both monetary and trade manoeuvres on food commodity prices. This is because monetary policy tends to be more focused on core inflation - i.e. a measure of inflation that excludes the rate of increase of prices for food and energy products - than on total inflation, the so called headline inflation. Since households spend a major portion of their budgets on food and energy, a focus on both core and headline inflation would therefore be necessary when determining the appropriate stance of monetary policy. At the same time, trade restricting policies could have an undesirable impact as they drive international market prices further up. Trade policies thus should avoid allowing the commodity market to become too thin.

Furthermore, the study has shown that an additional factor behind the rise in wheat price is the increase in oil price. This makes wheat production more expensive by raising the cost of inputs like fertilizers, irrigation, and transportation, with a consequent decrease in profitability and production of wheat and a rise in its price. More recently, oil price surges have also caused an increase in the demand for biofuels. This has put a further squeeze on food supplies, and therefore the price of wheat, maize and soybeans went up. This indicates that biofuel policies should be carefully monitored and in some cases changed to avoid unnecessary subsidization.

The variables with the largest effects on price movements over the period 1995-2012 are the global demand, speculation, and the real effective exchange rate. This testifies that the financial and wheat markets have become more and more interwoven, and "speculation" based on investing in futures contracts on commodity markets, to profit from price fluctuations, is an important determinant of price dynamics. The wider and more unpredictable price changes are caused by greater possibilities of realizing large gains by speculating on future price movements of the commodity in question. Although the presence of "speculators" on the derivatives markets is a necessary condition for functioning markets and efficient hedging, price fluctuations can also attract significant speculative activity and destabilize markets, which are both the cause and effect of increased prices. In this context, policy measures should be addressed toward supervising the financial market in order to avoid speculation becoming excessive.

Regarding the stocks-to-use variable, it seems important to develop better data collection systems at the global level and across countries. This will be important to have a better knowledge of the state of the food commodity market and facilitate policy makers in their decisions.

The adopted model satisfies the stability conditions as well as other residuals properties and indicates that cointegrating vectors converge towards their long-run equilibrium in the presence of a shock to the system after 14.7 months and 11.7 months, respectively, for the two sample periods.

References

Acworth, W., 2005. Going Long on Commodities, Future Industry, May/June, 24-28.

Anzuini A., Lombardi M.J. , Pagano, P., 2012. The Impact of Monetary Policy Shocks on Commodity Prices, Bank of Italy Temi di Discussione Working Paper No. 851

Asteriou, D., Hall, S. G., 2007. Applied Econometrics. A Modern Approach Using Eviews and Microfit, Palgrave Macmillan, New York.

Büyükşahin, B., Harris, J. H., 2011. Do Speculators Drive Crude Oil Futures Prices?, *The Energy Journal*, 32(2), 167-202

Bakucs, Z.L., Fałkowski, J., Fertő, I., 2009. Monetary policy and overshooting of flexible sectors in transition economies: the case of Poland, In: Zawojska, A. (ed.), Agri-food System and its Linkages with Global, International and Domestic Economies, Warsaw University of Life Sciences Press, Warsaw: 84-95.

Borensztein, E., Reinhart, C.M., 1994. The Macroeconomic Determinants of Commodity Prices, IMF Staff Papers, Palgrave Macmillan, 41(2), 236-261, June.

Brunner, A.D., 2002. El Niño and World Primary Commodity Prices: Warm Water or Hot Air?, *The Review of Economics and Statistics*, MIT Press, 84(1), 176-183.

Calvo, G., 2008. Exploding commodity prices, lax monetary policy and sovereign wealth fund, VoxEU, 20th June.

Campos, J., Ericsson, N., Hendry, D., 1996. Cointegration tests in the presence of structural breaks, *Journal of Econometrics*, 70(1), 187-220.

Chen S. T., Kuo H.I., Chen, C.C., 2010. Modeling the relationship between the oil price and global food prices, *Applied Energy* 87(8), 2517–2525.

Cevik, S., Sedik, T.S., 2011. A Barrel of Oil or a Bottle of Wine: How Do Global Growth Dynamics Affect Commodity Prices? IMF WP/11/1

De Long, B., Shleifer, A., Summers, L., Waldmann, R., 1990. Positive Feedback Investment Strategies and Destabilizing Rational Speculation, *Journal of Finance*, 45(2), 374-397.

Dwyer, A., Holloway, J., Wright, M., 2012. Commodity Market Financialisation: A Closer Look at the Evidence, Reserve Bank of Australia Bulletin, March Quarter.

Dwyer, A., Gardner, G., Williams, T., 2011. Global Commodity Markets – Price Volatility and Financialisation, Reserve Bank of Australia Bulletin, June Quarter.

Dickey, D. A., Fuller, W. A., 1981. Likelihood ratio statistics for autoregressive time series with a unit root, *Econometrica*, 49(4), 1057 - 72.

Domanski, D., Heath, A., 2007. Financial Investors and Commodity Markets, BIS Quarterly Review, March.

Dornbusch, R., 1976. Expectations and exchange rate dynamics, *Journal of Political Economy*, 84(6), 1161-1176

Enders, W., 2009. Applied Econometric Time Series, Wiley, New York.

Engle, R.F., Granger, C. W. J., 1987. Cointegration and Error Correction: Representation, Estimation and Testing, *Econometrica*, 55(2), 251-276

EPA, 2012. Renewable Fuel Standard, US Environmental Protection Agency. Available at http://www.epa.gov/otaq/fuels/renewablefuels/index.htm.

Erten, B., Ocampo, J.A., 2012. Super-cycles of Commodity Prices Since the Mid- Nineteenth Century, DESA Working Paper No. 110, ST/ESA/2012/DWP/110

FAO, 2009. The State of Agricultural Commodity Markets: High Food Prices and the Food Crisis—Experiences and Lessons Learned. Available at ftp://ftp.fao.org/docrep/fao/012/i0854e/i0854e.pdf.

Fawley, B. W., Juvenal, L., 2011. Commodity Price Gains: Speculation vs. Fundamentals, the Regional Economist, July.

Frankel, J. A., Rose, A. K., 2009. Determinants of Agricultural and Mineral Commodity Prices, Reserve Bank of Australia Annual Conference Volume acv2009-02.

Frankel, J. A., 2006. The Effect of Monetary Policy on Real Commodity Prices, NBER Working Paper, 12713.

Frankel, J. A., 2008. The Effect of Monetary Policy on Real Commodity Prices, *Asset Prices and Monetary Policy*, John Campbell, ed., U. of Chicago Press, pp. 291-327.

Frankel, J. A., 2012. Commodity Prices and Interest Rates, in CoBank Outlook Economic Data and Commentary, October, Vol. 9, No. 10, pp. 1-6.
Friedmann, M., 1953. The Case for Flexible Exchange Rate, *Essays in Positive Economics,* 157–203. Chicago: University of Chicago Press.
Gilbert, C. L., Morgan, W.C., 2011. Food price volatility, in Methods to Analyse Agricultural Commodity Price Volatility Chap. 4, pp. 45-61, Edt. Di Isabelle Piot-Lepetit and R. M'barek, Springer, Berlin.
Gilbert, C. L., 1989. The Impact of Exchange Rate Changes and Developing Country Debt on Commodity Prices, *Economic Journal*, 99(397), 773-784.
Goodwin, B.K., Schroeder, T.C., 1991. Dynamics in international wheat markets, *Canadian Journal of Agricultural Economics,* 39(2): 237-54.
Gonzalo, J., 1994. Five alternative methods of estimating long-run equilibrium relationships, *Journal of Econometrics* 60(1), 203-33.
Hamilton, J., 2009. Understanding Crude Oil Prices, *Energy Journal*, 30(2), 179–206.
Heap A., 2005. China. The engine of a commodities super-cycle, Working Paper, Smith Barney; Citigroup New York City.
Hurtado, R., Berri, G.J., 1998. Relationship between wheat yields in the humid Pampa of Argentina and ENSO during the period 1970-1997, 10th Brazilian Congress of Meteorology, Brasilia, Brazil.
IMF, 2006. Global Financial Stability Report, September, Washington DC.
IMF, 2011. Commodity Price Swings Batter Most Vulnerable in Poorest Countries, IMF Survey Magazine: Countries & Regions, 23 September
Irwin, S.H., Sanders, D.R., Merrin, R.P., 2009. Smart Money? The Forecasting Ability of CFTC Large Traders in Agricultural Futures Markets, *Journal of Agricultural and Resource Economics* 34(2), 276-296.
Irwin, S. H., Sanders D. R., 2010. The Impact of Index and Swap Funds on Commodity Futures Markets: Preliminary Results", *OECD Food, Agriculture and Fisheries Working Papers*, No. 27, OECD Publishing.
Islam, A. M., Ahmed S. M., 1999. The Purchasing Power Parity Relationship: Causality and Cointegration Tests Using Korea-U.S. Exchange Rate and Prices, *Journal of Economic Development***,** 24(2), 95-111.
Jacks, D.S., O'Rourke, K.H., Williamson, J.G., 2011. Commodity Price Volatility and World Market Integration since 1700, *The Review of Economics and Statistics, 93(3), 800-813*
Jacks, D.S., 2012. Commodity Price Booms and Busts: A Primer, paper was prepared for the ANU Centre for Economic History /Centre for Applied Macroeconomic Analysis conference on "Commodity Price Volatility, Past and Present" held in Canberra on November 29-30.
Johansen, S., 1995. Likelihood based Inference in Cointegrated Vector Autoregressive Models, Oxford University Press, Oxford.
Johansen, S., Juselius, K., 1990. Maximum likelihood estimation and inference on cointegration with applications to the demand of money, Oxford Bulletin of Economics and Statistics, 52(2), 169 – 210
Kwiatkowski, D., Phillips, P. C. B., Schmidt, P., Shin, Y., 1992. Testing the null hypothesis of trend stationanity, *Journal of Econometrics*, 54(1-3),159-178.
Kremers, J., Ericsson, N., Dolado, J., 1992. The power of cointegration tests, *Oxford Bulletin of Economics and Statistics*, 54(3), 349-67.
Krugman, P., 2008. Running out of Planet to Exploit, 21st April, New York Times.
Krugman, P., 2010a. Nobody Believes in Supply and Demand, The New York Times, 28, December.
Krugman, P., 2010b. The Finite World, The New York Times, 26, December.
Krugman, P., 2011. Commodities: This Time is Different, 29th January, New York Times.
Lütkepohl, H., Krätzig, M. 2004. Applied Time Series Econometrics, Cambridge University Press.
MacKinnon, J.G., 1991. Critical Values for Cointegration Tests, in Long-Run Economic Relationships: Readings in Cointegration, eds. R.F. Engle and C.W.J. Granger, Oxford: Oxford University Press, 267-276.
MacKinnon, J.G., Haug A.A., Michelis L., 1999. Numerical Distribution Functions of Likelihood Ratio Tests for Cointegration, *Journal of Applied Econometrics*, 14(5), 563-577.
Masters, M.W., 2008. Testimony before the Committee on Homeland Security and Government Affairs, U.S. Senate. May 20.

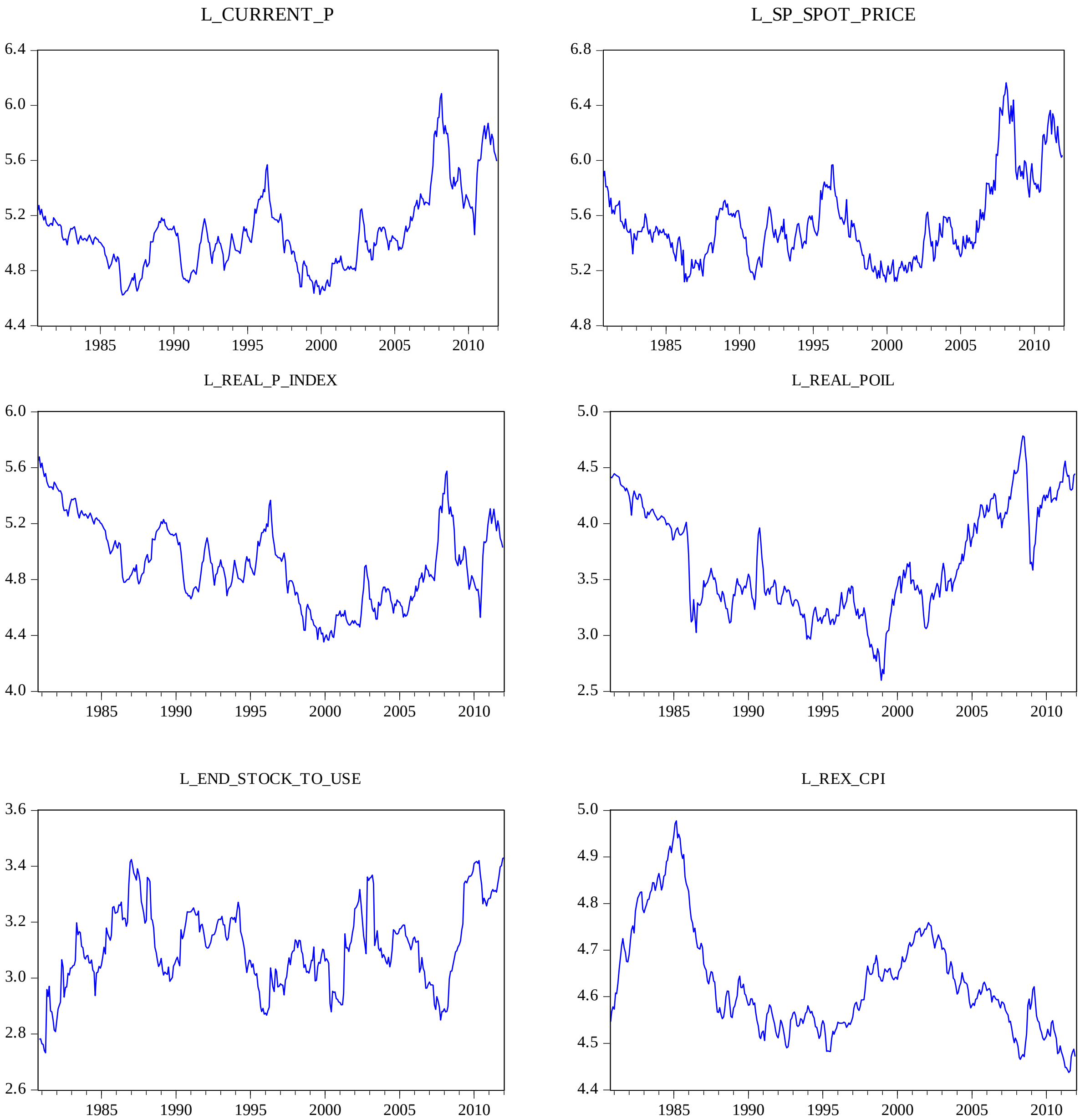
Mercer-Blackman, V., Samiei, H., Cheng, K., 2007. Biofuel Demand Pushes Up Food Prices, IMF Survey Magazine: IMF Research. http://www.imf.org/external/pubs/ft/survey/so/2007/RES1017A.htm
Micu, M., 2005. Declining Risk Premia in the Crude Oil Futures Markets, BIS Quarterly Review, December.
Miffre, J., 2011. Long-Short Commodity Investing: Implications for Portfolio Risk and Market Regulations, EDHEC-Risk Institute Publication, August, France.
Mitchell, D., 2008. A Note on Rising Food Prices. The World Bank. Development Prospects Group. July 2008
Mussa, M., 1986. Nominal Exchange Rate Regimes and the Behavioural of Real Exchange Rates: Evidence and Implications, Carnagie-Rochester Conference Series on Public Policy, Vol.25 pp.117-214.
OECD, 2008. Rising Food Prices: Causes and Consequences, OECD.
Orden, D., Fackler, P., 1989. Identifying Monetary Impacts on Agricultural Prices in VAR models, *American Journal of Agricultural Economics* 71(2), 495-502.
Phillips, R. C. B., Perron, P., 1988. Testing for a Unit Root in Time Series Regression, Biometrika, 75(2), 335-346.
Pindyck, R. S., 2001. The Dynamics of Commodity Spot and Futures Markets: A Primer, *The Energy Journal*, 22(3), 1-29.
Portillo, R., Zanna, F., 2011. Inflation in Sub-Saharan Africa during the 2008 commodity price surge, World Economic outlook, IMF, Chapter 3: Target What You Can Hit: Commodity Price Swings and Monetary Policy, IMF Washington D.C.
Roache, S., 2010. What Explains the Rise in Food Price Volatility? *IMF Working Paper*, No. 10/129
Roberts, M. J., Schlenker, W., 2010. Identifying Supply And Demand Elasticities Of Agricultural Commodities: Implications For The Us Ethanol Mandate, NBER WP No. 15921, Cambridge.
Robles, M., Torero, M., von Braun, J., 2009. When speculation matters, Issue Brief 57, Washington, DC: International Food Policy Research Institute, available at http://www.ifpri.org/sites/default/files/publications/ib57.pdf
Rogers, J., 2004. Hot Commodities: How Anyone Can Invest and Profit in the World's Best Market, New York: Random House.
Russell, J.S., Mcleod, I., Dale, M.B., 2010. Combined Southern Oscillation Index and Sea Surface Temperatures as Predictors of Seasonal Rainfall CSIRO Division of Tropical Crops and Pastures, Brisbane, Australia. http://icoads.noaa.gov/Boulder/Boulder.Russell.pdf
Sanders, D.R., Irwin S.H., Merrin R.P., 2010. The Adequacy of Speculation in Agricultural Futures Markets: Too Much of a Good Thing? *Applied Economics Perspectives and Policy*, 32(1), 77-94.
Stewart, H., 2008. Speculators fuel bubble in global food costs, *The Observer*, 20 April.
Svensson, L.E.O., 2008. The effect of monetary policy on real commodity prices: Comment. In *Asset Prices and Monetary Policy.* Ed. John Y. Campbell, NBER, University of Chicago, Chicago. And NBER Working Paper 12713.
Tang, K., Xiong, W., 2012. Index Investment and Financialization of Commodities, *Financial Analysts Journal*, 68 (6), 54-74.
The Economist, 2011. May, 26th Food in Africa. A recipe for riots.
The World Bank, 2012. Global Monitoring Report 2012 Food prices, Nutrition, and the Millennium Development Goals, the World Bank, Washington D.C.
Thompson, W., Meyer, S., Westhoff, P., 2009. How Does Petroleum Price and Corn Yield Volatility Affect Ethanol Markets with and without an Ethanol Use Mandate? *Energy Policy*, 37(2), 745–749.
Timmer, C. P., 2009. Rice price formation in the short run and the long run: the role of market structure in explaining volatility, Center for Global Development Working Paper Number 172, Center for Global Development, Washington DC.
Trostle, R., 2008. Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices, Washington DC. Available at http://www.ers.usda.gov/Publications/WRS0801/
United States Senate, Permanent Subcommittee on Investigations (USS/PSI), 2009. Excessive Speculation in the Wheat Market, Washington, D.C., June 24.
von Braun, J., Tadesse, G., 2012. Global Food Price Volatility and Spikes: An Overview of Costs, Causes, and Solutions, ZEF DP, 161.

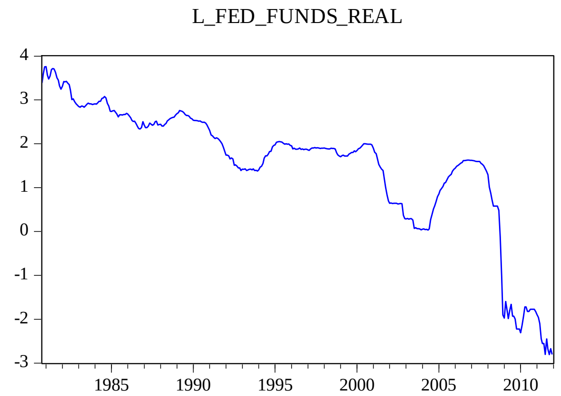
Yellen, J. L., 2011. Commodity prices, the economic outlook and monetary policy. New York, NY, Economic Club of New York, Feb 11 http://www.federalreserve.gov/newsevents/speech/yellen20110411a.pdf
Westcott, P. C., Hoffman, L. A., 1999. Price Determination for Corn and Wheat: The Role of Market Factors and Government Programs, U.S. Department of Agriculture/Economic Research Service, Market and Trade Economics Division, Technical Bulletin No. 1878, Washington DC.
Williams J. C., Wright B., 1991. Storage and Commodity markets, Cambridge University Press, Cambridge, UK.
Wolf, M., 2008. Life in a tough world of high commodity prices, *Financial Times* Wednesday, March 4.
Working, H., 1953. Futures Trading and Hedging, *American Economic Review* 43(3), 314-343.

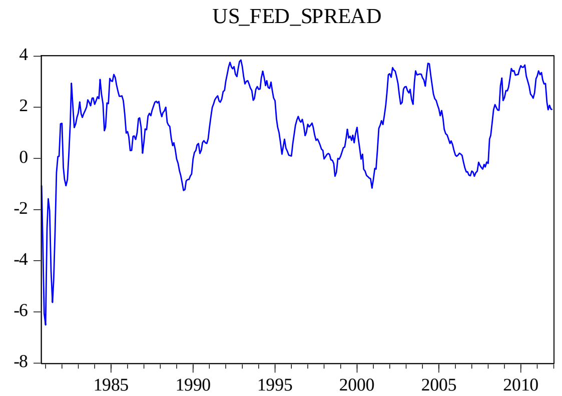
ANNEX

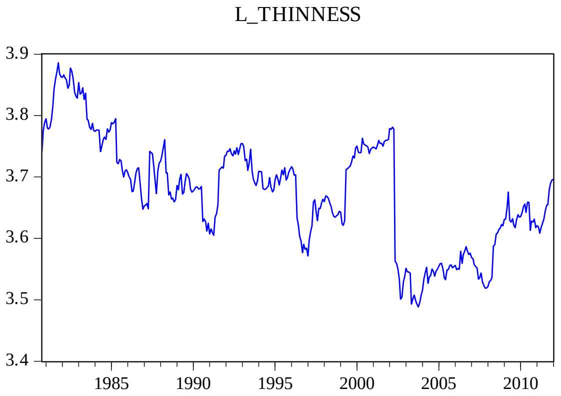
Market price for wheat	This is a market price series for wheat, with values expressed in US dollars and averaged from daily quotations. The commodity and market specifications are: US No. 1 hard red winter, ordinary protein, prompt shipment, FOB Gulf of Mexico ports. The series has been collected from Datastream.
Real effective exchange rate	The US real effective exchange rate series take into account not only changes in market exchange rates, but also variations in relative price levels (using, consumer prices). Data have been taken from Datastream USOCC011
Oil spot prices	This variable has been collected from EIA database and refers to Cushing, Oklahoma WTI (West Texas Intermediate) Spot Price FOB (Dollars per Barrel), Datastream USWTIOIL
Stock-to-use	Data have been taken from USDA http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1194
El Nino region 3.4 sea surface temperature anomalies (SST)	Data taken from the National Climatic Data Center US Department of Commerce and NOAA Satellite and Information Service using the extended reconstructed sea surface temperature; http://www.ncdc.noaa.gov/ersst/ ftp://ftp.ncdc.noaa.gov/pub/data/cmb/ersst/v3b/pdo ftp://ftp.ncdc.noaa.gov/pub/data/cmb/ersst/v3b/pdo/el_nino.dat
The southern oscillation index (SOI)	Data are taken from National Oceanic and Atmospheric Administration National Climatic Data Center http://www.ncdc.noaa.gov/teleconnections/enso/indicators/soi.php http://www.cpc.ncep.noaa.gov/data/indices/soi
Real federal funds	The US money market rate (federal funds) deflated by the consumer price. The Series refers to the weighted average rate at which banks borrow funds through New York brokers. Monthly rate is the average of rates of all calendar days. Data are collected from Datastream.
US interest rate spread	It has been constructed as difference between the 10 year treasury bonds and the federal fund.
Global Activity	It is measured as industrial production index taken from IMF, IFS, via Datastream
Thinness	It has been computed using data provided by the USDA http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1194

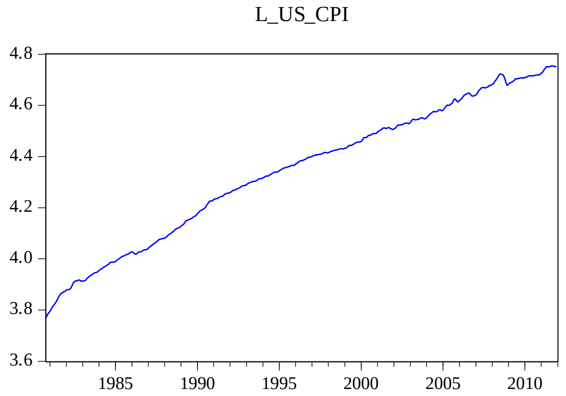
Chart 4 Variables developments

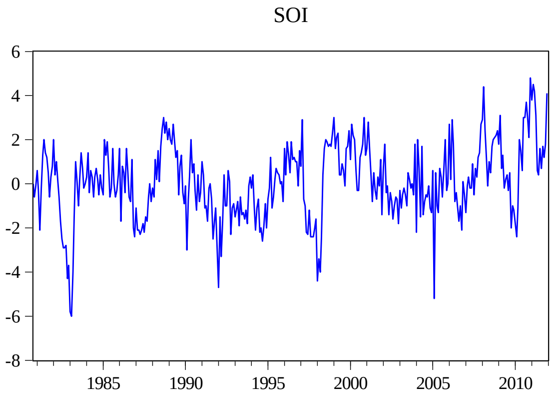


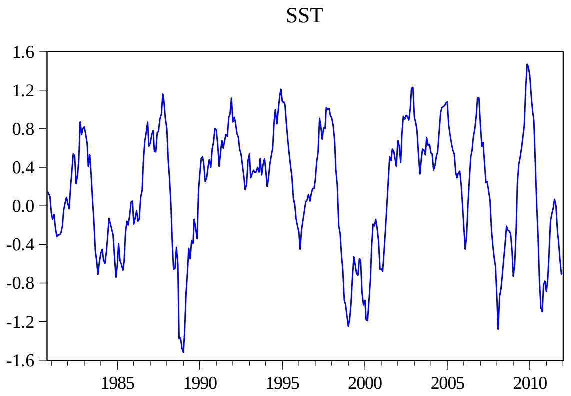

L_FED_FUNDS_REAL
4
3
2
1
0
-1
-2
-3
1985
1990
1995
2000
2005
2010

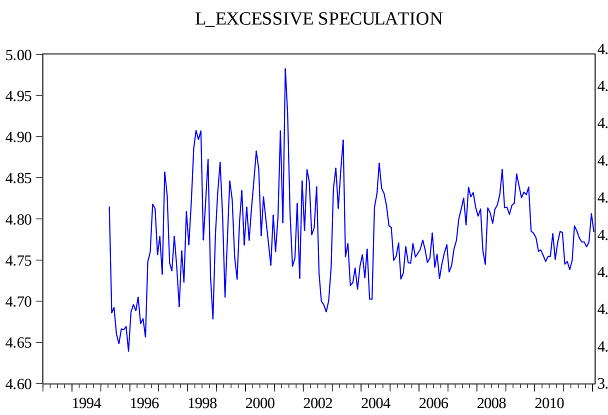

US_FED_SPREAD
4
2
0
-2
-4
-6
-8
1985
1990
1995
2000
2005
2010


L_THINNESS
3.9
3.8
3.7
3.6
3.5
3.4
1985
1990
1995
2000
2005
2010


L_US_CPI
4.8
4.6
4.4
4.2
4.0
3.8
3.6
1985
1990
1995
2000
2005
2010


SOI
6
4
2
0
-2
-4
-6
-8
1985
1990
1995
2000
2005
2010


SST
1.6
1.2
0.8
0.4
0.0
-0.4
-0.8
-1.2
-1.6
1985
1990
1995
2000
2005
2010


L_EXCESSIVE SPECULATION
5.00
4.95
4.90
4.85
4.80
4.75
4.70
4.65
4.60
1994
1996
1998
2000
2002
2004
2006
2008
2010

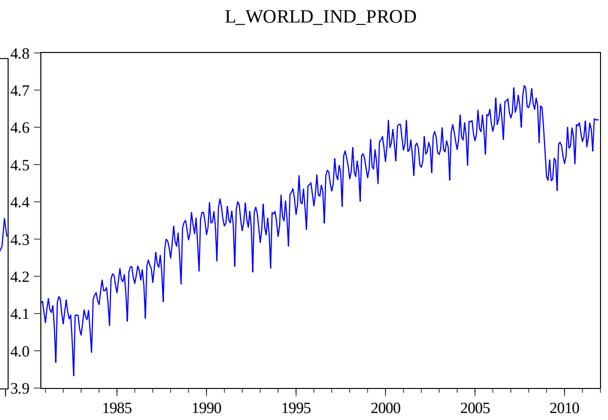

L_WORLD_IND_PROD
4.8
4.7
4.6
4.5
4.4
4.3
4.2
4.1
4.0
3.9
1985
1990
1995
2000
2005
2010

Table 5 VECM System short-run coefficients

Variables	Equation 1	Equation 2
Δ ln real price index $_{t-1}$	0.236 (4.66)	0.283 (3.35)
Δ ln real price index $_{t-2}$	0.022 (0.41)	-0.006 (-0.06)
Δ ln real price index $_{t-3}$	0.049 (0.98)	-0.104 (-1.16)
Δ ln real price index $_{t-4}$		0.059 (0.69)
Δ ln real price index $_{t-5}$		0.100 (1.14)
Δ ln poil$_{t-1}$	-0.056 (-1.60)	-0.084 (-1.35)
Δ ln poil$_{t-2}$	0.065 (1.81)	0.107 (1.97)
Δ ln poil$_{t-3}$	0.012 (0.33)	-0.058 (-0.99)
Δ ln poil$_{t-4}$		0.032 (0.58)
Δ ln poil$_{t-5}$		0.038 (0.06)
Δ ln real fed funds $_{t-1}$	-0.114 (-3.20)	-0.153 (-3.03)
Δ ln real fed funds$_{t-2}$	0.050 (1.20)	-0.145 (-2.30)
Δ ln real fed funds$_{t-3}$	-0.037 (-1.04)	-0.126 (-1.97)
Δ ln real fed funds$_{t-4}$		-0.040 (-0.62)
Δ ln real fed funds$_{t-5}$		0.083 (1.59)
Δ ln rex$_{t-1}$	-0.144 (-0.76)	-0.086 (-1.07)
Δ ln rex$_{t-2}$	0.152 (0.75)	0.088 (1.07)
Δ ln rex$_{t-3}$	-0.193 (-1.03)	-0.115 (-1.40)
Δ ln rex$_{t-4}$		0.157 (1.89)
Δ ln rex$_{t-5}$		-0.030 (-0.40)
Δ ln end-stock-to-use $_{t-1}$	-0.029 (-0.48)	0.017 (0.16)
Δ ln end-stock-to-use $_{t-2}$	-0.064 (-1.06)	0.127 (1.21)
Δ ln end-stock-to-use $_{t-3}$	-0.013 (-0.22)	0.172 (1.66)
Δ ln end-stock-to-use $_{t-4}$		-0.209 (-2.09)
Δ ln end-stock-to-use $_{t-5}$		0.097 (0.95)
Δ sst $_{t-1}$	-0.022 (-1.27)	0.039 (1.26)
Δ sst $_{t-2}$	-0.008 (-0.46)	-0.035 (-1.01)
Δ sst $_{t-3}$	-0.035 (-2.16)	0.007 (0.20)
Δ sst $_{t-4}$		-0.009 (-0.28)
Δ sst $_{t-5}$		0.002 (0.08)
Δ soi $_{t-1}$	-0.010 (-3.85)	-0.005 (-0.98)
Δ soi $_{t-2}$	-0.001 (-3.19)	0.001 (0.11)
Δ soi $_{t-3}$	-0.007 (-3.18)	-0.003 (-0.58)
Δ soi $_{t-4}$		-0.000 (-0.04)
Δ soi $_{t-5}$		-0.005 (-1.21)
Δ ln us world ind prod $_{t-1}$	0.114 (1.71)	0.106 (0.87)
Δ ln us world ind prod $_{t-2}$	0.106 (1.77)	0.091 (0.64)
Δ ln us world ind prod $_{t-3}$	0.061 (1.05)	0.285 (1.75)
Δ ln us world ind prod $_{t-4}$		0.235 (1.63)
Δ ln us world ind prod $_{t-5}$		0.140 (1.19)
Δ fed spread $_{t-1}$	-0.015 (-2.08)	-0.002 (-0.08)
Δ fed spread $_{t-2}$	-0.003 (-0.47)	-0.016 (-0.89)
Δ fed spread $_{t-3}$	-0.009 (-1.34)	0.004 (0.20)
Δ fed spread $_{t-4}$		0.022 (1.26)
Δ fed spread $_{t-5}$		-0.024 (-1.37)
Δ ln thinness $_{t-1}$	0.021 (0.16)	-0.401 (-1.96)
Δ ln thinness $_{t-2}$	-0.128 (-0.97)	-0.577 (-2.83)
Δ ln thinness $_{t-3}$	0.011 (0.07)	-0.147 (-0.71)
Δ ln thinness $_{t-4}$		-0.741 (-3.55)
Δ ln thinness $_{t-5}$		0.087 (0.41)
Δ ln speculation $_{t-1}$		0.096 (2.83)
Δ ln speculation $_{t-2}$		-0.057 (-1.66)
Δ ln speculation $_{t-3}$		-0.028 (-0.92)
Δ ln speculation $_{t-4}$		-0.048 (-1.67)
Δ ln speculation $_{t-5}$		-0.031 (-1.19)
Rsquared	*53.8*	*69.6*
S.E. equation	0.04	0.05

Notes: The symbol Δ is the difference operator. Figures in brackets are t-statistics.

Table 6 Group unit root test on residuals, long sample

Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic selection of lags based on SIC: 0 to 12
Newey-West bandwidth selection using Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu	-67.8824	0	10	3628
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-59.2576	0	10	3628
ADF - Fisher Chi-square	1374.93	0	10	3628
PP - Fisher Chi-square	1503.67	0	10	3640

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution.

Table 7 Group unit root test on residuals, short sample

Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic selection of lags based on SIC: 0 to 12
Newey-West bandwidth selection using Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu	-46.8404	0.0000	11	1880
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-40.8681	0.0000	11	1880
ADF - Fisher Chi-square	943.531	0.0000	11	1880
PP - Fisher Chi-square	1028.61	0.0000	11	1892

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution.

Table 8 VEC Residual Serial Correlation LM Test, equation 1

Lags	LM-Stat	Prob
1	142.3434	0.0035
4	117.4257	0.1124
6	90.10649	0.7506
8	92.01819	0.7029
10	134.8271	0.0116
Probs from chi-square with 100 df.		

Null Hypothesis: no serial correlation at lag order h

Table 9 VEC Residual Serial Correlation LM Test, equation 2

Lags	LM-Stat	Prob
1	113.6360	0.6701
4	119.3675	0.5249
6	101.1936	0.9043
8	123.7742	0.4130
10	131.4847	0.2426
Probs from chi-square with 121 df.		

Null Hypothesis: no serial correlation at lag order h

Table 10 VEC Residual Heteroskedasticity Test: No Cross Terms (only levels and squares). Joint test, equation 2

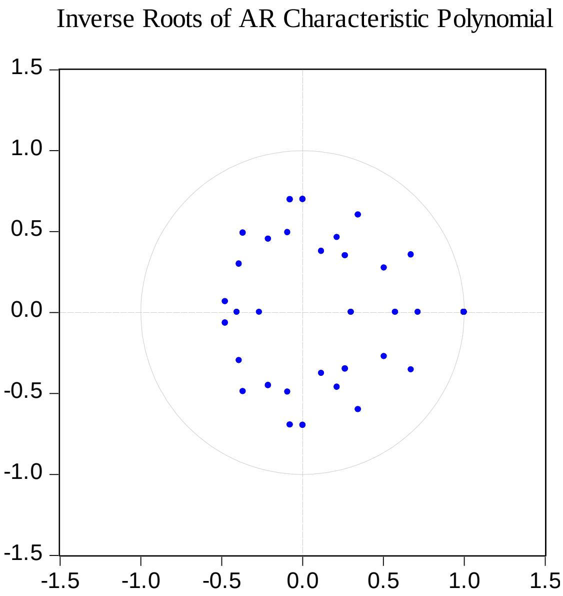
Chi-sq	df	Prob.
7912.907	8052	0.8637

Null Hypothesis: no heteroskedasticity

Table 11 VEC Residual Normality Joint Test.

	Joint Jarque Bera	df	Prob.
Long sample	29145.76	22	0.0000
Short sample	9728.504	22	0.0000

Chart 5 Stability tests



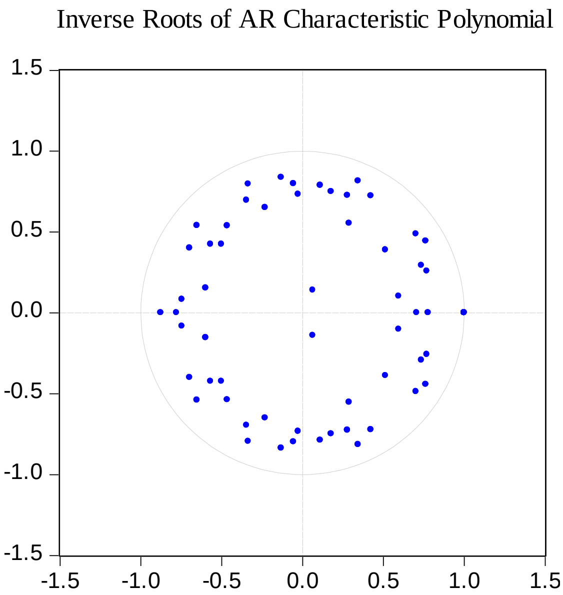
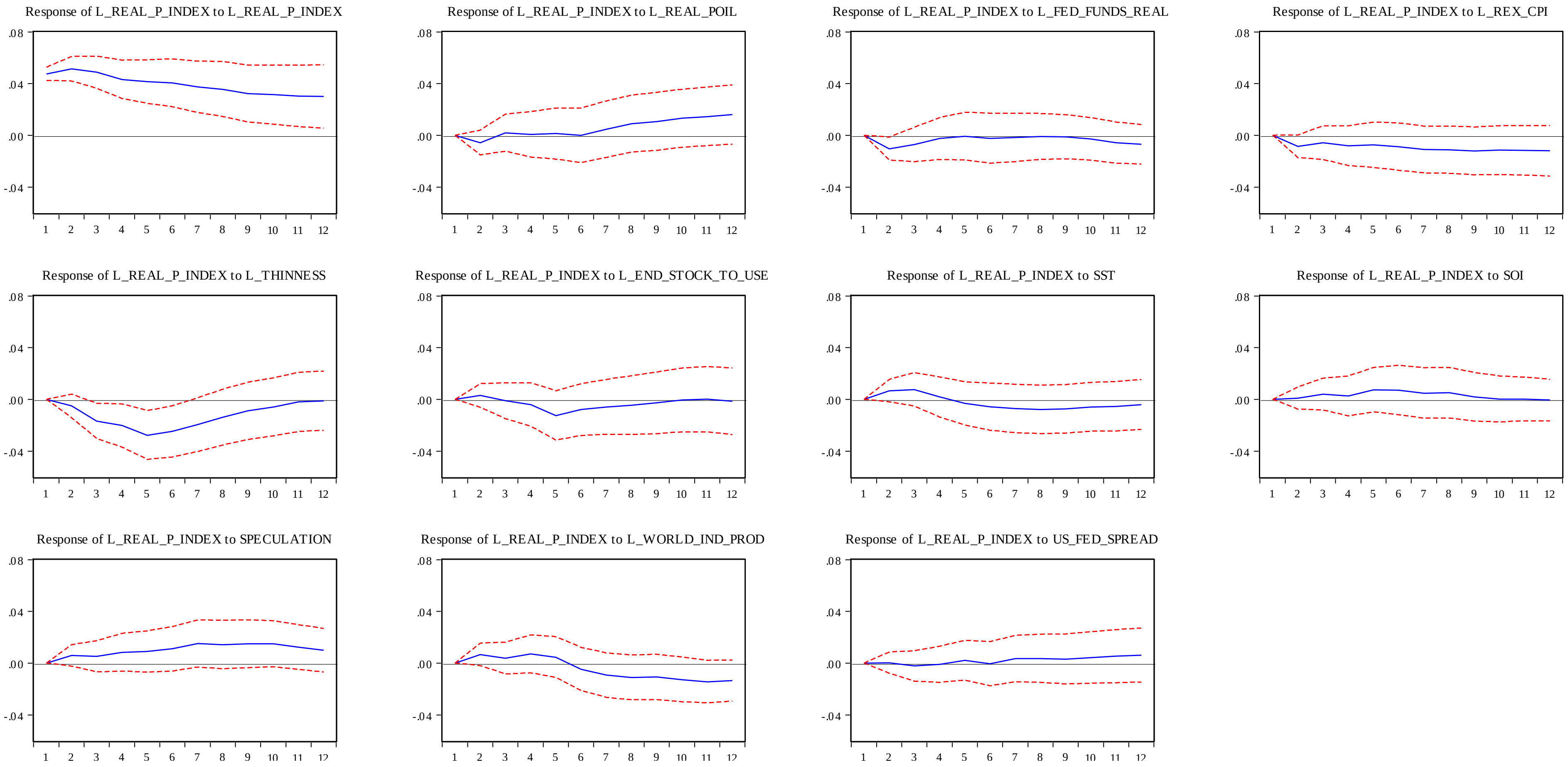
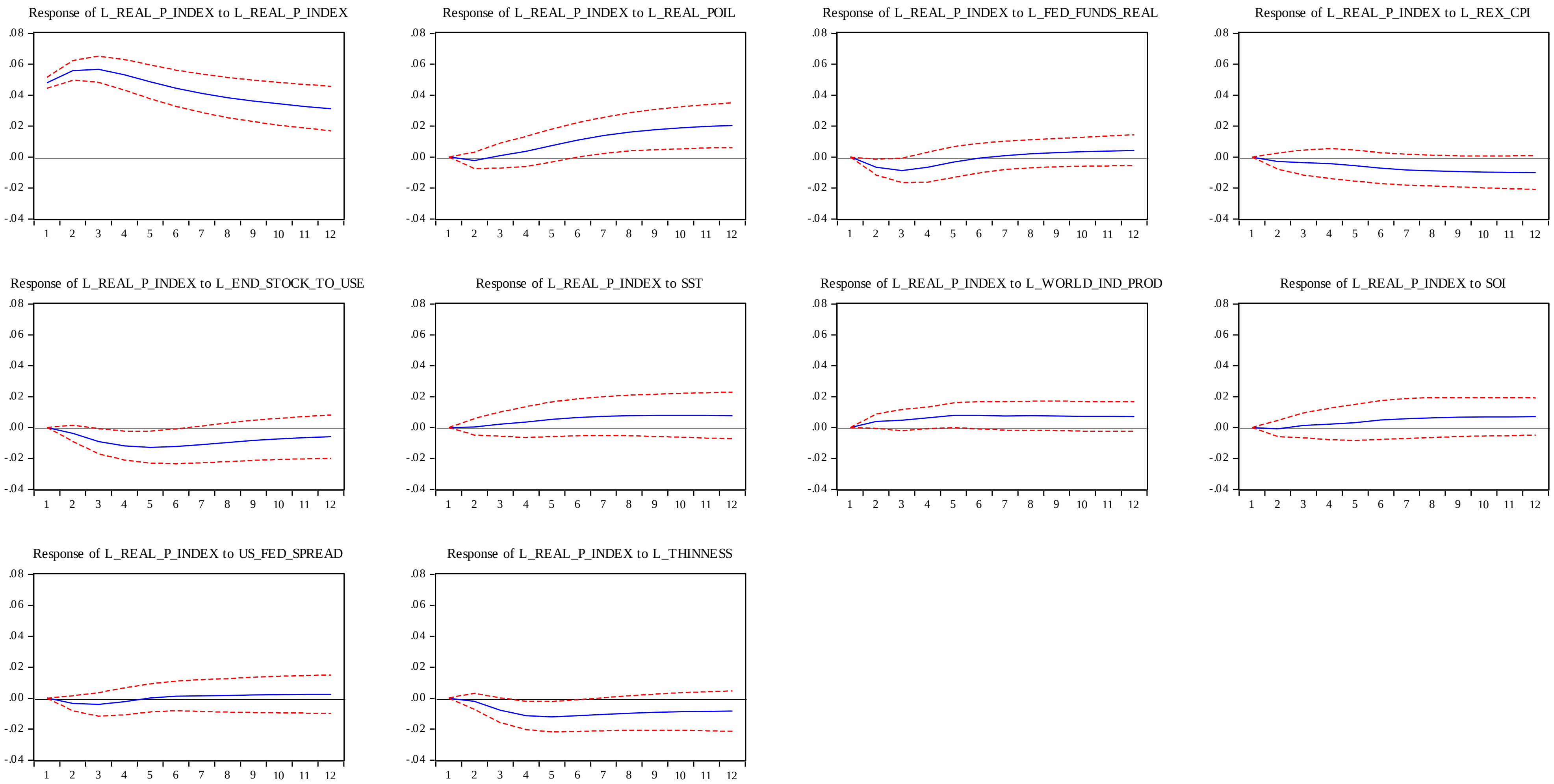


Chart 6 Impulse response function. Response to Cholesky One S.D. Innovation +2;-2 S.E. Short sample 1995-2012



Note: The impulse responses are bounded by two standard error (S.E.) bands (dotted lines) based on the asymptotic normal distribution of impulse responses. S.D. stands for standard deviation

Chart 7 Impulse response function. Response to Cholesky One S.D. Innovation +2;-2 S.E. Long sample 1980-2012



Note: The impulse responses are bounded by two standard error (S.E.) bands (dotted lines) based on the asymptotic normal distribution of impulse responses. S.D. stands for standard deviation

Table 12 Variance Decomposition of ln real wheat price, short sample

Period	S.E.	l_real_p_index	l_real_poil	l_fed_funds_real	l_rex_cpi	l_thinness	l_end_stock to_use	sst	soi	l_specul	l_world_ind_prod	us_fed_spread
1	0.047486	94.42702	5.572979	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.072701	90.27557	3.244782	1.661897	1.887800	0.463882	0.163483	1.043574	0.117749	0.856791	0.276878	0.007597
3	0.090315	85.51369	4.341666	1.537855	1.763658	3.281497	0.120304	1.556762	0.428380	0.918312	0.179848	0.358032
4	0.103207	81.92838	4.445356	1.199849	1.988566	6.083300	0.250322	1.282193	0.534677	1.542052	0.258545	0.486763
5	0.116234	76.40478	4.426187	0.947756	1.960951	10.24846	1.373054	1.037787	1.079585	1.854769	0.204798	0.461877
6	0.127001	73.61406	4.282625	0.793946	2.134358	11.95858	1.508082	1.035835	1.351856	2.156181	0.621172	0.543303
7	0.135968	70.94831	4.725882	0.704199	2.517345	12.32233	1.462221	1.183922	1.392286	2.835927	1.433388	0.474186
8	0.143512	68.81780	5.681728	0.659470	2.859290	11.87607	1.384720	1.382591	1.436372	3.229503	2.240696	0.431761
9	0.149625	67.01584	6.694265	0.627576	3.284870	11.22896	1.290411	1.544233	1.363754	3.728551	2.812133	0.409411
10	0.155454	65.21338	7.909193	0.583268	3.611621	10.52416	1.196093	1.608181	1.270196	4.141371	3.514889	0.427651

Cholesky Ordering: l_real_poil l_real_p_index l_rex_cpi l_world_ind_prod l_fed_funds_real l_specul l_end_stock_to_use sst soi us_fed_spread l_thinness