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M. Peri[a], L. Baldi[a] and D. Vandone[b]

[a] *Department of Agricultural, Food and Environmental Economics*
Università degli Studi di Milano
Via Celoria, 2
20133 Milano, Italy

[b] *Department of Economics, Business and Statistics*
Università degli Studi di Milano
Via Conservatorio, 7
20122 Milano, Italy

This article investigates the long-run relationship between spot and futures prices for corn and soybean. We apply cointegration methodology allowing for the presence of potentially unknown structural breaks in the commodities prices and we then study the causality relationships between spot and futures prices within each specific sub-period identified, with the aim to analyze where changes in spot and futures price originate and how they spread. Empirical estimates highlight the following evidence: i) multiple breaks exist in the cointegrating relationship between spot and futures prices for corn and soybean; ii) sub-periods consequently identified express different dynamics in the causal relationship between spot and futures prices and support the idea that supply and demand fundamentals are important in explaining the 2007/08 food price increase.

Corresponding author:
Daniela Vandone
Department of Economics, Business and Statistics
Università degli Studi di Milano
Via Conservatorio, 7
20122 Milano, Italy
E-mail: daniela.vandone@unimi.it

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I. Introduction

Over the last few years, commodity prices have undergone strong fluctuations as a consequence of economic, political and financial issues that have reshaped the global economic equilibrium.

Most of the anomalies recorded during this period were attributed to the growing role played by financial instruments, specifically derivatives. In fact, although it is well known that derivatives provide economic benefits, such as information dissemination, price discovery and efficient allocation of resources, the tightened cross-market linkages that result from derivatives trading also fuel a common public and regulatory perception that derivatives generate or exacerbate volatility in the underlying asset markets, since they represent not only an important tool for managing risk exposure, but also an opportunity for trading and speculation. In particular, the low cost of futures trading may induce excessive speculation which, in turn, may cause commodity prices to vary excessively, with destabilizing effects in the markets.

In this regard, the study of the dynamics of futures and spot prices for agricultural commodities assumes particular importance, especially within the framework of the recent global food crisis in 2007/08, where concerns have been raised about the possible role of futures and speculation in increasing the price of some agricultural commodities. Indeed, recent years have witnessed a heated debate over the role of the "financialization" of commodity futures and spot markets, causing important consequences from a policy perspective, with practical implications on the efficient pricing of commodities. In particular, some economists and policy-makers assert that the dramatic rise and fall of world food prices in 2007/08 was largely a result of speculative activity in global commodity market and that a "bubble" was generated forcing commodity futures prices well above "fundamental values" (Masters, 2008; Cooke and Robles, 2009; Ghosh, 2010; Gilbert, 2010; Tang and Xiong, 2010). Other authors have instead expressed scepticism over this "bubble" argument, arguing that commodity markets in the same period were driven by fundamental supply and demand factors, like increased use of biofuel, growth in demand from China and India, decline of stocks, increased oil prices, and Dollar depreciation (Headey and Fan, 2008; Stoll and Whaley, 2010; Irwin and Sanders, 2011). Specifically, they argue that limiting trading activity on futures markets might cause more damages than benefits, reducing the efficiency of markets, and intervention would be unjustified. Finally, other authors have highlighted the need to deepen empirical evidence to better identify the relationship between spot and futures prices using appropriate methodological instruments (Headey and Fan, 2008; Irwin and Sanders, 2011).

We contribute to this debate with the specific aim to investigate the long-run relationship between spot and futures prices for corn and soybeans, two of the most significant food commodities traded in global financial markets, which have particularly suffered the combined effect of crisis and biofuel demand growth. Specifically, we apply cointegration methodology in the presence of potentially unknown structural breaks in the prices, using a recent methodology proposed by Kejriwal and Perron (2010). We then study the causality relationships between spot and futures prices within each specific sub-period identified, using the procedure developed in Toda and Yamamoto (1995), in order to analyze where changes in spot and futures price originate and how they spread (i.e. "price discovery"). We use weekly data of spot and future prices from January 2004 to September 2010, a time span that allows us to fully capture price dynamics before and after the 2007/08 financial crisis.

This work offers two new insights. Firstly, we specifically focus on the price discovery role of spot and future markets, that is one of the most concrete problems to the assessment of the ability of agricultural futures markets to assimilate and transmit information and to transfer risk. Secondly, from a methodological point of view, while previous studies analyzed the long-run equilibrium relationship between spot and futures prices using conventional cointegration analysis, we use a refined methodology to analyze the existence of a potential structural break in the cointegration vector in order to gather the time-dynamics of the relationship, particularly important in a period of high price movements.

The article is organized as follows: Section 2 describes the theoretical framework. Section 3 presents the dataset used for the purpose of the study and a brief analysis of spot and futures price trend. Section 4 proposes the econometric methodology and section 5 presents the empirical results. Section 6 includes the discussion and final remarks.

II. Theoretical framework

Theoretically, the relationship between spot and futures prices can be derived from the spot-future parity, which implies that spot and futures prices should move together across time to avoid constant arbitrage opportunities based on the spot-futures relationship (Hull, 1997). Intuitively, since spot and futures prices for any commodity are driven by the same underlying information, they should be closely related; the exact nature of this relationship depends on many factors, among which seasonal effects, the nature of the commodity (storable or non-storable) and market expectations.

The study of the causal relationship between spot and futures prices is functional to the analysis of the "price discovery" role of spot and futures markets, defined as the lead-lag relationship and information flows between spot and futures markets (Schroeder and Goodwin, 1991; Yang et al., 2001; Brooks et al., 2001). Accordingly, a market reflecting new information more rapidly is said to have a price discovery function.

The issue of price discovery is significant in the light of the debate about the relation between the diffusion of financial instruments and an increase in food commodities prices. Indeed, some authors use the notion of price discovery to evaluate hypothesis about the role of speculation in commodities price increase and decrease: when changes in prices appear first in the futures market, speculation may be an important determinant, vice-versa if changes in prices appear first in the spot market, they are caused by changes in market fundamentals that affect the supply/demand balance for the commodity (Kaufmann and Ullman, 2009; Robles et al., 2009). Although price discovery does not necessarily reflect the existence of speculation, but the way prices echo new or unexpected information and spread it through markets[1], if spot prices lead futures prices one can argue that demand and supply pressures over physical commodities are at least as important as trading on the futures market to increase prices. Although some studies find that spot prices lead futures prices (Quan, 1992; Kuiper et al., 2002; Mohan and Love, 2004), empirical findings generally support the price discovery role of futures markets, i.e. spot prices are usually discovered in the future markets. Indeed, spot and futures prices on the same commodity have the same fundamentals and change if new information emerges that causes market participants to revise their estimates of physical supply and/or demand. Since contracts sold on futures

[1] See Irwin et al. (2009) for a comprehensive explanation on the misunderstanding of the role of speculation in commodities price boom.

markets generally do not require the delivery of the commodity but can be implemented immediately with little up-front cash, futures markets generally react more quickly than spot markets (Silvapulle and Moosa, 1999); prices respond rapidly to new information throughout the marketing system, and provide unbiased although imprecise forecasts of subsequent cash prices (Garbade and Silber, 1983; Crain and Lee, 1996; Carter, 1999; Williams, 2001; Yang et al., 2001; Garcia and Leuthold, 2004; Hernandez and Torero, 2010). In particular, Garbade and Silber (1983) analyze the price discovery for four storable commodities including corn and soybean and conclude that futures markets generally dominate spot markets in registering and transmitting information. Crain and Lee (1996) also find that changes in wheat futures prices lead changes in spot prices, confirming that futures markets dominate spot markets in the price discovery process. Similarly, Yang et al. (2001) confirmed the dominant role of futures markets in the price discovery process for storable commodities. More recently, Hernandez and Torero (2010), who analyzed spot and futures prices for wheat, corn and soybeans, find evidence that the price of futures Granger-cause spot prices more often than the reverse - particularly for corn and wheat. They also find that the causal relationship is remarkably stronger than in the past and adduce this result to the increasing importance of electronic trading of futures contracts, which results in more transparent and widely accessible prices.

The present analysis intends to extend these previous studies by examining and interpreting, across the recent commodity price bubble, the causal relationships in spot and futures markets within the sub-periods identified by structural breaks. What did it happen to the price discovery process during the global food crises? Did futures prices lead spot prices? Or, vice-versa, were price movements driven by fundamentals?

The understanding of this relationship is quite relevant since there is the possibility that regulators over-react to the recent global food crises introducing futures markets reforms that actually may reduce the overall efficiency of futures markets, with negative consequences on risk management where the potential benefits of using futures contracts to hedge price risk have been identified for a variety of contracts and market situations (e.g. Tomek and Peterson, 2001; Lien and Tse, 2002; Irwin et al. 2011).

III. Data issues

This Section introduces the data to analyze the price discovery role of spot and futures prices for corn and soybeans. The specific spot prices considered are corn U.S. No.2 yellow FOB U.S. Gulf and soybeans No.1 FOB U.S. Gulf. These quotations are the leading benchmark price for international trade and are considered as reported by the USDA on Friday of each week. Future prices are collected from DataStream and are from CBOT. Futures prices are those from the nearby contract, but contracts are rolled over to the next contract on the first business day of the contract month; this is the standard procedure in the literature since the nearby futures contract is highly liquid and the most active (Yang et al., 2001). The sample period comes from January 2004 to September 2010, a time window that enables us to properly investigate the price bubble of 2007/08. Indeed, we set the window size with the aim to capture the price dynamics before, during, and after the commodity price crisis. All prices are in U.S. dollars per metric ton (US$/MT). Futures prices are denoted in U.S. cents per bushel, which were subsequently converted into US$/MT for comparison purposes with spot prices.

As we are interested in longer-term price movements, we use weekly values instead of daily observations (Kaufmann and Ullman, 2009). This change reduces the likelihood of finding a causal relationship (Schwarz and Szakmary, 1994). However, there is no evidence that the use of weekly data affects our results and conclusions, since these are essentially unaffected when we repeat the analysis using daily data.

Price evolutions over the period considered are showed in Figure 1, whereas the summary statistics for a seven-year period are presented in Table 1. The main evidence is that these prices reached unprecedented heights during mid-2008 and then subsequently declined with remarkable speed. Volatility, observed through the coefficients of variation, indicates that corn and soybean spot prices were quite similar over the period, whereas the corn futures price appeared to fluctuate more than soybean futures prices.

Several factors influenced the price dynamics during the period considered. Among them we recall the strong increase in commodities demand from China and India; the adverse weather conditions; the biofuels rush; the uncontrolled oil price growth; and the global financial crisis. With regard to soybean, from the end of 2006 harvested areas recorded a steep fall as farmers shifted to corn, which offered attractive returns and prices that started a continuous and uninterrupted growth. The supply scarcity in the following months pushed the price up to very high levels within a year time, but prices dropped suddenly the following year. This decline was triggered by the prospect of improved crop output, combined with weak demand for oilseed products. In the case of soybean, the downturn in energy prices also contributed to the fall in prices.

With regard to corn, prices increased first during the beginning of 2007, then slipped slightly to be followed by a new, very strong increase. In 2007, corn prices went through a moment of particular impetus induced by the ethanol boom, which absorbed an increasing amount of production (about one-fifth of the previous harvest was used for the distillation of biofuel). This situation was intensified by the dry climate that reduced yields. However, in the following period, high maize prices gave way to a substantial increase in plantings and this, together with favorable weather conditions, boosted world output with an ensuing slight fall in prices.

<Insert Figure 1>

<Insert Table 1>

As far as the size of commodities futures markets, the following figures show the average weekly dollar value of open interest in contracts, for both soybean and corn; as clearly highlighted, during the period under analysis there has been a growing number of contract outstanding in the marketplace, indicating a strengthening of the trading.

<Insert Figure 2>

IV. Econometric methodology

The theoretical equilibrium relationship between spot and future prices is a long-run, rather than a short-run, connection, and can be tested by examining whether spot and futures prices are cointegrated. There already exists a vast literature that highlights the long-run equilibrium relationship between commodities spot and futures prices (among others, Martin and Garcia, 1981; Hokkio and Rush, 1989; Wahab and Lashgari, 1993; Giot, 2003; Garcia and Leuthold, 2004; Hernandez and Torero, 2010), but only a few studies examine the time dynamic of such a relationship, i.e. the existence of a potential structural break in the cointegration vector (Dawson et al., 2010; Maslyuk and Smyth, 2009).

Such a methodological refinement is important. In conventional cointegration analysis, cointegration vectors are assumed to be time invariant; however, in the long-run, the relationship between the series may change due to a break, and the time-invariant formulation of the cointegrating vector will no longer be appropriate (Hansen, 1992). Since commodities have experienced in recent years sizeable and long-lasting price changes (see Figure 1 in Section 3), it is likely that this methodology is able to capture more accurately the relationship between spot and futures prices, and, specifically, to properly analyze their causal relationship.

Specifically, to address the research question of this article, the approach starts by investigating the order of integration of the variables. With this objective in mind, considering that testing for unit root of a series in presence of structural break using a traditional augmented Dickey-Fuller (1979) technique provides biased results (Perron, 1989), the order of integration of the variables is tested using also an alternative methodology. The first test used is the GLS augmented Dickey-Fuller (ADF-GLS) test of Elliot et al. (1996) and the second is the Zivot and Andrews (1992). The ADF-GLS has a unit root under the null hypothesis and does not assume the presences of structural breaks. On the other hand, the Zivot and Andrews (1992) test is a sequential test that allows the existence of one endogenous break, where the null hypothesis is that the series is integrated without exogenous structural break.

Once the series are found to be of the same order of integration, we test for cointegrating relationship allowing the presences of multiple structural breaks. The literature presents several different approaches for the analysis of structural breaks. These differ on the estimation and inference about break dates, the inclusion of tests for structural changes, tests for unit root in presence of structural changes in the trend function, as well as tests for cointegration allowing for structural changes (see Perron 2005 for a exhaustive review). One of the most important issues concerns the possibility to manage multiple structural breaks when series are related to each other. Bai and Perron (1998) first dealt with these issues proposing a methodology limited to I(0) series, while Kejriwal and Perron's (2010) extended the procedure also to the I(1) variables. However, to fit within the purpose of this article, focused on the analysis of the changing dynamics between spot and future price of corn and soybean during the recently financial crisis, Kejriwal and Perron's (2010) approach was utilized to estimate, test and compute multiple endogenous breaks dates in conintegrated regressor.

From the econometric point of view, the Kejriwal and Perron (2010) model is an extension of the Bai and Perron (1998) procedure to a more general model allowing for the possibility of both $I(0)$ and $I(1)$ variables in the regression.

The Kejriwal and Perron (2010) model is based on the following linear regression with m breaks and $(m+1)$ regimes:

$$y_t = c_j + z'_{ft}\theta_f + z'_{bt}\theta_{bj} + x'_{ft}\beta_f + x'_{bt}\beta_{bj} + u_t \qquad t = T_{j-1}+1,\dots,T_j \qquad (1)$$

where y_t is the $I(1)$ dependent variable at time t, z_{ft} $(q_f \times 1)$ and z_{bt} $(q_b \times 1)$ are vectors of unit root variables, while x_{ft} $(p_f \times 1)$ and x_{bt} $(p_b \times 1)$ are vectors of stationary variables. The symbols θ_f, θ_{bj}, β_f and β_{bj} (j = 1, ..., m+1) are coefficients of these vectors, while u_t is the stochastic disturbance at time t. The subscripts f and b respectively represent the regressor that are fixed or change across the regimes. Conventionally, T_0=0 and T_{m+1}=T.

The purpose of the Kejriwal and Perron (2010) model is to estimate the unknown break points (T_1,...,T_m) together with the regression coefficients allowing for both a partial or a pure structural change model. In the partial structural change model, only a subset of coefficient changes across the *j* regimes; when $p_f = q_f = 0$, the model is referred to a pure structural change model (the specification adopted in this article), where all coefficients in the equation change across regimes. To analyse the significances of the procedure, we start with the use of a Sup F_T (k) type test based on the null hypothesis of no structural breaks (m=0), against an alternative of m=k breaks. In a second step, the null hypothesis of no structural breaks is tested against the alternative of an unknown number of breaks given some upper bound *M* for the number of breaks in a *double maximum test* (*UD max*). Finally, based on a series of Wald-type test, the sequential test supF_T(l + 1|l) compares the null hypothesis of l breaks *versus* the alternative of (l + 1) breaks. Asymptotic critical values for these tests can be found in Kejriwal and Perron (2010).

For both commodities considered and for each of the sub-periods detected by the breaks in the spot and futures prices relationship we then investigate the Granger causality. Considering that when the series are integrated Toda and Yamamoto (1995) have shown that the conventional Granger non-causality test is not valid as the test does not have a standard distribution; thus, we apply the Toda and Yamamoto (1995) procedure following the Rambaldi and Doran (1996) approach. It is firstly necessary to select the maximum order of integration (d_{max}) of the variable considered (in our case, it is one), next it is necessary to determine the optimal lag (k) of the VAR model using information criteria, the preferred lag value being selected on the basis of AIC, HQIC and SBIC statistics. Then a VAR(k+d_{max}) has to be estimated in a Seemingly Unrelated

Regression (SUR) framework, lastly the hypothesis is tested using a Wald statistic test (MWALD) which has an asymptotic chi-square distribution. In our case, considering the relationship between spot (S) and futures (F) prices the VAR assumes the following specification:

$$S_t = \gamma_0 + \sum_{i=1}^{k} \gamma_{1i} S_{t-1} + \sum_{j=k+1}^{k+d_{\max}} \gamma_{2j} S_{t-j} + \sum_{i=1}^{k} \delta_{1i} F_{t-1} + \sum_{j=k+1}^{k+d_{\max}} \delta_{2j} F_{t-j} + \varepsilon_{1t} \quad (2)$$

$$F_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} F_{t-1} + \sum_{j=k+1}^{k+d_{\max}} \alpha_{2j} F_{t-j} + \sum_{i=1}^{k} \beta_{1i} S_{t-1} + \sum_{j=k+1}^{k+d_{\max}} \beta_{2j} S_{t-j} + \varepsilon_{2t} \quad (3)$$

The null hypothesis that spot price does not Granger cause futures price is formulated as $\beta_{11}=\beta_{12}=\ldots=\beta_{1k}=0$, while when futures does not Granger cause spot prices the null is: $\delta_{11}=\delta_{12}=\ldots=\delta_{1k}=0$.

V. Empirical results

The degree of integration of the variables was tested using the ADF-GLS test and the Zivot and Andrews (1992) test (ZA) that permits the presence of structural changes. Table 2 shows the results of the tests using different alternatives: with level shift, with trend and with level and time trend shift. The tests indicate that all series are I(1) in all the cases considered and are stationary in the first differences. In particular the ZA test highlights the presence of unit root when breaks are considered.

<Insert Table 2>

Provided that series are integrated of the same order, we can analyze the cointegration between them. To investigate the presence of multiple breaks and estimate the data of the breaks in a cointegrating framework we then adopt the Kejriwal and Perron (2010) procedure. The approach defines a pure structural change model (p=0) where the spot prices are a function of futures prices, and a time trend. In the practical implementation of the procedure, the maximum number of breaks allowed was set as 5 ($M=5$), along with a trimming value $\varepsilon=0.15$, corresponding to a minimum of h=52 observations for each segment. Results of the test for multiple structural changes applied to the relationship of the two price series are reported in tables 3 and 4.

For both the commodities the Sup$F_T(k)$ tests significantly reject the null hypothesis of no structural breaks for k=1 to k=5 at 0.01 significance level, and provides evidence of the existence of at least one break in the prices relationships. This is supported by highly significant results of the *UD max* tests, which confirm the existence of at least one break. The use of a sequential procedure test [SupF_T $(l+1|l)$] suggests the existences of two and three structural breaks, with significant coefficients at 0.01 level, for soy and corn respectively.

Since in our approach the detection of breaks has the purpose to identify sub-periods within which to analyze the relationship between spot and futures prices, we do not focus on the analysis of the determinants of breaks and their economic explanation; however, some comments may be helpful to understand the dynamic of commodity prices. Specifically, as regards corn, the first break is detected at the beginning of 2005. This break can be attributed to the 2005 Energy Policy Act, which fixed a biofuel obligatory mandate for ethanol use with a first step of 15 billions of litres for 2006; since corn is the raw material to produce ethanol, it is likely that the biofuel policy heavily influenced new pressures on the demand side of corn. Two remarkable breaks are then detected, both for corn and soybean, during the recent economic and financial crisis. Specifically, for corn the first of these two breaks is detected in December 2006, during the first rise of prices due to the strong demand for feed use, in particular from developing countries like China, and for ethanol production. For soybean, the first break is detected a few months later, at the beginning of 2007. This break can be attributed to several factors, among which the constant rise in the demand of soybean during a period where some external factors, such as weather, weakened the total production, leading to a gradual tightening in global stocks. Furthermore, steadily growing biodiesel requirements led to increased demand for vegetable oil, notably soybean in the U.S., rapeseed in Europe. Finally, the last break is detected, for corn and soybean, in Autumn 2008. This break coincides with the bursting of the commodities price bubble. In this period, international prices of all coarse grains declined sharply due to favorable global crop prospects and ample supplies in world markets. The downturn was further aggravated by the market expectation that a global economic slowdown could lower demand for coarse grains and that the steep drop in crude oil prices could also depress demand (for corn in particular) from the ethanol sector. Not to be overlooked, moreover, was the simultaneous collapse of the U.S. financial system, which then extended to the rest of the world economy, and the concurrent lack of liquidity and trading volume that limited the ability of the futures market to transmit price information to spot markets effectively.

<Insert Table 3>

<Insert Table 4>

These breaks define sub-periods where different directions of causality in spot and futures prices could be present and where, alternately, prevails the role of market fundamentals or financial issues, therefore the analysis focuses on the study of Granger causality following Toda Yamamoto's approach. It has to be noted that Granger causality requires careful interpretation. Hamilton (1994) suggests it is better to describe "Granger causality" tests between X and Y as tests of whether X helps forecast Y rather than whether X causes Y, i.e., causality has to be interpreted as a forecast and not a causality. For this reason, as outlined in section 2, the relationship between spot and futures prices we detect cannot be interpreted only as a mere relation of cause and effect (speculation *vs*. fundamentals or vice-versa), but also as the ability of a price to anticipate (forecast) the pattern of the other.

As reported in table 5, empirical results highlight different outcomes for the two commodities examined. For what concerns corn prices, in the first and in the last sub-period detected by breaks, futures prices lead spot prices, highlighting the forecasting role of the futures market, in line with prevalent findings in previous empirical studies (Garbade and Silber, 1983; Crain and Lee, 1996; Hernandez and Torero, 2010). Conversely, in the second and in the third sub-period, during the peak of the commodity price crisis, empirical data highlight that there are bidirectional information flows between spot and futures markets. In line with Irwin et al. (2009), it can be argued that demand and supply pressures over physical commodities are as important as trading on the futures market to increase the price discovery role of spot markets.

For soybeans, the detected breaks distinguish different dynamics in different periods. In particular, before the first break there is no clear evidence of a causality relation, that is, even though variables are related in a long-run way, the price discovery function is unclear. Instead, during the second sub-period, when we recorded the highest and sharpest soybean price increase, there is evidence of a Granger causality effect from spot to futures prices, but futures prices do not contain any information about spot prices. Finally, similar to corn in the third sub-period there is evidence of information flows from futures to spot markets.

<Insert Table 5>

If we tie these results back to previous argument about supply/demand drivers versus financial trading in order to provide an economic explanation to our empirical findings it appears that, both in corn and soy market, spot prices take a more dominant role during large price increases. This leads us to assume that future contracts may not be culprit for the recent commodity price increase, which should be of importance from a regulator's perspective. Indeed, after the recent crises both the U.S. Commodity futures trading commission and the European Union are discussing the possibility to introduce position limits and higher margin requirements to curb speculative activity on commodities futures markets. However, if futures regulation becomes more restrictive – for example through reduced volume of trade, by means of limiting the participation of index fund investors and/or reducing position limits for all speculators in commodities – hedgers may not be able to transfer the risk of price fluctuations to speculators, especially in particularly volatile markets. Such initiatives could severely compromise the ability of commodity markets to accommodate the needs of firms to manage price risks, limiting the role of speculators in providing liquidity. At the end, this reduced efficiency may translate into higher costs for producers and higher prices for consumers.

VI. Conclusion

The exceptional price rises recorded in the last few years has destabilized the world economic scenario and has lowered the level of world agricultural stocks to levels unseen for 25 years. Among the main causes we can find firstly, the strong increase in the demand for commodities from China and India, countries with increasingly higher standards of living and the surge in energy demands that this entails. The rush to biofuels, initially considered as the main cause of this inflationary pressure, is another major factor: increasingly significant quantities of agricultural products are, in fact, being diverted away from their traditional food markets. The uncontrolled increase in the oil price, has had repercussions throughout the economy and has had in particular a crucial impact on the fertilizer market and transport. Last but not least, financial speculation, which caused considerable price volatility and prevented the planning of supply in many countries, contributed to creating a situation of marked instability.
Over the period January 2004 – September 2010 we apply an econometric methodology (Kejriwal and Perron, 2010) allowing us to test for multiple structural changes in the cointegrated system between spot and futures prices of corn and soybean; we then utilize a specific approach (Toda and Yamamoto, 1995) to investigate, in the different sub-periods detected by the breaks, their causal linkages. Results show that breaks were detected at specific stages in the food commodity markets and relate to events that have significantly affected the supply and demand of corn and soybeans for food and energy purposes. The sub-periods consequently identified express different dynamics in the

causal relationship between spot and futures prices. In line with the main findings that emerge in the literature investigating the spot-futures price relationship in food commodity markets, futures prices play a major role in price discovery, that is in registering and transmitting information from the related real market; due to the greater transparency and, often, greater liquidity of commodity futures over physical commodities, futures markets react more quickly to new or unexpected information than the underlying spot market. However, in times of crisis and in particular in phases of strong price increase, the cash market also becomes an important actor in the price discovery process. Specifically, during the recent drastic world increase in food prices, our findings emphasize that price discovery is more related to fundamental patterns rather than financial trading on futures markets. Such results may be of importance from a regulator's perspective: a more restrictive regulation on commodities futures markets aimed at limiting speculative activity may compromise the overall functioning of commodities markets, reducing the mechanism of risk transfer, and creating added costs.

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Table 1. Summary statistical information

	Soybean		Corn	
	Spot	***Futures***	***Spot***	***Futures***
Mean ($/Ton)	334.2	338.9	149.0	134.0
Standard Deviation ($/Ton)	95.9	101.2	44.6	45.5
Coefficient of variation	28.7%	29.9%	29.9%	34.0%
Range ($/Ton)	425	453	214	224
Min. ($/Ton)	204	197	90	75
Max. ($/Ton)	629	649	303	298

Source: our elaboration of USDA and CBOT data

Table 2. Results of the Unit root tests

	ADF-GLS		ZA		
	Trend	Level Trend	Level	Trend	Level Trend
Spot-Soy	-1.175	-1.546	-3.416	-2.545	-3.254
Futures-Soy	-1.190	-1.473	-3.424	-2.692	-3.347
Spot-Corn	-0.629	-1.851	-3.701	-2.838	-3.361
Futures -Corn	-0.646	-1.672	-3.705	-2.852	-3.633
Critical Value					
1%	*-2.572*	*-3.475*	*-5.43*	*-4.93*	*-5.57*
5%	*-1.942*	*-2.900*	*-4.80*	*-4.42*	*-5.08*
10%	*-1.616*	*-2.588*			

Table 3. Kejriwal and Perron (2010) tests of multiple structural breaks - Soy

Specifications					
z_t={futures-soy}	q=1	M=5	ε=0.15	h=52	x_t={0} p=0
Tests					
SupF_T(1)	SupF_T(2)	SupF_T(3)	SupF_T(4)	SupF_T(5)	*UD max*
61.942**	171.546**	132.028**	102.839**	80.405**	171.546**
SupF_T(2|1)	SupF_T(3|2)	SupF_T(4|3)			
233.088**	7.510	3.706			
Dates and confidences interval					
$\hat{T}_1$	$\hat{T}_2$				
02/02/07	**08/15/08**				
(01/26/07 - 02/23/07)	(08/01/08 - 08/29/08)				

Notes: The sup$F_T(k)$ tests and the standard errors use the following specifications: no serial correlation in the errors, different variances of errors and different distribution for the data across segments. The confidence intervals are reported in parenthesis.

** denote significance at the 1% level. Critical values are obtained from table 1 and 3 of Kejriwal and Perron (2010).

Table 4. Kejriwal and Perron (2010) tests of multiple structural breaks - Corn

Specifications					
z_t={futures-corn}	q=1	M=5	ε=0.15	h=52	x_t={0} p=0
Tests					
SupF_T(1)	SupF_T(2)	SupF_T(3)	SupF_T(4)	SupF_T(5)	*UD max*
136.431**	91.600**	74.978**	58.661**	47.018**	136.431**
SupF_T(2|1)	SupF_T(3|2)	SupF_T(4|3)			
34.828**	22.656**	8.834			
Dates and confidences interval					
$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$			
01/14/05	**12/15/06**	**10/10/08**			
(11/12/04 - 03/04/05)	(12/01/06 - 01/12/07)	(05/16/08 - 01/16/09)			

Notes: The sup$F_T(k)$ tests and the standard errors use the following specifications: no serial correlation in the errors, different variances of errors and different distribution for the data across segments. The confidence intervals are reported in parenthesis.

** denote significance at the 1% level. Critical values are obtained from table 1 and 3 of Kejriwal and Perron (2010).

Table 5. Toda-Yamamoto test of Granger Causality

	k	*d*	X^2	p-*value*	Causality direction
Corn					
1st sub period					
Futures	2	1	23.69	0.0000	F -----→ S
Spot	2	1	3.07	0.2157	S ---X→ F
2nd sub period					
Futures	2	1	67.39	0.0000	F -----→ S
Spot	2	1	7.84	0.0199	S -----→ F
3rd sub period					
Futures	2	1	71.64	0.0000	F -----→ S
Spot	2	1	6.93	0.0313	S -----→ F
4th sub period					
Futures	2	1	122.84	0.0000	F -----→ S
Spot	2	1	0.47	0.7898	S ---X→ F
Soy					
1st sub period					
Futures	1	1	2.31	0.1286	F ---X→ S
Spot	1	1	0.62	0.4319	S ---X→ F
2nd sub period					
Futures	1	1	0.95	0.3297	F ---X→ S
Spot	1	1	9.18	0.0024	S -----→ F
3rd sub period					
Futures	1	1	4.24	0.0396	F -----→ S
Spot	1	1	0.02	0.8835	S ---X→ F

Notes: See table A and B, respectively for soy and corn, for definition of the sub period detected by the breaks. In the last column F and S indicate Futures and Spot prices while the symbol -----→ and ---X→ respectively indicate *Granger cause* and *does not Granger cause*.

Since the different IC utilized to detected the optimal lag length provide different results for the corn series, spanning from 2 to 3 lags, we also test for k=3, without detecting any relevant differences in respect to 2 lags.

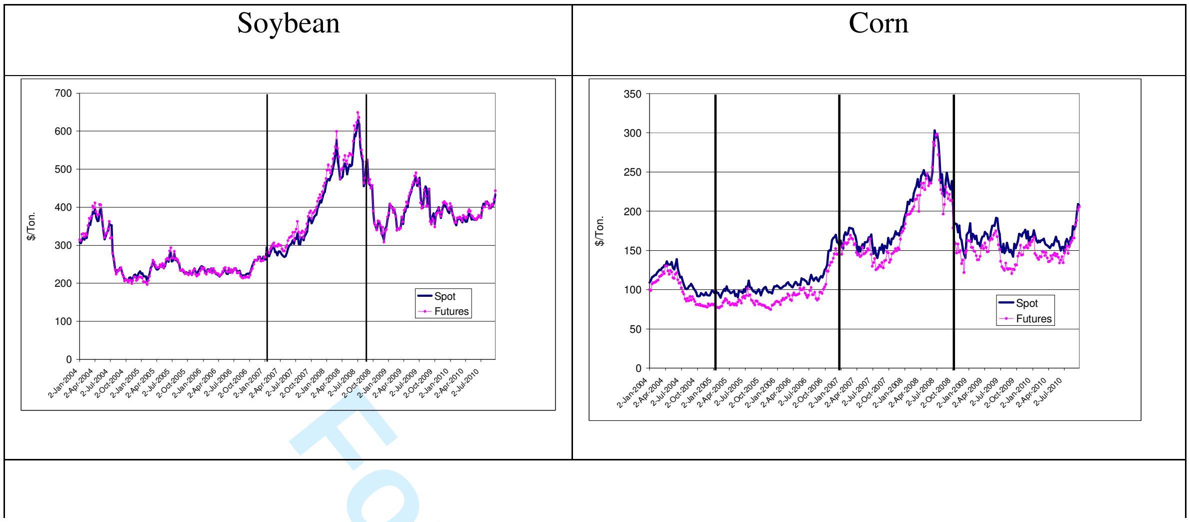

Fig. 1. Trend of spot and futures price of Soybean and Corn

Source: USDA and CBOT

Note: Black vertical lines denote structural breaks detected in par. 5

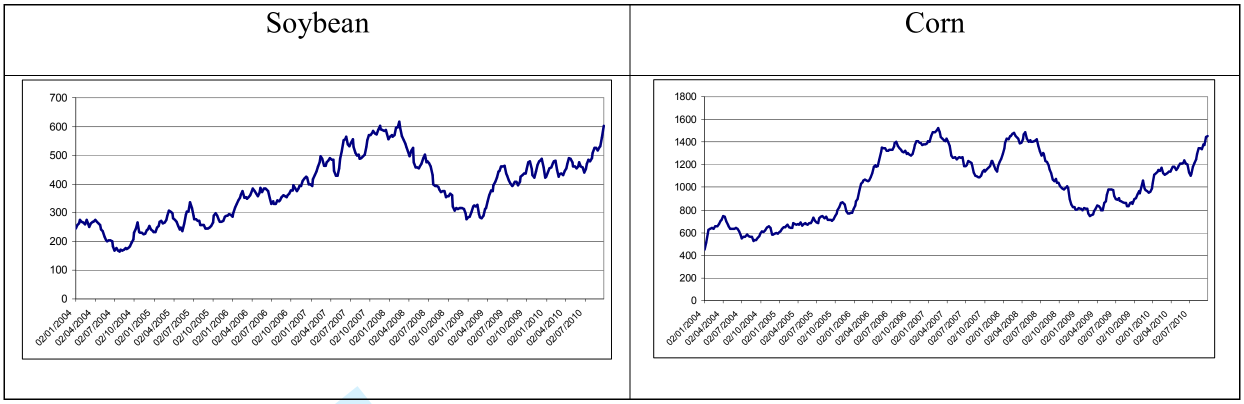

Fig. 2. Soybean and corn futures markets: open interest (in thousands)

Sources: US Commodity Futures and Trading Commission (CFTC)