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Volatility in US and Italian agricultural markets, interactions and policy evaluation

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Abstract

The aim of this paper is to analyse the volatility and interactions among prices of agricultural commodities in Italy and US using the time series analysis. The cross market interactions are examined to test the hypothesis that the increased volatility of agricultural prices has been caused by crude oil price, then the cointegration and causality among different markets is also tested. For this analysis the spot prices of wheat, corn, soybeans in US and Italy and crude oil prices spanning from 2002 to 2010 are used. The results suggest the following considerations: i) the existence of causality in US markets with exogeneity of the oil on the US agricultural commodities, ii) evidence of cointegration between US and Italian commodities, suggesting a condition of market efficiency, iii) no evidence of cointegration between oil and Italian agri-commodities. The conclusion is that the oil volatility is transmitted to the US Ag- markets while US Ag- markets have influenced the volatility of the Italian agricultural markets.

Keywords: time series analysis, agricultural commodity prices, linear and nonlinear Granger causality, market integration

JEL classification: C14, C19, Q13.

1. INTRODUCTION

The prices of agricultural and oil commodities rose sharply in 2007, peaking in the second half of this year for some products and in the first half of 2008 for other ones. The '07-‘08 price spike seems to have been caused by different factors: a macroeconomic instability influencing the world commodity markets as the rapid growth of food demand by the BRIC countries, due to rising GDP, the international financial crisis, and the growing influence of the oil price volatility on the other commodity markets (Piot-Lepetit and M’Barek, 2011). The agro-fuel commodities deserve an additional so-called knock-on effect due to the expanding U.S. corn production for ethanol use, reducing the oilseed acreage, such that the oilseed prices tended to increase for the expected tightening supplies. The upward price trend is enhanced by the rising demand for meals being the cereal feedstock substitutes and for vegetable oils used for bio-diesel production (OECD-FAO, 2008). Most agricultural commodity markets seems to manifest in recent times a higher volatility; however, a physiological price fluctuation is accepted for the changes of agricultural output from period to period caused by natural shocks such as weather ad pests. A second reason is the rigidity of demand due to the length of time for the production to adjust to market changes. The movements of the agricultural commodity prices are expected to be influenced by:

- Growth in world population, incomes and food consumption with rising demand of staples from China and India due to new consumption patterns and demand growth for meat, catching the demand for grain and oilseeds used to produce meat (Headey and Fan, 2008);

- Change in stocks, stock replenishment rates and consequences for the international trader expectations and decisions (Trostle, 2008). Rising commodity prices are reflective of higher inflation costs and increase in worldwide demand for food. Investors can buy grain stocks by buying commodity funds or stocks that are needed to produce grain stocks;
- Growing speculation in financial markets, responsible for the increasing agricultural commodity prices in 2007–08 leading to unreasonable or unwanted price fluctuations (Robles *et al.*, 2009). The price surges caused by speculation could cause turbulence to the global grain markets affecting the market's efficiency in responding to fundamental changes in supply, demand, and costs of production.
- Exchange rates fluctuations affecting the relative prices. Price fluctuations for soft commodities can destabilize real exchange rates and cause difficulties for the governments in preserving a stable economic environment. Fluctuations in agricultural commodity prices generate substantial risk for producers, processors and traders in managing revenues and the cost of future production. Volatility leads to inefficiency and impairs the efficient allocation of resources for farmers. Moreover, the uncertainty reduces the opportunities to access to credit markets and drives farmers to prefer lower risk production techniques (John, 2007; Moschini and Hennessy, 2001).
- Growth of financial and future markets and speculative fund positions. There are three ways to invest in agricultural commodities markets: i) *investing directly in futures markets* with sufficient capital and a large tolerance for risk by examining the fundamentals and technical outlook in greater detail and opting for the food commodities holding the greatest potential gain; ii) *focusing on the individual stocks* of companies that either harvest or distribute basic foods and will benefit from rising demand, or companies that develop the new agricultural technologies and equipment needed to meet those demands (i.e. BRF-Brazil Foods S.A., Deere & Company or Monsanto Company); iii) *sharing in one or more of the exchange-traded funds*[1] that target agricultural commodities markets (Spears, 2011), perhaps the easiest way to gain access to a broader spectrum of higher food prices.
- Policies encouraging biofuel production from agricultural commodities, limited supplies of fossil fuel causing the rising oil prices, and increased concerns for global warming have influenced the growth of demand for renewable energy and biofuel, (Sarris, 2009), causing the raise in corn and oilseed prices and the acreage invested in biofuel crops. This

[1] An Exchange-traded fund is a financial instrument composed by a basket of stocks that reflect an index. An ETF's price changes during the day trading, and fluctuates with supply and demand. Commodity ETFs invest in commodities and provide exposure to an ever-increasing range of commodities and commodity index, including energy, metals, softs and agriculture. The first Commodity ETF was conceptualised in 2002.

has caused a reduction in soybean planting, competing with corn, with a significant surge in price up to 75% from April 2007 to April 2008 (Headey and Fan, 2008).

In more recent years, the increased volatility seems to have been caused by growing interactions among agricultural and energy markets (Sumner, 2009). Oil price behaviour could have affected the stability of agricultural market conditions and caused the substitution of market fundamentals (demand-supply-stock) with other signals of reference (Headey and Fan, 2008; Tyner and Taheripour, 2008). To predict more accurately the future price behaviour many authors started to use composite forecasting models (Granger and Ramanathan, 1984; Manfredo et al., 2001; Fang, 2002).

These preliminary considerations suggest to test the price behaviour of agricultural market by studying the interaction of agri-commodity prices with the oil price using the time series analysis, (Tomek and Myers, 1993; Rosa, 1999; Thompson et al., 2002; Gutierrez et al., 2007; Listorti, 2009, Nazlioglu, 2011). The analysis is developed as it follows: in the first part stationarity conditions with and without structural break are verified, in the second part the cointegration among price series is explored, in the third part the causality (linear and non linear) is analysed, and in the last part are reported the discussion of the results, main conclusions and suggestion to cope with the increased uncertain decision environment in farm planning.

2. DATA ANALYSIS

For the research, are used the Italian weekly prices of hybrid corn, good mercantile soft wheat and soybeans with 14% of moisture provided by Datima-ISMEA[2] and American agri-commodities prices of corn (no. 2, Yellow US Gulf), wheat (no. 2, Soft Red Winter US Gulf) and soybeans (no.1, Yellow U.S. Gulf), collected by the FAO and USDA. Weekly data are the average of daily quotations, monitored for a period spanning from January 2002 to December 2010. The oil prices are the world crude oil, US crude oil and Europe (UK), brent blend provided by EIA (Energy Information Administration, Independent Statistics and Analysis). By observing the correlation matrix among these series reported in Table 1, the brent crude price series is preferred since two thirds of the world's transaction prices are referred to this product.

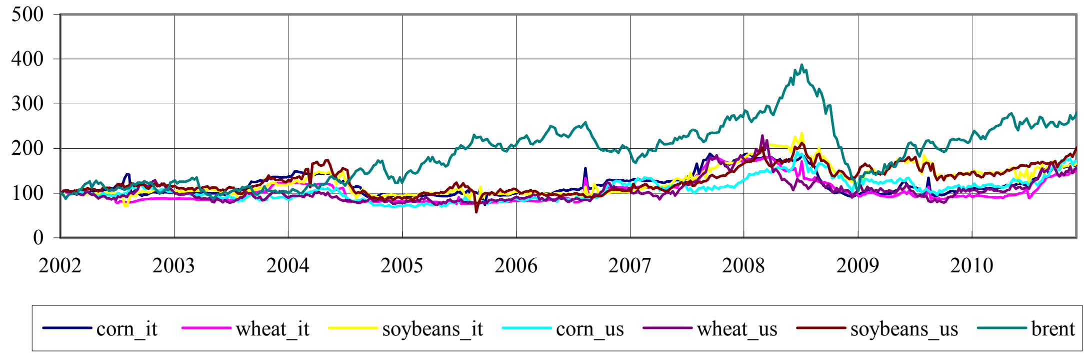
Table 1. Correlation coefficients between oil prices

Brent	world crude oil	us crude oil	
1.0000	0.9983	0.9973	Brent
	1.0000	0.9994	world crude oil
		1.0000	us crude oil

[2] Datima is a collection of statistical databases including foreign trade and agricultural market data.

The agricultural commodity prices are expressed in €/ton and oil prices in €/barrel; for the conversion $/€ is used the official exchange rate[3]; the missing values are replaced by using the imputation algorithm proposed by King et al. 2001[4]. The price series used for the analysis are reported in Figure 1; as it is expected, there is a close co-movement of the agricultural series with the exception of the brent. This evidence doesn't suggest any conclusion about the cross market influences that will be tested later with cointegration and causality.

Figure 1. Weekly current price indices (2002w1 =100)



Source: our elaboration

Table 2. Correlation coefficients

	us_corn	us_soybeans	us_wheat	it_corn	it_soybeans	it_wheat	brent
us_corn	1.0000						
us_soybeans	0.8312	1.0000					
us_wheat	0.7109	0.6436	1.0000				
it_corn	0.6448	0.6408	0.7881	1.0000			
it_soybeans	0.8032	0.9103	0.7022	0.7014	1.0000		
it_wheat	0.6791	0.6390	0.8617	0.9356	0.7480	1.0000	
brent	0.6037	0.5087	0.5232	0.5302	0.6576	0.5179	1.0000

Table 2 presents the correlation coefficients among the price series: the oil prices are positively correlated with the Italian and US agricultural prices, but the values are not very high and are quite similar in the two market areas. Descriptive statistics of the observed price series, suggest that the standard deviation is closely related to the level and the volatility is diffused among the all markets for the entire period (see Table 3). The results of Jarque-Bera test indicate non-normal commodity price distribution in both markets[5] due to high correlation among the prices.

[3] Available at: http://it.finance.yahoo.com/valute/convertitore/
[4] The execution of the algorithm is made with the R-package AMELIA II developed by Honaker et al., 2009
[5] The **Jarque–Bera test** is a goodness-of-fit measure of departure from normality, based on the sample kurtosis and skewness. The test statistic *JB* is defined as $JB = \frac{n}{6}\left(S^2 + \frac{1}{4}K^2\right)$
where *n* is the number of observations (or degrees of freedom in general); *S* is the measure of skewness (third moment), and *K* is the kurtosis (fourth moment) of the data. The statistic *JB* has an asymptotic chi-square distribution with two degrees of freedom used to test the null hypothesis that the data are from a normal distribution.

Table 3. Descriptive statistics for prices (470 observations 2002 w 1 – 2010 w 52)

	corn_us	wheat_us	soybeans_us	corn_it	wheat_it	soybeans_it	brent
Mean	110,1673	140,9159	244,0434	153,8532	162,8025	285,9887	44,5712
Median	106,6786	131,8335	225,1407	140,4150	148,2150	257,4150	46,0844
Maximum	196,0036	304,5164	401,6400	240,5000	278,1500	526,6336	90,9004
Minimum	69,6316	97,7824	108,1742	94,7889	117,1117	143,7444	20,5902
Std. Dev.	26,1954	35,8705	56,1670	33,9268	41,7853	73,5270	15,6328
Skewness	0,8741	1,6738	0,5809	1,0295	1,2988	0,8434	0,3908
Kurtosis	3,5454	5,6964	2,4540	2,9211	3,8254	2,8771	2,4928
Jarque-Bera	65,6773	361,8332	32,2732	83,1438	145,4832	56,0100	17,0004
Probability	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0002

3. Empirical analysis and results

3.1. Unit root analysis

The check for stationary condition of the price series is the first test of the analysis; the literature suggests different tests: augmented Dickey-Fuller unit root test (1979), Phillips and Perron (1988) test and the KPSS proposed by Kwiatkowsky et al. (1992) test. The ADF tests for the null hypothesis of non-stationary against the alternative hypothesis of stationary condition; the rejection of the null hypothesis of the unit root suggests that the stationary condition is achieved. The Phillips and Perron is a nonparametric test to check for serial correlation; the PP method modifies the non-augmented DF test so that the serial correlation does not affect the asymptotic distribution of the test. Finally, the KPSS method is performed, to test the null hypothesis of stationary. The ADF and PP tests results, reported in Table 4, suggest the rejection of the stationary condition in all cases on the level of prices and the KPSS test indicates that the null hypothesis is rejected for the level forms except for corn_it that becomes stationary with the inclusion in the equation of trend and intercept. The all tests suggest that the all series are stationary with the first difference.

Table 4. Unit root tests

		Levels			First differences		
		ADF	PP	KPSS	ADF	PP	KPSS
Constant	corn_us	-0.644	-0.431	1.414***	-23.118***	-23.161***	0.221
	soybeans_us	-1.752	-1.520	1.394***	-23.021***	-23.322***	0.096
	wheat_us	-1.560	-1.559	0.816***	-14.163***	-23.546***	0.127
	corn_it	-1.685	-1.579	0.465**	-23.669***	-23.667***	0.111
	soybeans_it	-1.345	-1.625	1.521***	-19.307***	-28.938***	0.057
	wheat_it	-0.998	-1.058	0.590**	-18.405***	-25.314***	0.122
	brent	-1.407	-1.554	1.754***	-18.779***	-19.145***	0.042
Constant and trend	corn_us	-1.834	-1.662	0.247***	-23.187***	-23.257***	0.066
	soybeans_us	-2.754	-2.522	0.277***	-23.021***	-23.380***	0.045
	wheat_us	-2.212	-2.276	0.151**	-23.655***	-23.574***	0.051
	corn_it	-2.012	-1.922	0.116	-17.847***	-23.674***	0.082
	soybeans_it	-2.534	-2.680	0.179**	-19.295***	-28.922***	0.044
	wheat_it	-1.493	-1.545	0.145*	-18.451***	-25.358***	0.089
	brent	-2.265	-2.596	0.192**	-18.759***	-19.127***	0.043

The optimal lags for ADF test were selected on the base of SIC; the bandwidth for PP and KPSS tests was selected with Newey-West using Bartlett kernel. For ADF and PP tests, only with constant, critical values are -3.444 at 1%, -2.867 at 5% and -2.570 at 10% significance level. If linear trend is included they are -3.978 at 1%, -3.419 at 5% and -3.132 at 10% respectively. For KPSS test with constant, critical values are 0.739 at 1% significance, 0.463 at 5% and 0.347 at 10%. With constant and linear trend, critical values correspond to 0.216, 0.146 and 0.119 at 1%, 5% and 10% level of significance respectively.***/**/* denote statistical significance at 1%, 5% and 10%.

The unit root tests may produce misleading results if structural breaks are present. Assuming the time of the break to be exogenous, Perron (1989) showed that the power to reject a unit root decreases when the stationary alternative is true and a structural break is ignored. Zivot and Andrews (1992) propose a variation of the Perron's original test by assuming that the exact time of the break-point is unknown. Following Perron's characterization of the form of structural break, Zivot and Andrews[6] use three models to test for a unit root: model A, which allows a one-time change in the level of the series; model B, which allows for a one-time change in the slope of the trend function, and model C, which combines one-time changes in the level and the slope of the trend function of the series.

The null hypothesis in all the three models implies that the series contains a unit root with a drift that excludes any structural break, while the alternative hypothesis implies that the series is a trend-stationary process with a one-time break occurring at an unknown point in time.

Perron suggested that most economic time series can be adequately modelled by using either model A or model C.

Table 5. Results of Zivot and Andrews one-break test

	Model A: breaks in level			Model C: breaks in level and trend		
Variables	[k]	statistics	break	[k]	statistics	break
corn_us	[2]	-2,68	June 11, 2004- w24	[2]	-2,95	June 19, 2009- w25
soybeans_us	[0]	-4,72	July 16, 2004- w29	[0]	-4,72	July 16, 2004- w29
wheat_us	[2]	-2,85	Apr 13, 2007- w15	[2]	-3,20	June 12, 2009- w24
corn_it	[2]	-2,57	July 18, 2008- w28	[2]	-3,03	Aug 22, 2008- w34
soybeans_it	[2]	-3,46	May 11, 2007- w19	[2]	-3,57	May 11, 2007- w19
wheat_it	[3]	-2,48	July 11, 2008- w28	[3]	-2,12	July 11, 2008- w28
brent	[3]	-5,01*	Sept 05, 2008- w36	[3]	-5,75***	Oct 10, 2008- w41

[k] = lag length. The asymptotic critical value for Zivot and Andrews test are -5.57, -5.08 and -4.82 at 1%, 5% and 10% levels of significance respectively. *** /* denote statistical significance at 1% level and 10% respectively.

The results are reported in Table 5; minimum ZA t-statistics for the levels of the variables show similar results with those obtained from the unit root tests without accounting for structural breaks with exception for brent series whose results suggest that it is possible to reject the null hypothesis of the unit root. Even though brent prices seem to be stationary in model C, this condition is not so evident in model A. The conclusion is that all the variables are integrated of order one. The test identifies also endogenously the point of the single most significant structural break for the series examined. Even if one knows at what point in time a regime shift had occurred, one does not necessarily know when this happened.

[6] Details of ZA test are not explained here; for interested and complete reading, refer to Zivot and Andrews.

As underlined by Piehl et al., (1999), the knowledge of the break point is essential for an accurate evaluation of any program intended to capture the structural changes, as the tax reforms, banking sector reforms or regime shifts etc. The breakpoints are quite similar for brent and the Italian agri-series both in Model A and C while there are some discrepancies in the American agri-commodities and brent.

3.2. Cointegration analysis

The co-movements between oil and agri-commodity prices during the recent years suggest to test for the cointegration among the variables using the first difference of the all price series. If two or more series are individually integrated (in the time series sense) but some linear combination of them have a lower order of integration, then the series are assumed to be cointegrated. Two cointegrated time series can only diverge from an equilibrium relationship for a short period. If two time series variables are no stationary but cointegrated, at any point in time, the two variables may drift apart but there will be always a tendency for them to retain a reasonable proximity to each other.

The cointegration between brent and the agricultural commodities is tested using the maximum likelihood approach suggested by Johansen (1988)[7] on I(1) time series.

This test is not strong enough to capture the impact of structural breaks and the cointegration test over the full period may induce to misleading interpretation of the result (Bekiros and Diks, 2008). This is the reason for testing the cointegration on the full sample, and selected sub-periods extrapolated from the results of ZA test: 2002w1-2004w28, 2004w29-2008w35 and 2008w36-2010w52.

Table 6. Cointegration test without structural break

	Ho:r cointegration vectors	2002w1-2010w52	2002w1-2004w28	2004w29-2008w35	2008w36-2010w52
		trace statistics	trace statistics	trace statistics	trace statistics
corn_us-brent	0	7.81	20.98***	6.19	7.85
	1	1.03	1.99	0.04	0.16
soy_us-brent	0	6.68	13.52*	9.58	4.84
	1	1.19	0.75	0.03	0.48
wheat_us-brent	0	15.03**	15.26**	8.25	16.60**
	1	0.52	2.47	0.50	1.98
corn_it-brent	0	8.57	16.27**	5.28	9.53
	1	1.45	2.50	1.03	1.80
soy_it-brent	0	8.03	10.73	8.53	9.11
	1	1.49	0.77	0.00054	2.01
wheat_it-brent	0	10.53	16.47**	8.11	10.26
	1	1.42	2.43	1.33	1.90

[7] There are two types Johansen test, either with trace or with eigenvalue. The trace statistic reports the null hypothesis of r cointegrated relations against the alternative of k cointegrating relations, where k is the number of endogenous variables. The maximum eigenvalue test, on the other hand, considers the null hypothesis of r cointegrating vectors against the alternative hypothesis of r + 1 cointegrating vectors. The rank is calculated with the eigenvalues of a matrix. If all the eigenvalues are significantly different from zero, all processes are stationary. If there is at least one eigenvalue equal to zero, the process y_t is integrated. On the other side, if none eigenvalue is significantly different from zero, not only the process y_t is non stationary but this is for all the linear combinations. In other words there is no evidence of cointegration.

corn_us-corn_it	0	13.94*	15.88**	8.74	15.98**
	1	1.82	2.02	2.03	0.17
soy_us-soy_it	0	14.72*	18.42**	19.11**	19.15***
	1	1.80	2.28	0.0006	1.80
wheat_us-wheat_it	0	21.17***	8.58	22.95***	18.88***
	1	1.34	1.50	1.20	0.55

p-values are MacKinnon-Haug-Michelis (1999) p-values; ***/**/* denotes rejection of the null hypothesis at the 1/5 and 10% level respectively.

The first part of Table 6 reports the results of the cointegration test between brent and agri-commodities in the US market for the entire 2002-2010 period and selected sub-periods. The best cointegration results for all the commodities are obtained for the sub-period 2002-2004; this is the less turbulent period. Studies on other periods suggest different results as reported by Campiche et al. (2007) by examining the co-movements between world crude oil prices and corn, sorghum, sugar, soybeans, soybean oil, and palm oil prices during the period 2003–2007. The empirical analysis with the Johansen cointegration test shows that while there is no evidence of cointegrating among the variables for the period 2003–2005, corn and soybean prices are cointegrated with crude oil prices during the period 2006–2007. Harri et al. (2009) report a consistent cointegrating relationship between crude oil and corn, soybeans starting in April 2006. Nazlioglu (2011), analysing the cointegration between oil and the three key agri-commodity prices (corn, soybeans and wheat spot prices in US market), suggests that corn and soybeans are cointegrated with the oil prices during the period 2008-2010 and that the null hypothesis of cointegration between wheat_us and brent is rejected for the entire period of observation.

The second part of Table 6 reports the cointegration results for brent and Italian agri-commodity prices; there are evidence of no cointegration between oil and Italian commodities with the exception of corn and wheat for the sub-period 2002-2004. These results suggest to further investigate about the cointegration among the American and the Italian commodity markets because this condition would demonstrate the presence of a unique market based on the assumption that a product of equivalent quality must be sold for the equivalent price that includes the transport cost; in practice prices traded in two integrated market areas should move together with higher approximation (Buccola, 1985, Rapsomanikis et al, 2003).

Commodity arbitrage ensures that each good has a single price (defined in a common currency unit) throughout the world (Isard, 1977). The results are reported in the third part of the table and suggest evidence of cointegration, statistically significant for the entire period of observation and for the sub-periods. This support the hypothesis that volatility in Italian agri-commodity market was caused by US market. Since the structural breaks are determined *a priori* instead of finding them endogenously in the cointegration model, we analysed the relationship between brent and ag-commodity prices with the Gregory-Hansen test that is a residual-based test for cointegration in models with regime shift (Gregory and Hansen, 1996).

They examine tests for cointegration which allow the possibility of regime shift and develop ADF^*, Z_t^* and Z_α^* type tests designed to test the null hypothesis of no cointegration against the alternative of cointegration in the presence of a possible structural break that can occur in intercept (level shift, model C), with trend (level shift with trend, model C/T) or in cointegration vector (regime shift, model C/S). The structural change is endogenously determined by the smallest value (the largest negative value) of the cointegration test statistics across all possible break point. Tables below reports the results of this test. Table 7 shows the results of cointegration between oil and US agri-commodity prices. As far as brent and corn price relation is concerned, ADF* fails to reject the null hypothesis of no cointegration; the same results are obtained in model C and C/T of Z_t^* and Z_α^* type tests, whereas, in the regime shift model (C/S), the most general alternative which allows for both the intercept and the slope coefficient to shift (Gregory and Hansen, 1996), the null hypothesis is rejected with a break date in Summer 2006. For the case of soybeans and brent, all three tests do not reject the null hypothesis of cointegration with the level shift and trend showing a structural break in August 2004; besides, Z_t^* and Z_α^* fail to reject the null in the regime shift model with a break even in July 2007. Considering the long run relationship between wheat and brent prices, the are no evidences of cointegration relationship. These results confirm the finding of Harri et al. (2009) who tested for the presence of cointegration between crude oil and agricultural commodities in US markets (corn, soybeans, soybean oil, cotton and wheat). The authors conclude that in the most recent periods no cointegration exists between crude oil and wheat, likely because wheat prices have been heavily influenced by weather events, as well as because that wheat is not significantly used in ethanol production).

Table 7. Cointegration test with structural break between oil and US commodities

		brent-corn_us		brent-soybeans_us		brent-wheat_us	
		test stat	break date	test stat	break date	test stat	break date
ADF^*	C	-2,67	March 02, 2007-w9	-3,93	Sept 28, 2007-w39	-3,21	June 04, 2004-w23
	C/T	-3,75	Aug 06, 2004-w32	-4,99**	Aug 06, 2004-w32	-3,54	Apr 20, 2007-w16
	C/S	-3,87	Aug 04, 2006-w32	-4,82	July 13, 2007-w28	-3,84	Apr 21, 2006-w17
Z_t^*	C	-4,32	Oct 20, 2006-w43	-3,92	Sept 28, 2007-w39	-2,63	May 21, 2004-w21
	C/T	-4,76	Oct 20, 2006-w43	-4,98*	Aug 20, 2004-w34	-2,89	June 29, 2007-w26
	C/S	-5,01**	Aug 11, 2006-w33	-4,69*	July 13, 2007-w28	-3,13	Aug 11, 2006-w33
Z_α^*	C	-28,07	Nov 17, 2006-w47	-32,92	Sept 28, 2007-w39	-15,54	May 11, 2007-w19
	C/T	-33,73	Nov 17, 2006-w47	-48,21**	Aug 20, 2004-w34	-19,59	May 18, 2007-w20
	C/S	-42,02*	Aug 11, 2006-w33	-44,17*	July 13, 2007-w28	-21,23	Aug 11, 2006-w33

Model C: Level shift, Model C/T: level shift with trend, Model C/S: Regime shift. Null hypothesis: no cointegration. For ADF* and Zt* tests, critical values in Model C are: -5.13 at 1%, -4.61 at 5% and -4.34 at 10%; in Model C/T:-5.45 at 1%, -4.99 at 5% and -4.72 at 10%; in Model C/S: -5.47 at 1%, -4.95 at 5% and -4.68 at 10%. Critical values for Zα* test are -50.07, 40.48, -36.19 respectively at 1, 5 and 10% in Model C; -57.28, -47.96 and –43.22 at 1, 5 and 10% in Model C/T; -57.17, -47.04 and -41.85 at 1, 5 and 10% in Model C/S. The optimal lag length for ADF* test was selected by Akaike information criterion. ***/**/* denote statistical significance at 1%, 5% and 10% level of significance, respectively.

The tests do not support the evidence of cointegration among the brent prices and the Italian commodity prices except the linkage between soybeans and brent tested with Z_t^* and Z_α^* tests model C/S. Even in this case the break date is in July 2007 likely to the American situation (Table 8).

Table 8. Cointegration test with structural break between oil and Italian commodities

brent-corn_it	brent-soybeans_it	brent-wheat_it

		test stat	break date	test stat	break date	test stat	break date
ADF^*	C	-3,15	Oct 01, 2004-w40	-3,46	Aug 03, 2007- w31	-2,96	Oct 01, 2004- w40
	C/T	-3,21	Oct 08, 2004- w41	-4,15	July 27, 2007- w30	-3,02	Oct 01, 2004- w40
	C/S	-3,53	Aug 18, 2006- w34	-4,02	June 22, 2007- w25	-3,54	July 21, 2006 -w30
Z_t^*	C	-3,50	July 23, 2004- w30	-4,16	July 13, 2007- w28	-2,55	June 11, 2004- w24
	C/T	-3,79	Aug 11, 2006- w33	-4,69	July 13, 2007- w28	-2,78	Aug 18, 2006 - w34
	C/S	-3,91	Aug 11, 2006- w33	-5,13**	July 13, 2007- w28	-3,32	Aug 18, 2006- w34
Z_α^*	C	-22,69	July 23, 2004- w30	-32,48	July 13, 2007- w28	-13,76	June 11, 2004- w24
	C/T	-24,45	Aug 11, 2006- w33	-41,08	July 13, 2007- w28	-17,88	Aug 18, 2006- w34
	C/S	-28,63	Aug 11, 2006- w33	-47,44**	July 13, 2007- w28	-22,38	Aug 18, 2006- w34

The results of Gregory-Hansen test reported in Table 9 clearly emphasize the existence of cointegration relationships between Italy and US commodity markets. In the case of wheat and soybeans there is a strong evidence of such relation for all the tests confirming the results obtained in the Johansen test, whereas in the case of corn evidence of cointegration is only supported by ADF* test.

Table 9. Cointegration test with structural break between US and Italian commodities

		corn_it-corn_us		soybeans_it-soybeans_us		wheat_it-wheat_us	
		test stat	break date	test stat	break date	test stat	break date
ADF^*	C	-4.38*	July 11, 2008- w28	-3.91	June 25, 2004- w26	-4.25	Nov 21, 2008- w47
	C/T	-4.78*	May 09, 2008- w19	-4.99**	Aug 08, 2008- w32	-4.77**	May 02, 2003- w18
	C/S	-4.37	June 27, 2008- w26	-4.89**	June 12, 2009- w24	-4.28	July 23, 2004- w32
Z_t^*	C	-4.30	May 09, 2008- w19	-6.08***	July 30, 2004- w31	-5.34***	Dec 05, 2008- w49
	C/T	-4.65	May 09, 2008- w19	-7.20***	Nov 14, 2008- w46	-6.05***	May 09, 2003- w19
	C/S	-4.31	May 09, 2008- w19	-6.34***	Dec 19, 2008- w51	-5.38**	May 02, 2003- w18
Z_α^*	C	-34.95	May 09, 2008- w19	-65.66***	July 30, 2004- w31	-51.74***	Dec 05, 2008- w49
	C/T	-41.21	May 09, 2008- w19	-88.29***	Nov 14, 2008- w46	-65.33***	May 09, 2003- w19
	C/S	-35.11	May 09, 2008- w19	-69.29***	June 12, 2009- w24	-52.15**	July 23, 2004- w32

The next step of the research consists in finding the direction of causality, by testing the dynamic relationship between brent and agri-commodity prices, with linear Granger causality. This test allows to examine whether changes in the price of oil will cause changes in prices of the agricultural commodities. The idea is to make inferences about the direction of information flows among markets. Granger causality is used to test for the presence of exogenous condition that will help to improve the forecast of the endogenous variable (Bessler and Brand, 1981).

The rejection of the null hypothesis allows to assume the causality between two series; this test, as the Johansen cointegration test, is not able to capture the effect of structural breaks and may lead to misleading interpretation of the result. For this reason linear causality tests is performed over the entire sample period, and sub-periods, to analyse whether the dynamic relationship between oil and ag-commodities prices has changed across time.

Table 10 reports Granger-test results. The upper section of the table reports the F-statistic for the null hypothesis that brent prices do not Granger-cause US agricultural commodity prices and *vice versa*; the results suggest that there is no causal linkage between oil and wheat_us in both directions In the case of corn, the analysis shows that there is causal linkage from brent to corn in the whole period of observation but there are bi-directional linkages in the sub-period 2004-2008. Less clear is the case of soybeans: the null hypothesis, that brent does not Granger cause the commodity, is rejected only in the second sub-periods whereas the null that soybeans does not cause brent prices is rejected in the entire period and sub-periods apart from the first sub-period. The middle section reports the results for the Granger Causality analysis between brent and the Italian commodities. A general comment is that there is no linkage between brent prices and the local Italian agri-commodity prices which is consistent with the results found by Zhang and Reed (2008) for the local Chinese grains; the analysis supports the neutrality hypothesis for soybeans and corn (entire period) and an inverse relationship between brent and wheat.

The results are more clear for the agricultural commodities in the two markets reported in the third section of the table. In all three cases the US ag-commodities do Granger-cause the Italian prices in the entire sample period. The most turbulent sub-period highlights a critical situation, since bi-directional causality is observed for soybeans and wheat and a reverse linkage for corn in contrast with our expectations.

Table 10. Linear Granger causality test

	2002w1-2010w52	**2002w1-2004w28**	**2004w29-2008w35**	**2008w36-2010w52**
oil-us_commodities				
brent →corn_us	3.946 **	0.018	2.562 *	0.340
corn_us →brent	0.394	0.952	2.556 *	0.024
brent →soybeans_us	1.994	0.789	3.353 **	0.125
soybeans_us →brent	3.240 **	0.907	5.847 ***	2.670 *
brent →wheat_us	1.725	0.000	0.315	0.761
wheat_us →brent	1.478	0.227	2.064	0.625
oil-it_commodities				
brent →corn_it	1.455	0.116	0.400	2.190
corn_it →brent	1.424	1.167	0.118	3.898 **
brent →soybeans_it	1.049	0.043	0.139	0.440
soybeans_it →brent	1.069	0.249	2.116	0.068
brent →wheat_it	0.320	0.514	1.377	2.109
wheat_it →brent	3.833 **	2.329	1.713	1.663
us-it_commodities				
corn_us →corn_it	6.852 ***	3.499 **	0.003	3.373 ***
corn_it →corn_us	1.561	1.048	3.622 **	2.590 **
soybeans_us →soybeans_it	8.575 ***	3.994 ***	6.378 ***	6.657 ***
soybeans_it →soybeans_us	1.836	1.691	7.496 ***	2.037
wheat_us →wheat_it	16.743 ***	0.821	8.434 ***	15.210 ***
wheat_it →wheat_us	1.909	0.595	3.336**	0.342

→means non Granger causality hypothesis. ***/**/* denote statistical significance at 1%, 5% and 10% level of significance, respectively. The optimal lag length was selected by Akaike information criterion.

Some authors argue that the traditional Granger causality test, designed to detect linear causality, is ineffective when nonlinear causal components are present and recommend to use nonlinear causality tests (Baek and Brock,1992; Hiemstra and Jones, 1994).

Assuming that linear causality tests might overlook nonlinear dynamic relations between brent and ag-commodities (Nazlioglu, 2011), we used the nonparametric causality test proposed by Diks and Panchenko (2006, hereafter DP) which avoids the over-rejection observed in the test proposed by Hiemstra and Jones. The DP test detects nonlinear causal relationships with high power, but does not provide any guidance regarding the source of nonlinear dependence.

The DP analysis is carried out in two steps: first applied to stationary series, and then, to remove any linear dependence, the test is applied to the estimated residual series from the VAR model with the pair of variables of interest. "By removing linear predictive power with a linear VAR model, any remaining incremental predictive power of one residual series for another can be consider non linear predictive power" (Hiemstra and Jones, 1994). The tests are performed for different lag values. Following Diks and Panchenko, the data are also normalized to unit variance before the test is applied and the bandwidth, which value plays an important role on the existence of non linear causality, is set to 1, as it is one time the standard deviation. The embedding dimension which corresponds to the maximum lag to which the causality test is carried out, is set to two. Causality tests on sample subperiods are not performed in this case because nonparametric tests rely on asymptotic theory.

Table 11 reports the T values for DP test statistic applied to the variables and to their residuals in both directions and for different lag lengths (1–2 lags).

Table 11. Nonlinear Granger causality test (Diks –Panchenko test)

		Raw data		Residuals	
	lags	**1**	**2**	**1**	**2**
oil-us_commodities	brent →corn_us	1.513 *	1.999 **	1.337 *	1.771 **
	corn_us →brent	0.323	1.186	-0.076	0.488
	brent →soybeans_us	0.481	0.996	1.341 *	0.150
	soybeans_us →brent	0.360	1.550 *	0.225	0.080
	brent →wheat_us	0.859	2.013 **	0.939	1.046
	wheat_us →brent	1.585 *	0.698	0.737	1.623 *
oil-it_commodities	brent →corn_it	1.491 *	0.844	1.133	1.238
	corn_it →brent	0.765	0.435	0.674	0.732
	brent→soybeans_it	0.546	0.633	1.702 **	1.166
	soybeans_it →brent	0.446	1.670 **	0.360	1.284 *
	brent →wheat_it	2.627 ***	2.473 ***	1.133	1.238
	wheat_it →brent	1.061	1.724 **	0.674	0.732
us-it commodities	corn_us →corn_it	3.574 ***	3.596 ***	3.585 ***	3.578 ***
	corn_it →corn_us	2.682 ***	2.716 ***	3.076 ***	3.079 ***
	soybeans_us →soybeans_it	2.704 ***	2.697 ***	3.081 ***	3.065 ***
	soybeans_it →soybeans_us	2.011 **	1.983 **	1.746 **	1.732 **
	wheat_us →wheat_it	2.547 ***	2.537***	2.252 **	2.221 **
	wheat_it →wheat_us	1.613 *	1.596 *	2.236 **	2.202 **

→means non Granger causality hypothesis. ***/**/* denote statistical significance at 1%, 5% and 10% level of significance, respectively.

The results of the non linear Granger causality test between *oil* and *us_corn* show that there is evidence of unidirectional causality for raw data confirmed after filtering the series with VAR model. Brent prices seem to transmit volatility to corn when using a non linear causality; these findings are consistent with the results obtained by Nazlioglu. The main reason for this is the growing importance of fuel ethanol as a percentage of total demand for US corn. With the current large size of the ethanol industry, corn prices have become closely related to crude petroleum prices because corn is now a major energy crop. With rapid growth of the ethanol industry in the last few years, corn has become very much an energy crop as well as the world's most important source of feed grains for production of livestock, poultry, and dairy products.

In the case of *brent* and *us_soybeans*, the non linear causal test on raw data shows an inverse relationship between the pair of variables of interest as found in the linear Granger causality test (Table 10). After removing any linear dependence, the results of the VAR residuals, at lag one, support the existence of a close nonlinear price transmission from the brent to the soybeans prices which does not persist over the long run. Even in this case, then, the crude oil market has a strong influence on the agri-commodity prices, since it influences biofuel market, and soybeans are still the dominant feedstock for biodiesel.

For the causality between *brent* and *us_wheat*, the nonparametric results suggest the presence of bi-directional relationship between the variables (raw data). Further investigation with the VAR residuals indicates that the causal relationship goes from wheat to oil. These unexpected results partly correspond to those reported in Table 7 and table 10 related to cointegration and linear causal linkage between oil and wheat. These findings suggest a different behaviour of the wheat compared to corn and soybeans justified by the larger use in industry and food.

The second section of table 11 reports the results for the nonlinear causality analysis between *brent* and the *Italian commodities*. In general there is no linkage between brent and agri-commodity prices. In the case of corn_it and wheat_it, the non parametric results after removing the linear dependence support the neutrality hypothesis; with respect to the non linear causal linkages between brent and soybeans_it prices, results denote a fluctuating relationship.

Finally the last section of the table suggests the non linear causality between the US and the Italian commodity prices. Raw data provide a feed-back evidence in the relationship between the variables prices and the same findings are presented after filtering the series. Such misleading results could be explained with the fact that there is a one way strictly *linear causality* among the examined variables (Table 10), whereas a unidirectional non linear causality from the American to the Italian commodity prices does not appear.

4. CONCLUSION

The main goal of this work was to investigate about the volatility and transmission of crude oil prices to agricultural commodity markets. To give empirical evidence to this hypothesis the time series analysis was performed and cointegration and causality nexus were explored using linear and non linear Granger causality approaches. The results of the linear Granger causality analysis suggest to accept the presence of neutrality hypothesis in the US markets which means that the prices of oil and the agricultural commodities do not cause each other in a strictly linear sense, especially for wheat. Same results are evident in the Italian market. In Italy the prices are co-integrated with US corresponding prices of agri-commodities and there is also evidence of linear unidirectional Granger causality from US to Italian market.

In Italy co-integration and causality among commodities suggest that the volatility is transmitted from global to local agri-commodity prices and the local agricultural commodity prices do not respond to the world oil prices. These results are confirmed by the Law of One Prices. Diks Panchenko test provide clear evidence of the *strong non linear relationship* between oil and corn, which is indicative of the growing use of corn for ethanol. The crude oil is also a *leading indicator* for soybeans, it is exogenous to the formation of its prices and able to affect their realization. The brent volatility contributes to destabilize the prices of corn and soybeans because of their energy and industrial use. The case of wheat prices is completely different: the world has consumed more wheat than has been produced in six of the last seven years. The resulting drawdown in wheat stocks is largely responsible for the large increase in wheat prices. This perception of food insecurity, due to the diminishing supply of food, has brought wheat prices to surge upwards dramatically for the financial speculation prevailing on market fundamentals. In conclusion, the agricultural commodity prices are becoming more unstable because influenced by the movement of the oil prices that affect the agricultural input prices directly and indirectly (through the price of fuel and fertiliser). Higher volatility of oil prices procure higher instability in agricultural price commodities. Volatility becomes an issue for policy analysis when it induces risk averse behaviour that could lead to inefficient investment decisions and creates problems of decoding information about planting that are beyond the capacity of producers, consumers or nations to cope with. To be more effective the market policies need to stabilize the prices and to better information about the agri-food supply chain, producers, consumers and traders to avoid that biased information would cause market inefficiency. It is necessary to focus on the policy options designed to prevent or reduce price volatility and mitigate its consequences: some would help to avert a threat, others are in the nature of contingency plans to improve readiness, while still others address long-term issues of resilience.

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