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The Relationship of U.S. Agricultural Commodities with Oil and Ethanol Prices

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Table of contents

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Abstract

The impact of the oil and ethanol price changes on the agricultural market in the past decades has been largely examined by researchers. However, it is of great interest to consider what happened during the recent financial crisis which affected hugely the global economy. The oil sector appears to have played a role in the subprime crisis and the question is whether its shocks were transferred to the already instable agricultural sector. The purpose of this paper is not only to identify possible interconnections between the two markets but it is also an effort of trying to indicate the specific impact that fuels have in agriculture. Hence, besides the empirical results derived through time-series analysis and Granger Causality we perform the Impulse Response in order to consider a possible structure of the impact. The results indicate that there is a correlation between the sectors but the most interesting thing is that the oil price changes seem to have a negative effect on the agricultural commodities and a lot of discussion could be held in terms of interpretation.

Key Words: ethanol, crude oil, wheat, corn, soybean, time-series analysis, causality, impulse response.

Introduction

During the period of financial crisis and the upcoming years, we observed a variety of occurrences regarding the agricultural sector in the U.S. The extreme volatility and the higher averages of the prices from 2008 until the first months of 2014 are of great interest. It is also important that the oil market experienced intense price hikes and most economists believe that movements in the energy sector have impact on other commodities as well.

Early 2014 reports from Morgan Stanley state that besides the hefty crops of soybean and corn in the U.S., South America is very likely to produce a record harvest until the end of 2014. Brazil might find itself pegging with the US in production and this might have a major effect in the US prices. China which is a very important market for the US grains, might cancel future imports, according to researchers and it seems that the future of the US food commodities export is uncertain. The high energy prices affect transportation costs and make things really complex. Since the situation becomes very crucial, this paper is an endeavor to specify the interconnections that oil and ethanol prices may have with the three most popular agricultural commodities of the US; corn, soybean and wheat. Moreover, we try to explain the causal structure of a possible impact.

Ethanol is a fuel launched in the 1980s mainly for transportation usage. The main concept is to blend it with gasoline (at concentrations of 5-10%), in order to increase the level of its octane. In California it has completely replaced MTBE (methyl tertiary butyl ether), as a gasoline constituent. The main source for ethanol production is corn, while soybean could be used as alternative raw material. Ethanol was introduced as an eco-friendly fuel that would help us restrict greenhouse gas emissions produced by transportation. Thus, its production increased heavily in the past 10 years, leading to 13 billion gallons of ethanol fuel produced in 2013, according to *YES! Magazine.* However, in April of 2014 the United Nations Intergovernmental Panel on Climate Change published two working group reports that strongly argue the supposed environmental benefits of ethanol. A third report is even more categorical, stating that biofuel crops might even hurt biodiversity and ecosystems. The completely non-diplomatic report claims that there are no CO2 benefits at all from using biofuels instead of petroleum fuels. Finally it refers to the conflicts between acreage for fuels and acreage for food, as another negative impact of ethanol. Today, more than sixty nations have biofuel mandates. The high demand for ethanol in the previous years pushed the prices of corn, creating moral issues as the poor cannot afford to pay for it.

Back in the year of 2000 a high majority of 90% of corn production was used as food for people or livestock, while only 5% was used for biofuel production. In 2013 only 15% was used to feed people, as a percentage of 40% was used as a raw material to produce ethanol. In 2014 the predicted percentage of corn bushels intended for ethanol was even greater. However despite the fact that the US year's mandate was 16.5 billion ethanol gallons, Washington proposed to produce only 15.2. The initial plan was to produce 18.2. It is the first time that the mandates are cut, since 2005 when the RFS (Renewable Fuel Standard) was introduced. Despite the complaints by ethanol producers it seems that in the near future the mandates will be scrapped entirely. On the other side the demand for natural gas peaked in 2008, in contrast with the forecasts that expected the demand to continue its upward trend. This fact allows for lower use of gasoline. As regards ethanol it is expected that its production will be based on alternative sources such as cellulosics in the future. This means that it is very likely that the linkages of corn with ethanol might finally come to an end. Apparently this paper might be one of the last that examine the interconnections of ethanol as a fuel with the agricultural grains. It would make more sense in future studies to examine the impact of other fuels such as natural gas for possible impact on agri-commodities prices. However at that point it is necessary to state the effect of ethanol along the one of crude oil. Hence the objective of the analysis is to identify and interpret the connections of oil and biofuels with the food commodities, through econometric analysis.

Literature Review

The factors that instigate commodity prices over time, have long been studied by agricultural economists. It seems that in the past years they were mainly interested in the effects of the exchange rate policy on agricultural markets. In 1974 Schuh believed that the value of dollar, which has a serious impact on the agri-commodity prices, is not significantly affected by the US macro policy changes. Once the "overshooting hypothesis" was introduced, the issue of the agricultural commodity prices was highlighted by Frankel (1986) and Saghaian, Reed and Marchant (2002), as a result of the concern that the variability of farm prices could be affected by agricultural overshooting.(Despite the fact that in the past the attention of agricultural economists was mainly paid to the effect of monetary and exchange rates changes, it is important that in a modern approach we could never ignore the possible relationship among the energy and the food commodity sector.)

The main concept is that the uncertainty of the energy markets could be transferred to the already volatile markets. The agricultural commodity prices rose dramatically by 40% in 2007, according to reports from the United Nations Food & Agriculture Organisation. The prices continued the upward trend in 2008 as Rosengrant proved. In 2008 as well, Taheripour and Tyner delivered evidence that the main reason of the positive shocks of corn prices is a result of the price hikes of oil. Saghaian (2010) proved correlation of oil and ethanol prices with food commodities but he was reluctant to consider specific causal structures as he considered the results very mixed. Nazalioglu and Soytas (2011) studied interconnections between oil and 24 agricultural products, bearing in mind the value of dollar. They indicated that there is strong evidence of impact of oil prices on agricultural commodities, while a weak dollar affects positively the prices of the food commodities. Ghaith and Awad (2011) assumed unidirectional causality among some agricultural commodities and the prices of crude oil. Saban Nazalioglu (2011) investigated the nature of the causality between oil and food commodities. He argued that oil and agricultural prices influence each other in a linear way but delivered evidence of nonlinear causal linkages. Moreover, Kong, Hhan and Nayga (2012) examined the transmission of volatility from oil shocks on agricultural commodity prices. A short-run relationship among energy and grain markets means that 2012 co-movements of crude oil and grains could be considered a temporary phenomenon. On the other hand they proved that the volatility of energy markets affects the volatility of soybean and corn. During the financial crisis the things became very complex. Munier (2012) analysed the uncertainty and the volatility of Agricultural commodity prices in the crisis years. In a recent paper Grosche and Heckelei (2014) scrutinised the direction of the volatility spillovers among agricultural commodity prices, crude oil prices and other financial markets, because they believed that including food commodities in portfolios may lead to linkages with other markets during crises. Despite the fact that they indicated volatility spillovers from equity and real estate to commodities, they pointed out no linkages among crude oil and agricultural products during the financial crisis.

The main reason that linkages between energy markets and agricultural commodities are examined is due to the fact that the shocks in oil and its products affect transportation costs and, as a result, import and export of agricultural products are influenced. Braun and Torero (2009) looked into the 2007-2008 commodity price spike and they investigated trade policy matters such as the fall of import barriers and the rise of the export ones respectively. Taylor and Koo (2010) dealt with the levels of export of soybean in the modern world. According to their study, China is the world's leader in imports as it absorbs 60% of the world's soybean produced and it is forecasted to import 65% by 2019. U.S., Argentina and Brazil are the major exporters but the Latin American countries are expected to increase their production even more. Furthermore, Saghaian S. , Reed and Saghaian Y. (2014) examined the levels of export of grains from US to developed counties and found that China has the most elastic demand compared to Japan and EU.

Baffes (2007) proved that between non-energy commodities, the agricultural ones and the fertilisers are those mainly affected by oil price changes. Moreover, von Braun et al. (2008) found that the cost of transportation has been increased by the rise of oil prices and this led to more costly agricultural inputs (fertilisers, pesticides). Hence the production is more expensive. Zalewski (2011) examined global markets of mineral fertilisers bearing in mind the price changes in raw materials and direct energy carriers.

A very important factor to take into account, when we look into the linkages of agricultural markets and the energy sector, is the issue of the biofuels. Conley and George (2008) consider that the growing biofuel industry and the high demand for corn has no significant impact on grain farmers and agribusiness generally. In their conclusion they state that possible changes in the macro policy as regards ethanol would not only cause implications on US corn but they might also affect other grains such as soybean and wheat. Brown, Bekkerman, Arwood and Watts (2012) stated that the high prices of corn in 2000 ,which were followed by other grains as well, were mainly a result of the growing demand for ethanol. Due to the fact that it was believed that ethanol is eco-friendly, the U.S. Congress encouraged ethanol production. This study tried to model the effects of the simultaneous policy changes. McPhail and Du (2012) stated that the linkages among energy and food commodity prices are strengthened by ethanol. They considered biofuels to be the main reason of the correlation between oil and agriculture since 2008 when the demand for ethanol rose dramatically. In the most recent research, Akinfenwa (2014) uses a bivariate econometric approach to examine linkages among ethanol and rural income. He pointed out that the causality between these two sectors diminished in the long run.

Guo et al (2011) scrutinised the relationship of crude oil price trends, agricultural commodities and biofuels policy in developing countries. The results indicated a relationship and Guo stated that the developing countries should have their own policies for biofuels taking into account what happened with the developed countries. This is a very important matter in our times because scientists no longer believe that ethanol is eco-friendly and the majority of corn harvest every year should be used to feed people.

Econometric Model Development and Empirical Results

Emperical Framework

The majority of agricultural economists rely on the common supply/demand approach in order to prognosticate for the future prices of food commodities and such approaches are very common in the literature. Actually, this is very reasonable, since production and consumption are highly linked with the economic variables, according to strong conceptual foundations. Professionals have always valued these foundations which have been used for several decades. However, despite recent efforts, the economic analysis hasn't yet concluded the specific impact of movements of the energy commodities upon the prices of the agricultural ones.

Such an impact refers to the macroeconomic factors that affect the food commodities. Trying to isolate the relationship between individual commodity prices and macroeconomic variables is really challenging and it demands elimination of the simultaneous supply/demand linkages between the commodities. When trying to examine a period of 6 years, as we do in this paper, it is appropriate to collect daily data. Although daily prices of commodities allow for more accurate analysis, they make it difficult to isolate specific effects of ethanol policy changes or oil price variation from other factors such as crop/storage estimates and weather fears. However modern econometrics allows to use lag intervals that can help us isolate macroeconomic effects, as long as we do not hurt our model.

In the past several people tried to analyse the macroeconomic factor that affect commodities, empirically. Through the years and thanks to the help of Crane & Nourzad (1998) and Scmidt (2000) the theoretical approaches progressed based on econometric techniques (VAR, VECM) that help us explain stationarity and long-run relationships in a more efficient manner. Moreover, the advanced techniques that we use provide the results as predicted future movements of the commodities, based on examination of the past six-year prices.

Through this endeavor we initially rely on the existing approach by Saghaian, Hasan and Reed (2008). We take into account daily prices of 5 variables: soybean, corn and wheat prices bushel along with crude oil prices per barrel and ethanol prices per gallon. As regards ethanol it was extremely difficult to collect the physical data and we used ethanol futures. However, this is of minor interest since it does not affect significantly our analysis. We continue following the Robertson and Orden (1990) approach of cointegration and specifically we use the Johansen and Juselius (1992) estimation methodology. Before we do so, it is essential to test for the stationarity of our variables and we use the augmented Dickey-Fuller test which has been commonly used in the literature. Once stationarity is achieved we are allowed to use the cointegration test that indicates whether there is a possible long-run relationship between our five variables. The next step is a vector error correction model and we conduct hypothesis testing over this concept. Finally what follows is a Pairwise Granger Causality test that helps us examine the causal structure between our variables and an Impulse

Response function to indicate the specific effects that fuels have on the agriculture products.

Stationarity Testing

Daily time series data are collected from 3/31/2008-3/31/2014 for the variables. Wheat prices come from the HRW(Hard Red Winter Wheat, Kansas city) , corn prices come from Yellow Chicago and soybean from Yellow central Illinois. All provided by USDA Economic Research Service. Crude oil prices are taken from the West Texas Intermediate while for ethanol we use CBOT future which is very similar to the spot prices.

Table 1 provides the descriptive statistics of our data.

Table 1. Descriptive Statistics of our variables

	Oil	Wheat	Soybean	Ethanol	Corn
Mean	88.09456	6.71249	12.39061	2.145991	5.52874
Maximum	145.66	10.78	17.9	3.459	8.644
Minimum	30.81	4.05	7.595	1.398	2.8725
Std. Dev.	19.3744	1.392382	2.227976	0.400362	1.528552

Correlation Matrix

When we are about to examine cointegration between a number of variables, it is always interesting to have a look at the correlation matrix first. Hence table 2 helps us to grasp an idea about the degree of correlation between our data. Looking at the table, we observe a very high correlation of 87% between ethanol and corn. Bearing in mind what we have already mentioned as regards the corn being the main source in US for the production of ethanol, the 87% correlation degree makes absolute sense. The table also indicates high correlation between the agricultural commodities, especially between corn and soybean where they seem to be correlated at 86% level. We might also have expected an even higher than 68% correlation value between the two fuels but during the financial crisis the factors that affected them were mixed.

Before we go on with the stationarity tests we present the graphs of our data.

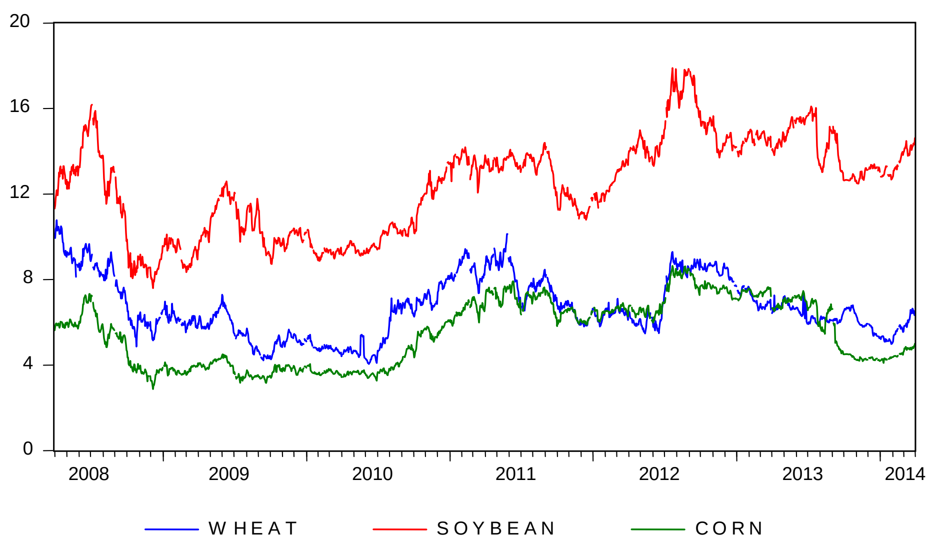

Figure 1. Grain trends 2008-2014

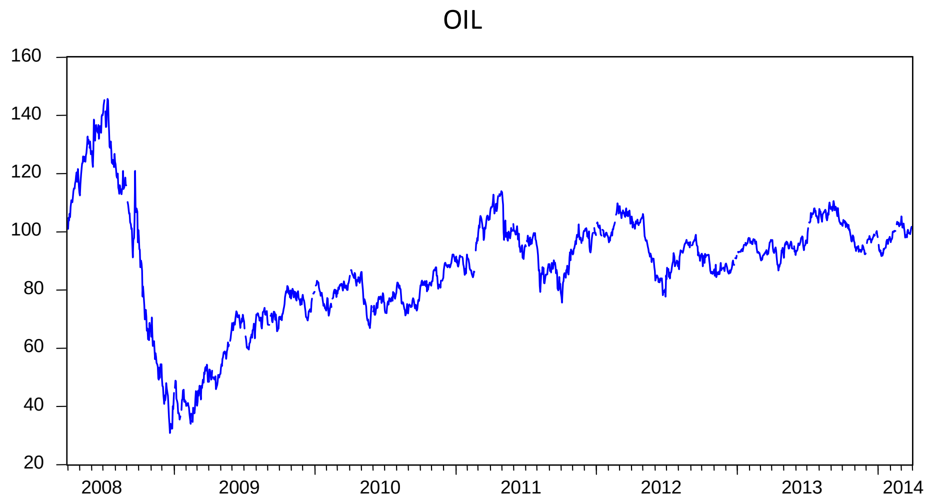

Figure 2. WTI crude oil trends 2008-2014

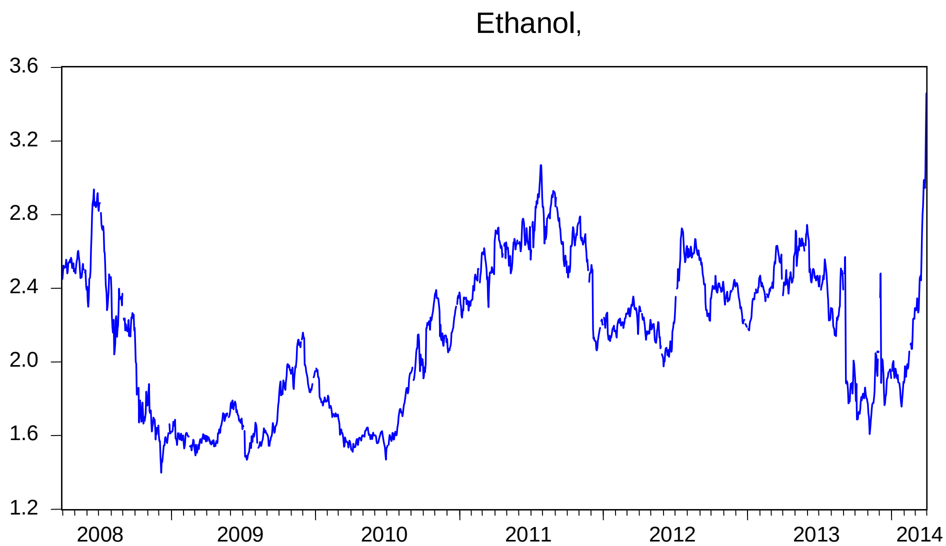

Figure 3. Ethanol trends in 2008-2014

The variables are presented in different tables because of the units of measurement of each commodity. In this way it is easier to compare their movements with each other. Overall we cannot say that there is a specific long-term trend in any of the commodities. As regards the ethanol graph we can see it rise dramatically from the beginning of 2014 and this could be a response to the change in policies from Washington. The grains seem to follow parallel movements and this could possibly mean that they are affected by the same factors in a degree.

It is essential to test for stationarity before we go on with the process and we will use the most favoured augmented Dickey-Fuller test (ADF) even though it has been highly criticised. The basic concept of the intuition of the test is that the series' lagged level won't provide relevant information in order to predict the changes, in case the series are not integrated. In practice, when we test for ADF we run a regression of the series' first difference against the one lagged period and a constant. For all our tests we imposed an intercept but not a trend. At first we performed the test for the variables in ''Level'', allowing for 23 lags and we were based on the SIC (Schwarz Info Criterion) which chose zero lag length. The same applies when we use AIC (Akaike Info Criterion). Only when we allowed for only 2 lags SIC chose one lag. What matters the most is that in any case we failed to reject the null hypothesis that our variables have a unit root which means that all of our commodities are non-stationary in ''Level''. What applies next is to check whether our variables are stationary in first differences. Hence, we performed the test in first differences using different values of allowed

Table 2. Correlation Matrix of the five commodities

	Oil	Wheat	Soybean	Ethanol	Corn
Oil	1				
Wheat	0.501054	1			
Soybean	0.647026	0.62331	1		
Ethanol	0.679552	0.720108	0.7563	1	
Corn	0.582198	0.735454	0.857694	0.872455	1

lags with AIK and SIC as well. At the end, all commodities seem to be stationary in first differences since we were able to reject the null hypothesis that they have a unit root.

In order to specify whether we reject or not the null hypothesis we can follow two approaches. In the first case we look at the probability value of the variable. If the value is lower than 5%, we reject the null hypothesis and our results are stationary. The other approach is to check if the t-values are greater than the critical ones in absolute values. In our case we check if the t-values are more negative than the critical in 1%, 5% and 10% level and it happened that for all commodities the t-values were more negative even from 1% critical value.

Table 3 summarises all the results of our tests. The first column contains the t-values when we performed the test in ''Level'' while the second presents their first-differences values. We can clearly see that the t-statistic of our variables rose dramatically in absolute values when we switched into first differences, allowing us to reject the null hypothesis and conclude all of our series are stationary.

Table 3. Results of the ADF test

Variables	Results for Level	Results for First Differences
Corn	-1.3	-36.2
Soybean	-1.6	-37.16
Wheat	-2.5	-40.9
Oil	-1.05	-17.07
Ethanol	-1.2	-36.4

Table 4. Results of the Johansen cointegration test

Hypothesised No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None*	0.05	39.47	34.8	0.013
At most 1	0.015	11.82	28.58	0.96
At most 2	0.01	7.73	22.3	0.96
At most 3	0.002	1.53	15.9	0.99
At most 4	0.0001	0.12	9.16	1

Johansen's Cointegration Tests

In most cases, if two variables that are I(1) are linearly combined, then the combination will also be I(1). More generally, if variables with differing orders of integration are combined, the combination will have an order of integration equal to the larger, according to Brooks. The basic concept behind cointegration is that if a group of two or more series shares a common stochastic drift, this implies that the series are cointegrated.

In order to test for cointegration we use the Johansen test which we prefer compared to the Engle-Granger test, since it allows for more than one cointegration relationships.

We initially ran the Johansen test for only 2 lags and both Trace Statistic and MAX-Eigen indicate that there is no cointegration equation among the 5 commodities. However things change as we use greater number of lags. More specifically for 14 lags Maximum Eigenvalue denotes rejection of the hypothesis of *None* cointegration equation at 5% level of significance and indicates 1 cointegration equation. For 30 lags the trace statistic indicates 1 cointegration equation while the Maximum Eigenvalue assumes 2. If the number of lags increases more, then the test provides even more than 4 cointegration equation. Before we try to interpret these results it is important to mention that when we try to specify a relationship between the agricultural products and the energy sector, it is difficult to isolate the impact of a fuel commodity on them if we use daily data. This is because agri-commodities are affected by factors such as weather and supply/demand. It is possible that monthly data could be more appropriate for detection of relationships and that may explain why increasing the lags leads to increased number of equations, but daily prices allow us to be more accurate about our results. It is interesting to mention that the more lags we use, the more we hurt the integrity of our model. Hence, we will go on with the results of the test with the 14 lags used and we will assume that we have 1 cointegration equation between the five commodities as Max-Eigen indicates. At that point, it is of interest to compare Max-Eigen and Trace and according to Lutkepohl, Saikkonen and Trenkler 2000 paper that contrasts them, the only case that we prefer Trace over Max-Eigen is when we run a small sample simulation which doesn't apply in our case.

In the Johansen test we compare the t-value with the 5% critical. If the first exceeds the other, this means that we reject the respective hypothesis of no. of cointegrated equations.

In table 4 we have presented the results of the Johansen test and we can clearly see that the t-value for "None" equation is rejected. This could also be indicated by the p-value which is less than 5%. We finally conclude that there exists a stationary linear combination between the agricultural and the energy commodities.

Vector Error Correction Model

Since the Johansen test indicates cointegration between the variables and the series are stationary, we must use a Vector Error Correction approach rather than the VaR method. In VEC the first difference of each variable is represented as a function of its own lagged values, the lagged values of the other variables and the cointegration equations. When we run the VEC model we assume one cointegration equation and the system decided to use two lags for each variable. All of our variables are automatically transformed into first differences by the system since they are only stationary in this way. What we aim to do in simple words is try to find whether the lagged values of the variables are significant to explain the variables themselves. Such an issue is always a bit difficult to specify clearly. However, when we examine the test and there is a p-value that also happens to be less than 5%, then we can assume that our hypothesis is true.

Since we have 5 variables and we include a constant as well, bearing in mind the two lags and the one cointegration equation we will finally have 5 models that each one of them will include 12 coefficients. We implicitly assume that the number of the p-values to be examined for significance will be 60 overall. In order to check for the significance of the probability values, we initially estimated all five models. Of all of our five models and the 60 coefficients, only 12 seemed to be significant. More specifically 2 variables were significant for wheat, 1 for soybean and 3 for oil, ethanol and corn. This means we can assume that maybe each one of oil, ethanol and corn can be somehow explained by the other 4 commodities. Empirically what makes more sense at that point is the case of corn which happens to be highly correlated with ethanol and maybe impacted by the shocks in energy markets.

Granger Causality

In order to be more accurate about the effects of each one of the variables upon all the other four commodities, we will use the Pairwise Granger Causality test. This will help us to ‘’investigate Granger causal directions among the variables’’. When we initially run the test for 2 lags we obtain peculiar results that indicate a supposed effect of the agricultural commodities on the energy sector which makes no sense. At this point it is important to mention that even Granger himself has stated that his test might produce ridiculous results some times since it is a concept based on prediction and it is not always appropriate to predict the future. However the interesting thing is that when we switch to 25 lags the results are different and close to our initial suspicion that the fuel commodities price changes might affect the agricultural ones in a way. For once more we state that a higher number of imposed lags could fit better to reality, since we expect the oil shocks to need some time until they are transferred to the agricultural markets.

More specifically, testing for Granger Causality, we observed that the causal direction runs mainly from oil prices to the food commodities, since we mostly rejected the hypothesis that oil prices do not Granger cause the agricultural products with soybean being the one that seems to be the most affected. Moreover, the test suggests that the soybean and especially corn instigate the ethanol prices, which was anticipated, while oil has an impact upon it as well in a relationship which is bidirectional. Finally the test indicates some minor relationship between the agricultural products as corn seems to cause soybean and soybean wheat, respectively. The outcome of the test which denotes that oil causes the food commodities in a degree is important but we do have to mention that the fact that one variable Granger causes another mainly means that it might have some information that could explain the future of the caused variable.

We provide our results in Table 5 summarised all together with the F-Statistic values and the probabilities of every one of the twenty hypotheses of the Pairwise Granger Causality test. Furthermore, we present a memorandum that specifies the significance level of every hypothesis' rejection.

Impulse Response

So far we have observed that there is a certain correlation between the energy and the agri-commodities during the years of the financial crisis. Besides that, we

Table 5. Pairwise Granger Causality test Results

Null Hypothesis	F-Statistic	Prob.
Corn does not Granger cause Ethanol	1.67	0.0229**
Ethanol does not Granger cause Corn	0.72	0.8336
Soybean does not Granger cause Ethanol	1.6	0.0349**
Ethanol does not Granger cause Soybean	0.83	0.7028
Wheat does not Granger cause Ethanol	0.6	0.9351
Ethanol does not Granger cause Wheat	1.01	0.4474
Oil does not Granger cause Ethanol	1.58	0.0399**
Ethanol does not Granger cause Oil	1.49	0.0637*
Soybean does not Granger cause Corn	0.74	0.8178
Corn does not Granger cause Soybean	1.54	0.0483**
Wheat does not Granger cause Corn	1	0.4553
Corn does not Granger cause Wheat	1.06	0.3903
Oil does not Granger cause Corn	1.14	0.2880
Corn does not Granger cause Oil	1.06	0.3895
Wheat does not Granger cause Soybean	0.83	0.7040
Soybean does not Granger cause Wheat	1.42	0.0877*
Oil does not Granger cause Soybean	1.92	0.0057***
Soybean does not Granger cause Oil	0.81	0.7246
Oil does not Granger cause Wheat	1.54	0.0497**
Wheat does not Granger cause Oil	1.09	0.3429

* 10% significance level, **5% significance level, ***1% significance level

presented the specific pairs and the directions of the impacts. However, what is the most challenging issue is to try to identify the nature of the impact and a potential effort to interpret the supposed results. Within this effort we will use the Impulse Response function which provides the reaction of a dynamic series in response to some external change. More specifically, in contemporary macroeconomic modeling, we can examine the particular effect in the movements of one variable, as a reaction to the shocks of another. The results pose as prediction for the movements of the supposedly affected variable. Furthermore, the recently introduced asymmetric impulse response can help us even diversify the positive from the negative impulses.

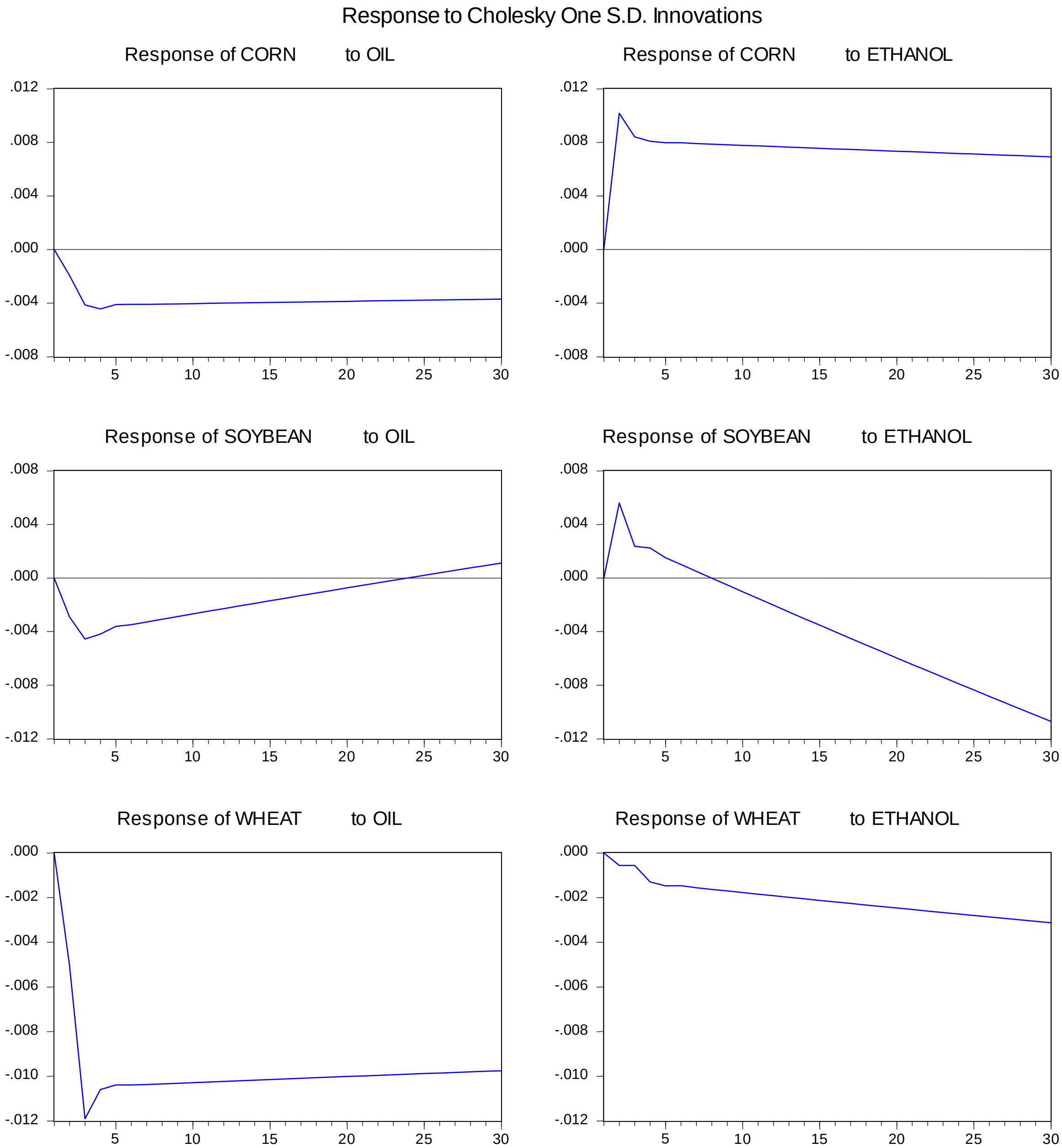

Figure 4. Impulse Response of grains to fuels for 30 future days

Bearing in mind all these, we use the impulse response function to examine the response of the agricultural products according to the movements of the oil and the ethanol prices, as we have conjectured so far that the socks of the latter are transferred to the agricultural market. We used the Cholesky dof-adjusted method and we examined the future movements in a period of 30 days. The results we found are provided below and they are very intriguing, especially in terms of interpretation.

In the six tables above, we can see the response of each one of our three food commodities to the oil and the ethanol, provided in multiple graphs. Before we explain the outcome of the test, we have to mention that the black horizontal line in the graphs refers to zero, while the blue line refers to the reaction of the food commodities for a lasting period of 30 future days. The main concept behind these graphs is to indicate the nature of the commodities reaction, if we give a positive shock of one standard deviation to the fuels.

As we can observe, the energy markets seem to have a negative effect upon the food commodities in most of the cases, which is very interesting. More specifically, as far as the impact of oil is concerned, corn experiences a drop in the first 3 days and then remains stable to -0.04. Soybean, despite an initial drop, similar to that of corn, rises gradually in the next days and from day 24 reacts positively in response to oil. Finally, wheat descends dramatically to -0.12 in the first 3 days and then remains stable at -0.1. Now, as regards the effect of ethanol, the test indicates a positive impact upon corn, which rises to 0.08 in the first two days and then remains stable to that point. However, the connection of corn with ethanol is an obstacle in the clarification of the use of the latter as a fuel for transport. Soybean which is also linked with the production of ethanol, rises initially to 0.05 but then starts to descend gradually to -0.1. From day 10, ethanol has a negative impact upon it. In the last graph, wheat descends progressively to -0.02 indicating a negative affect once more.

In the literature, agricultural economists mainly refer to a supposed positive impact of the energy sector to the agricultural market among mixed conclusions. This is contradictory to the outcome of our Impulse response test but before we try to explain some possible reasons of such results it is crucial to mention that we examine the period of the financial crisis which changed the global economy dramatically. For instance, when Saghaian in 2010 assumed tentatively a positive impact of oil prices to corn, wheat and soybean, he examined data from 1996 to 2008. According to an article in the FT by Javier Blas, the high oil prices of the recent years might be bad for global economy. He stated that particularly in agricultural commodities, supply-side factors are playing a crucial role. The high oil prices can be somehow linked to these supply/demand factors. Due to their rise, the export of agricultural products from US can be limited and that could lead to lower demand while the supply remains stable. Apparently this would make the agricultural product prices fall and could be an empirical explanation about our results. However the results are mixed and the period we examine is instable and thus it is very difficult to be accurate. Moreover the negative effect does never exceed 1.2% in any case which means that any impact of oil upon the food commodities in the future would not be that critical.

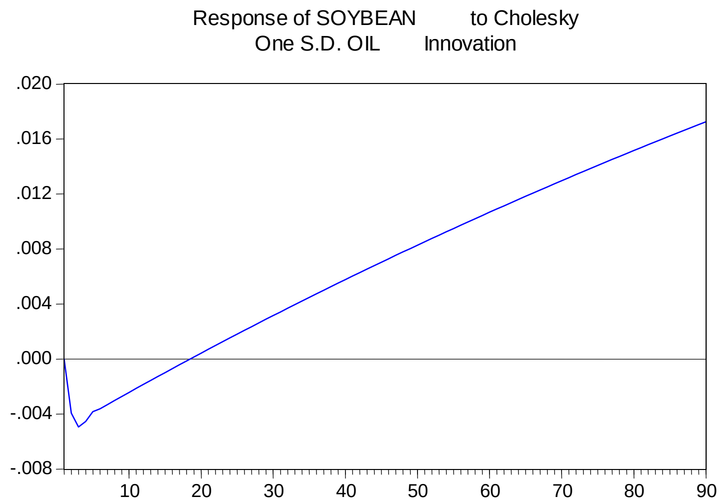

Figure 5. Impulse Response of Soybean to Oil for 90 future days

After all, soybean seems to react positively to the rise of oil prices and when we examined the test for more than 30 days, the commodity, seemed to follow an upward trend until it reached 1.6% of positive effect, as seen in the graph above. However, it is very risky to predict for 90 days, as we do in the graph above.

Conclusion

If we take a look at the existing literature on agricultural economics, we will clearly understand how important it is to consider macroeconomic factors in the determination of food commodity prices. Such factors include the energy sector impacts. Bearing in mind the recent financial crisis and the extreme volatility of oil prices, it is very likely that macroeconomics play a critical role in farm income and prices. Old-fashion approaches considered that agricultural prices were affected exclusively by microeconomic factors such as supply/demand. In modern economics, it is unacceptable to ignore macro-analysis which indicates short and long-run impacts that may lead to instable farm income.

The results of our analysis prove that there is an indisputable relationship between the energy and the agricultural sector. Johansen and Juselius' test assumes cointegration, while VECM suggest that the energy prices carry some information that could somehow explain future movements of the grains. Moreover, using Pairwise Granger causality, we delivered evidence that oil prices Granger cause wheat and soybean prices. This means that in the years of the financial crisis, it might be possible that the instability in the oil prices was transferred to the agri-markets. Going the extra mile, trying to specify the exact effect of oil on grains we used the Impulse response function. The results indicated a negative effect of oil to the agricultural commodities which is truly interesting. However, the low level impact could not be considered very significant and we are reluctant to assume that there is clear evidence of negative effect, especially since soybean is predicted to react positively in a longer future period. Nevertheless, there are facts that could lead us assume that the results of a negative impact might make some sense.

In University of Illinois, they believe that China might cancel a serious amount of expected purchases of grains from U.S. due to South America's growing production and the current bird-flu problem that may worsen during the year. Very high prices of exported grains were stated in 2012-2013 and the oil prices that rose consistently since 2009 are supposed to be a possible reason, since they lead to costly transportation. Hence a possible cancellation of export sales and larger US and South America crop estimations might lead to lower prices in food commodities. Another reason that could explain the negative impact is the rising shipments of crude oil by train, within the area of North America. Canada's two major railways were mainly occupied by crude oil transportation this year, leaving almost 3 million tons of wheat on the prairie. Keith Bruch, vice president of Paterson GlobalFoods Ltd operations stated that agricultural commodities shipments to export terminals were two months behind in February 2014. “It’s looking more and more that grain is becoming second choice to oil,” Bruch said in a Jan. 17 interview at his office in Winnipeg. “The railways make decisions on where they put their power and crews to maximize revenue.” The ironic thing is that grain harvest in US might be a record this year and it seems that either the prices will fall or some amount of the harvest will be wasted. At the end, it seems that there are more complex ways that energy markets could affect the prices of agri-commodities these days.

Despite all these, it is certain that the situation is very complicated and it is extremely difficult to indicate the specific effect of energy prices upon grains. After all, it is very likely that the whole correlation between our data could be an outcome of the oil-ethanol-corn linkages. As regards limited export from US, there are also other reasons causing it besides oil price hikes. For instance, Putin recently threatened to ban all the agricultural product imports from the US and other countries which have initiated sanctions against Moscow during the Ukraine crisis of 2014.

Since the whole situation is changing dramatically in our times, it remains to be seen whether the agricultural economists will take into account the impact of the energy sector when they try to prognosticate for grain prices in the future.

References

- Akinfenwa, S. O, .Qasmi B. A. “Ethanol, the Agricultural Economy, and Rural Incomes in the United States: A Bivariate Econometric Approach”, *Agricultural and Resource Economics Review,* August 2014
- Baffes, J. ‘‘Oil Spills on Other Commodities.’’ *Resources Policy* 32(2007):126–34.
- Brooks C. (2002), *“Introductory Econometrics for Finance”* The Press Syndicate of the University of Cambridge, Cambridge, UK.
- Brown J., Bekkerman, A., Atwood, J. A. Watts M. J. “An Empirical Assessment of Simultaneous Ethanol Policy Changes on U.S. Agricultural Markets”, *Agricultural and Applied Economics Association* in series 2012 Annual Meeting, August 12-14, 2012, Seattle, Washington 124177.
- Conley, D.M., and George A.. ‘‘Spatial Marketing Patterns for Corn under the Condition of In Increasing Ethanol Production in the U.S.*’’International Food and Agribusiness Management Review* 11,3 (2008) pp 81–98.
- Enge R.E.C., and Granger W.J.. ‘‘Cointegration and Error Correction: Representation, Estimation, and Testing.’’ *Econometrica* 55 (1987)pp 251–76.
- Frankel J.A. ‘‘Expectations and Commodity Price Dynamics: The Overshooting Model.’’ *American Journal of Agricultural Economics* 68(1986) pp 344–48.

- Grosche S.-C., Heckelei T. "Directional Volatility Spillovers between Agricultural, Crude Oil, Real Estate and other Financial Markets'", *Agricultural and Resource Economics",* Discussion Paper 2014 pp 4.
- Guo H., Li F., Yang W. and Yang Y. "Analysis of price trends of crude oil, agricultural commodities and policy choices of biofuels in developing countries" *African Journal of Business Management* 6(2), pp. 538-547,18 January, 2012.
- Holden D. and Perman R. ''Unit Root and Cointegration for the Economist.'' *Applied Economist.* B. Bhaskara Rao, ed. New York, NY: St. Martin's Press, 1994.
- Johansen, S., and K. Juselius. ''Testing Structural Hypothesis in a Multivariate Cointegration Analysis of the PPP and UIP for the UK.'' *Journal of Econometrics* 53(1992) pp 211–44.
- IPCC Working Group III - Mitigation of Climate Change Chapter 11, *Agriculture, Forestry and Other Land Use (AFOLU),* Cambidge University Press, NY, 2014.
- Kong, M, Han, D. B., Nayga, R. M. Jr., " Interrelationship and Volatility Transmission between Grain and Oil Prices", prepared for presentation at the Agricultural & Applied Economics Association's 2012 Annual Meeting, Seattle, Washington, August 12-14, 2012.
- Lüutkepohl H., Saikkonen P. and Trenkler C. "Maximum eigenvalue versus trace tests for the cointegrating rank of a VAR process" *The Econometrics Journal* 4, 2, pp 287–310, Dec. 2001.

- McPhail, L. L., Du, X. “Ethanol Strengthens the Link Between Agriculture and Energy Markets” United States Department of Agriculture, Economic Research Service in its journal *Amber Waves.* 10, 2 ,June 2012.
- Munier B. R. (ed.) “*Global Uncertainty and the Volatility of Agricultural Commodities Prices”* IOS Press, Amsterdam, 2012. ISBN 978-1-61499-036-9. pp. 256.
- Nazalioglu S., Soytas U. “Oil price, agricultural commodity prices, and the dollar: A panel cointegration and causality analysis” *Energy Economics* 34, 4, July 2012, pp 1098–1104.
- Nazalioglu S., “World oil and agricultural commodity prices: Evidence from nonlinear causality” *Energy Policy*39, 5, May 2011, pp 2935–2943.
- Rosegrant, M.W. “Biofuels and Grain Prices: Impacts and Policy Responses”. Washington, DC: International Food Policy Research Institute, May 2008.
- Robertson, J.C., and D. Orden “Monetary Impacts on Prices in the Short and Long Run: Some Evidence from New Zeland.” *American Journal of Agricultural Economics* 72(1990): 160-71.
- Saghaian, S.H., Reed M.R., and Marchant M.A.. ‘‘Monetary Impacts and Overshooting of Agricultural Prices in an Open Economy.’’ *American Journal of Agricultural Economics* 84,1(2002a) pp 90–103.

- Saghaian S. H. “The Impact of the Oil Sector on Commodity Prices: Correlation or Causation?” *Journal of Agricultural and Applied Economics*, 42,3(August 2010) pp 477–485.
- Saghaian Y., Reed M., and Saghaian S. “Export Demand Estimation for U.S. Corn and Soybeans to Major Destinations”, selected paper prepared for presentation at the *2014 Southern Agricultural Economics Association (SAEA) Annual Meetings*, Dallas, TX: Feb 1-4, 2014.
- Schuh, G.E. ‘‘The Exchange Rate and U.S. Agriculture.’’ *American Journal of Agricultural Economics* 56 (1974) pp 1–13.
- Taheripour, F., and W.E. Tyner. ‘‘Ethanol Policy Analysis—What Have We Learned So Far?’’ *Choices (New York, N.Y.)* 23,3(2008) pp 6–11.
- Taylor R.D and Koo W. W.” 2010 Outlook of the U.S. and World Corn and Soybean Industries 2009-2019”, Center for Agricultural Policy and Trade Studies, Department of Agribusiness and Applied Economics, North Dakota State University
- von Braun J., Ahmad A., Okyere K.A., Fan S., Gulati A., Hoddinott J., et al. “High Food Prices: The What, Who, and How of Proposed Policy Actions”. Washington, DC: International FoodPolicy Research Institute, May 2008.
- von Braun J. and Torero M. “Exploring the Price Spike” *CHOICES* 1st Quarter 2009•24(1) pp 16-21.
- Zalewski, Arkadiusz “The global market for mineral fertilisers with consideration of the changes in the prices of direct energy carriers and

raw materials", Institute of Agricultural and Food Economics 2011, Multi-annual program 2011-2014 no 16.1, Warsaw 2011.