WHAT IS THE REAL RELATIONSHIP BETWEEN BIOFUELS AND AGRICULTURAL COMMODITIES?

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ABSTRACT

In the last years we have witnessed the enormous increase in biofuel production. Biofuels involve the tradeoff between using scarce resources to produce fuel and to produce food. They are believed to be the driven force behind the strong increase in food prices. The main purpose of this paper is to analyze the statistical relationship among the fuel prices (oil, bioethanol) and selected food prices (maize, wheat and sugar). We conduct a series of statistical tests, starting with tests for unit roots, estimation of cointegrating relationships between price pairs, evaluating the inter-relationship among the variables using Vector Error Corrections (VECM) and Variance decomposition. The direction of causation in the variables is tested by means of Granger causality tests. According to our results, there is no cointegrating relationship between time series in the period 2005 – 2008, while in the later period there is a log run relationship among all of the variables.

KEY WORDS

Bioethanol Production. Agricultural Commodities. Cointegration.

INTRODUCTION

Increasing biofuel production involve the tradeoff between using scarce resources to produce fuel and to produce food (RUNGE, 2007; MSANGI, 2006; RAJAGOPAL, ZILBERMAN, 2007). In 2007 there was 93 million tons of wheat and coarse grains used for ethanol production, double the level of 2005 (OECD–FAO, 2008). In the last years we have witnessed also sharp increase in agricultural commodity prices. This was caused by several factors like food demand increases in growing Asian economies, supply suffered from the adverse weather as well as increasing biofuel demand. By early 2008, real food prices were 64 percent above the levels of 2002 after four decades of predominantly declining or flat trends (FAO, 2008). The results of MSANGI et al. (2006) show that when the demand for biofuels is growing very rapidly, holding crop productivity unchanged, world prices for crops increase substantially. However, when introducing second-generation cellulose technologies and allowing for crop productivity improvement, the impact on prices is small. How small depends of course on what assumptions we make concerning technological progress (BRÄNNLUND et al., 2008). Producing ethanol for use in motor fuels increases the demand for maize or other ethanol feedstock, which ultimately raises the prices that consumers pay for a wide variety of foods at the grocery store, ranging from maize syrup sweeteners found in soft drinks to meat, dairy, and poultry products. In addition, the demand for maize may help push up the prices of other commodities, such as soybeans (CBO, 2009).

O'BRIEN and WOOLVERTON (2009) quantify the recent relationships between ethanol and motor fuel prices and confirm that the maize market is closely related to the energy sector. A sizeable increase in maize processing for ethanol now tends to strengthen maize prices much more significantly than in the past. The relationship of maize prices to various fuel prices has major implications for crop and livestock farmers, the seed industry, grain elevators, food processors, suppliers of fertilizer, and other businesses closely associated with the crop sector.

The impact is less significant in rich countries such as the United States because only 7.3 percent of income is spent on food. However, in developing countries, about 20 percent of income is used in food consumption (BULLOCK, 2007).

Ethanol in the EU is essentially produced from wheat and to a lesser extent sugar beet (production from maize is marginal). Ethanol is still a very minor outlet for EU cereals (more specifically wheat) since it represents less than 1% of end use of the latter. According to the EC (2007), about 1 million tons of white sugar equivalents were processed into ethanol in 2005, that is 5% of total domestic consumption. Sugar used for ethanol is today only slightly less than gross sugar exports (1.3 million tons in 2006) (BAMIERE, et al., 2007). Price spikes are common in agricultural markets due to a combination of relatively inelastic demand and volatile supply. EU ethanol has had no discernible impact on the commodity price spike (EBIO, 2008).

The changes in the amount of biofuel produced over the last 5 years have not been enough to cause the big prices changes we have seen in commodities (SAUNDERS et al., 2008, 2009). EU biofuel policies led to an increase in food prices in Brazil of 0.5% and European food prices increased by 0.14%. A US report has supported the view that the increased link between maize and energy markets is one factor driving food prices (ABBOT, 2009).

MATERIALS AND METHOD

Most of the literature review suggests the current increase in ethanol production was an important factor that led to the rise in food prices. The main goal of our study is to check whether the relationship between fuel and food prices is statistically significant. We expect to find a positive relationship between ethanol prices and the prices of maize, wheat and sugar; in other words, we expect an increase in ethanol price to lead to an increase in the demand for maize, wheat and sugar beet and therefore, an increase in maize, wheat and sugar prices.

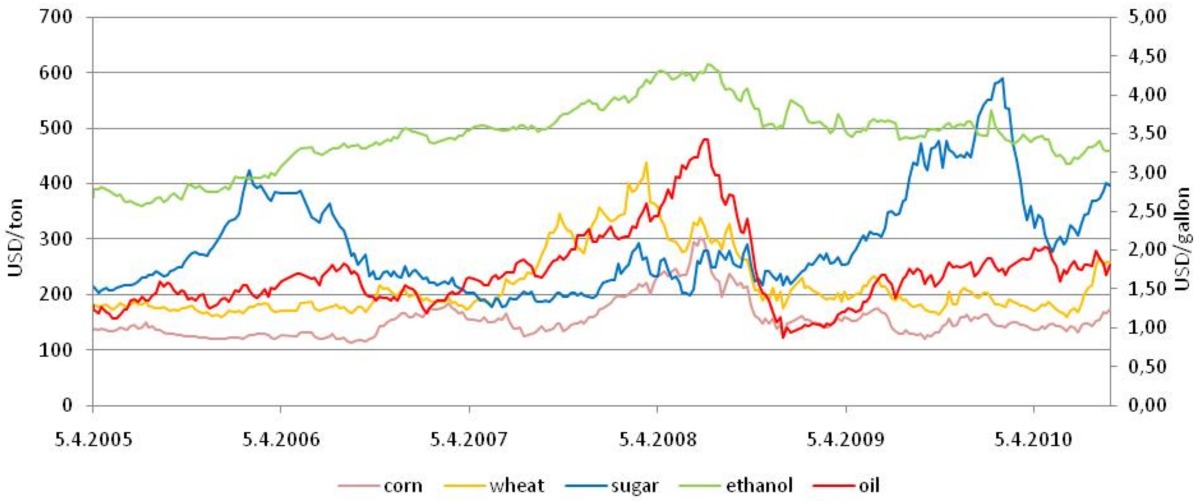
The article evaluates the relationship among the following variables: fuel prices (oil, bioethanol) and selected food prices (maize, wheat and sugar). We conduct a series of statistical tests, starting with tests for unit roots and stationarity, estimation of cointegrating relationships between price pairs, estimation of Vector Error Correction Model (VECM) and Variance decomposition. The direction of causation in the variables is tested by means of Granger causality tests.

We use weekly data (April, 2005 to August, 2010) for oil, bioethanol, maize, wheat and sugar prices. Prices are expressed in USD per gallon of fuel and USD per ton of food. German bioethanol prices come from Bloomberg database (2005-2010). Europe Brent oil prices are from Energy Information Administration (2005-2010) and German maize, wheat and sugar prices come from Deutsche Boerse database (2005-2010). German prices are used because Germany has been one of the most important bioethanol producers in Europe during the observed period. Logarithmic transformation of the prices is used due to the assumed multiplicative effect (Johansen, 1995). The use of the logarithm of the variables of the model implies that the corresponding coefficients are now interpreted in percentage terms.

RESULTS AND DISCUSSION

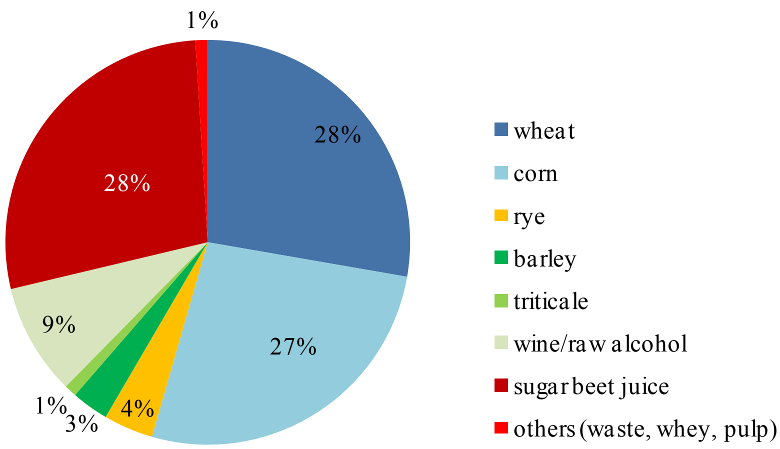
Since early 2000 ethanol prices in Europe have widely fluctuated. The highest price reached \$3.94 per gallon in March 2008, while the lowest price at the amount of \$1.33 per gallon in September 2000. The ethanol market in Europe was growing slowly in 1990s. It took almost 10 years for production to grow from 60 million liters in 1993 to 525 million liters in 2004. High increase in production has been driven by the combination of EU biofuel policy, reduction of production costs, and increase in oil prices.

Figure 1: Development of fuel and food prices



Source: Bloomberg - ethanol prices, EIA – gasoline prices, oil prices, Deutsche Börse – maize, wheat and sugar prices

Figure 2: Feedstocks for Biofuels in Europe



Source: European Bioethanol Fuel Association (2008)

Table 1: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Ethanol	268	3.465409	.434612	2.574981	4.393175
Oil	268	3.707415	1.042963	1.889796	7.344388
Maize	268	155.9015	35.58587	112.9921	302.7559
Wheat	268	218.2762	59.58824	159.0976	438.3451
Sugar	268	289.1843	90.29584	178	590

Source: Own calculation

Table 2: Correlation Matrix

Variable	Ethanol	Oil	Maize	Wheat	Sugar
Ethanol	1.000	-	-	-	-
Oil	0.6836	1.0000	-	-	-
Maize	0.7386	0.7729	1.0000	-	-
Wheat	0.7153	0.7028	0.7197	1.0000	-
Sugar	-0.0965	-0.0120	-0.2018	-0.3013	1.0000

Source: Own calculation

Correlation analysis (Table 2) revealed positive correlation between ethanol prices and maize prices (0.7386) and between ethanol prices and wheat prices (0.7153). Sugar prices are negatively and insignificantly correlated to all of the other price series. These results are in line with Abbot et al., (2009), who found the crude/maize price correlation to be high and positive at 0.80 for the period 2006-08 and Campiche et al. (2007) found sugar prices extremely negatively and significantly correlated with crude oil prices in 2007.

Table 3: Unit Root Tests

Time series	Level			First Differences		
	None	Constant	Constant & Trend	None	Constant	Constant & Trend
ADF - Ethanol	0.349	-1.706	-1.042	-15.644***	- 15.631***	-15.741***
ADF - Oil	-0.081	-2.107	-1.908	-15.886***	-15.867***	-15.848***
ADF - Maize	0.191	-2.010	-2.110	-9.066***	-9.053***	-9.035***
ADF – Wheat	0.376	-1.625	-1.663	-16.415***	-16.396***	-16.366***
ADF - Sugar	0.662	-1.367	-1.645	-16.816***	-16.817***	-16.787***
PP - Ethanol	0.467	-1.922	-1.142	-15.644***	-15.631***	-15.741***
PP - Oil	-0.030	-1.946	-1.786	-15.886***	-15.867***	-15.848***
PP - Maize	0.222	-1.996	-2.090	-17.327***	-17.301***	-17.269***
PP - Wheat	0.382	-1.642	-1.679	-16.415***	-16.396 ***	-16.366***
PP - Sugar	0.653	-1.400	-1.683	-16.816***	-16.817***	-16.787***

Source: Own calculation

Non-stationary time series can lead to statistically significant results due to purely spurious regression. We therefore tested for the stationarity of the price series. We use two tests to check for stationarity of time series: augmented Dickey Fuller (ADF) test and Phillips Perron (PP) test. The lags of the dependent variable were determined by Akaike Information Criterion (AIC). Both tests show that all the time series (oil, bioethanol, maize, wheat and sugar prices) are integrated of order 1, i.e. non-stationary. To make them stationary we therefore take the first differences. Zivot-Andrews (ZA) unit root test was used to check for the presence of structural break in the data. According to the result of ZA test we decided to divide the observed period into two time periods (summer 2008 was identified as a breaking point in all of the time series).[1]

The above stationarity tests showed that the original time series are non-stationary and could be used for cointegration test. Johansen Cointegration Test allows for testing the cointegration of several time series. This test furthermore does not require time series to be in the same order of integration. In the Johansen Cointegration Test, the cointegration rank (number of cointegration relationships) is obtained through the trace test.

Table 4: Johansen Cointegration Test

	2005 - 2008				**2008 - 2010**			
	L-max test		Trace test		L-max test		Trace test	
	r = 0	r = 1	r = 0	r = 1	r = 0	r = 1	r = 0	r = 1
Ethanol Oil	4.07^{***}	1.35	5.42^{***}	1.35	16.66	0.89^{**}	17.56	0.89^{**}
Ethanol Maize	5.07^{***}	1.51	6.59^{***}	1.51	12.22	4.44^{*}	16.66	4.44^{**}
Ethanol Wheat	5.93^{***}	1.14	4.79^{***}	1.14	9.65^{***}	1.45	11.10^{***}	1.45
Ethanol Sugar	5.61^{***}	1.96	7.57^{***}	1.96	6.80^{***}	1.92	8.71^{***}	1.92
Oil Maize	7.93^{***}	1.06	9.02^{***}	1.06	16.23	1.54^{**}	17.76	1.54^{**}
Oil Wheat	7.48^{***}	1.41	8.89^{***}	1.41	24.73	2.00^{**}	26.74	2.00^{**}
Oil Sugar	3.75^{***}	1.13	4.88^{***}	1.13	12.95	2.36^{*}	15.31	2.36^{*}

Source: Own calculation

As shown in the Table 4, there is no cointegrating relationship in the first period. All of the analyzed time series are cointegrated in the second period, except for the sugar-bioethanol and wheat – bioethanol price relationship. This may be a result of the fact, that EU production of ethanol from wheat only began in earnest in 2003. Cereal consumption for ethanol in the EU in

[1] Results of the tests are available upon request from the corresponding author

2007/08 only accounted for 0.09% of the global cereal production with over 40% of it being grown on set-aside land where food production was forbidden. Lack of cointegration among price series in 2005-2008 implies that their short-run dynamics may be examined using an unconstrained VAR model with first-differenced variables. Results from Zhang (2010) yield cointegration relationship between ethanol and maize prices for the 1989-1999 period. In contrast, results indicate no long-run relation between ethanol and maize prices in the 2000-2007 period. In contrast to popular belief, between 2000 and 2007 ethanol and maize do not appear to have any long-run price relationships. However, short-run relations may exist where ethanol prices do influence maize prices and vice versa.

To estimate parameters of the relationship between price time series in the first period we used Vector Autoregression (VAR) model because the variables were not cointegrated. Based on the AIC criterion, we estimated VAR(1) model on the first differences of the logarithms of each variable. In order to explore if there is a "Granger causality" among the analyzed variables we needed to run Granger causality test. The direction of causality between the prices in the second period is revealed through the parameter estimates from the VECM.

Table 5: Variance Decomposition

Weeks	relative variance in	percentage of forecast variance explained by innovations in				
		Δ ethanol	Δ oil	Δ maize	Δ wheat	Δ sugar
1	Δ ethanol	100.00	0.00	0.00	0.00	0.00
4		99.79	0.11	0.01	0.00	0.00
12		99.49	0.26	0.02	0.00	0.00
1	Δ oil	12.45	76.31	0.00	0.00	0.00
4		12.43	60.20	0.28	0.03	0.01
12		11.78	45.19	0.72	0.09	0.04
1	Δ maize	4.06	12.39	83.28	0.00	0.00
4		4.13	12.74	82.94	0.00	0.01
12		4.15	13.01	82.68	0.00	0.02
1	Δ wheat	4.06	9.09	33.16	53.43	0.00
4		4.03	8.70	33.44	53.63	0.00
12		4.00	8.41	33.65	53.77	0.00
1	Δ sugar	1.65	4.53	2.15	0.19	91.19
4		1.45	2.57	2.65	0.24	91.80
12		1.29	8.41	3.03	0.28	91.65

Source: own calculation

Variance decomposition provides information on the relative magnitude of the causation influence of one price on another. The results of variance decomposition indicate the effect of shocks in each price on the current and future values of a given price. As seen from the table 5, the variance of oil price explains approximately 13.01 % , 8.41 % and 8.41 % of the variance of the maize, wheat and sugar prices after 12 weeks, respectively. In contrast the relative variance in fuel prices caused by shocks in food prices is only less than 1%. The variance in maize is mostly explained by its own innovations (83.28 % - 82.68 %); however the contribution of maize to the wheat forecast error variance is also considerable (33.16 % - 33.65 %). Our results are consistent with Zhang (2009) supporting lack or minor causality relations of bioethanol prices on any agricultural commodity prices. Frank and Garcia (2010) suggest also that the shocks from oil prices contribute to explain agricultural commodities forecast errors, although the effect is smaller between one to two percent for grains and roughly six percent for livestock.

CONCLUSION

The main purpose of this paper is to analyze the statistical relationship between between fuel and food prices. In order to achieve our goal, we first collected weekly data for oil, bioethanol, maize, wheat and sugar prices from April, 2005 to August, 2010. In order to account for structural break we devide the observed period into two periods: 2005-first half of 2008 and second half of 2008 – 2010. The results provide no evidence of cointegrating relationship in the first period. All the variables were found to be cointegrated in the second time period, except for the sugar/bioethanol and wheat/bioethanol relationship. Using Variance decomposition we identify the effect of shocks in each price on the current and future values of a given price. According to our results the variance in agricultural commodity prices are explained mostly by their own innovations, the contribution of fuel price shocks account up to 4.15 % and 13.01 % for ethanol and oil price shocks respectively. In contrast the relative variance in fuel prices caused by shocks in food prices is only less than 1%.

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