Determination of European Biofuel Prices and their Impact on Agricultural Commodity Prices

Preise für Biokraftstoffe und ihr Einfluss auf die Preise für landwirtschaftliche Erzeugnisse in der Europäischen Union

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Summary

The main purpose of this paper is to analyze the statistical relationship among the fuel prices (oil, bioethanol) and selected food prices (corn, wheat and sugar). We conducted 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 Impulse Response Function (IRF). 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 April 2005 – July 2008 while in the later period (August 2008 – August 2010) there is a long run relationship among all of the variables.
Keywords: biofuels, crude oil, food, cointegration

Zusammenfassung

Das Hauptziel dieser Arbeit ist die Analyse des statistischen Zusammenhangs zwischen Brennstoffpreisen (Öl, Bioethanol) und Preisen für ausgewählte Nahrungsmittel (Mais, Weizen und Zucker). Es wurde eine Zeitreihenanalyse unter Verwendung folgender Methoden durchgeführt: Tests für „unit roots“, Schätzung kointegrierter Preispaarzusammenhänge, Analyse der Zusammenhänge zwischen den Produkten unter Verwendung von Vektorfehlerkorrekturen (VECM), der Impulsantwortfunktion (IRS), und Granger-Kausalitätstest. Die Ergebnisse zeigen keinen kointegrierten Zeitreihenzusammenhang für den Zeitraum April 2005

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bis Juli 2008, während im Zeitraum August 2008 bis August 2010 ein langfristiger Zusammenhang existiert.
Schlagworte: Biokraftstoff, Erdöl, Nahrungsmittel, Kointegration

1. The relationship between food and fuel prices

Biofuels involve the tradeoff between using scarce resources to produce fuel and to produce food (RUNGE and SENAUER, 2007; MSANGI et al., 2006). An estimated 93 million tons of wheat and coarse grains were used for ethanol production in 2007, double the level of 2005 (OECD–FAO, 2008). Agricultural commodity prices have risen sharply over the past several years. Several factors (food demand increases in growing Asian economies, supply suffered from the adverse weather, increasing biofuel demand) are believed contributed to the price rise. 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 cellulosic 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 corn or other ethanol feedstock, which ultimately raises the prices that consumers pay for a wide variety of foods at the grocery store, ranging from corn syrup sweeteners found in soft drinks to meat, dairy, and poultry products. In addition, the demand for corn 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 corn market is closely related to the energy sector. A sizeable increase in corn processing for ethanol now tends to strengthen corn prices much more significantly than in the past. The relationship of corn 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% of income is spent on food. However, in developing countries, about 20% of income is used in food consumption (BULLOCK, 2007).

Ethanol in the EU is essentially produced from wheat and to a lesser extent from sugar beet (production from corn is marginal). Ethanol is still a very minor outlet for EU cereals (more specifically wheat) since it represents less than one percent of end use of the latter. According to the EC (2007), about one 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 five years have not been enough to cause the big prices changes we have seen in commodities (SAUNDERS et al., 2009). EU biofuel policies led to an increase in food prices in Brazil of 0.5% and European food prices increased by 0.14%. An US report has supported the view that the increased link between corn and energy markets is one factor driving food prices (ABBOT et al., 2009).

2. Methods and Data

As mentioned above, 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 using time series analysis. We expect to find a positive relationship between ethanol prices and the prices of corn, wheat and sugar; in other words, we expect an increase in ethanol price leading to an increase in the demand for corn, wheat and sugar beet and therefore, an increase in corn, wheat and sugar prices.

The article evaluates the relationship among the following variables: fuel prices (oil, bioethanol) and selected food prices (corn, wheat and sugar). We conduct a series of statistical tests, starting with tests for unit roots. 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). 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 (end of July 2008 was identified as a breaking point in all of the time series).

Johansen Cointegration Test was used then to test for the existence of cointegration of selected time series. The null hypothesis of the test of JOHANSEN (1991) is that there are at most "r" cointegrating vectors. Existence of cointegration relationship affects the specification of the model used for causality testing. In case of cointegrated series, causality testing should be based on a Vector Error Correction model rather than an unrestricted VAR model (JOHANSEN, 1988, JOHANSEN and JUSELIUS, 1990). Impulse Response Functions are performed as the last step in order to show how a shock in one variable would persist in future periods.

We use weekly data (April, 2005 to August, 2010) for oil, bioethanol, corn, 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 corn, 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.

3. Results

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 ten 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.

Tab. 1: Correlation Matrix

Variable	Ethanol	Oil	Corn	Wheat	Sugar
Ethanol	1.000	-	-	-	-
Oil	0.6836	1.0000	-	-	-
Corn	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 1) revealed positive correlation between ethanol prices and corn 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. The negative correlation between sugar and bioethanol prices is due to regulated sugar market within the Common Agricultural Policy of the EU. Historically sugar prices were kept significantly above the world prices by means of production controls, high minimum price and import protection. Recent reforms of the CAP lead to sugar price reduction which could be the reason behind the negative correlation sign. These results are in line with ABBOT et al., (2009), who found the crude/corn 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.

Non-stationary time series can lead to statistically significant results due to purely spurious regression. We therefore started with the tests for the stationarity of the price series. Both ADF and PP tests show that all the time series are integrated of order 1, i.e. non-stationary. To make them stationary we therefore take the first differences. According to the result of ZA test we decided to divide the observed period into two time periods (end of July 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

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

cointegration of several time series. In the Johansen Cointegration Test, the cointegration rank ("r" represents the number of cointegration relationships) is obtained through the trace test statistics and maximal eigenvalue statistic (lambda max).

Tab. 2: Johansen Cointegration Test

	April 2005 – July 2008				August 2008 – August 2010			
	λ_{max} test		Trace test		λ_{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 Corn	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 Corn	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*

Note: *** significance at 1% level, ** significance at 5% level, * significance at 10% level
Source: Own calculation

As shown in the Table 2, 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 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.

There are five cointegrating relationships in the second period between ethanol and oil prices, ethanol and corn prices, oil corn prices, oil wheat and oil sugar prices. Results from ZHANG et al. (2010) yield

cointegration relationship between ethanol and corn prices for the 1989-1999 period. In contrast, results indicate no long-run relation between ethanol and corn prices in the 2000-2007 period. In contrast to popular belief, between 2000 and 2007 ethanol and corn do not appear to have any long-run price relationships. However, short-run relations may exist where ethanol prices do influence corn 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[2]. The direction of causality between the prices in the second period is revealed through the parameter estimates from the VECM.

Tab. 3: Granger Causality Results

April 2005 – July 2008	August 2008 – August 2010
Oil → Ethanol	Oil → Ethanol***
Oil → Corn **	Oil → Corn **
Oil → Wheat	Oil → Wheat*
Oil → Sugar	Oil → Sugar
Ethanol → Oil	Ethanol → Oil***
Ethanol → Corn	Ethanol → Corn*
Ethanol → Wheat	Ethanol → Wheat*
Ethanol → Sugar	Ethanol → Sugar

Note: *** significance at 1% level, ** significance at 5% level, * significance at 10% level
Source: Own calculation

As seen from the Table 3, we found a casual relationship between oil and corn prices in the first period. The Granger causality tests for the second period suggest long run unidirectional causality from energy prices to agricultural commodity prices and a bidirectional relationship between ethanol and oil prices. The coefficients of the error correction

[2] Be aware that there are some problems with testing for Granger causality in co-integrated relations (see TODA and PHILLIPS, 1994).

terms are statistically significant implying, that the integrated variables tend to return to their long run equilibrium when they deviate from it in all cases, except for sugar. The magnitude of the error correction term is small indicating that the integrated variables tend to return slowly to their long run relations. BALCOMBE and RAPSOMANIKIS (2007) also determined ethanol prices to be Granger caused by oil prices. The results of Granger causality tests in ARSHAD and HAMEED (2009) show that there exists a long run unidirectional causality from oil price to the three cereals prices, i.e., corn, rice and wheat. The said is not true for the reverse.

Impulse Response Functions were performed in order to show how a shock in one variable would persist in future periods. The forecast was made considering one year period. All the agricultural commodities are affected by fuel prices. The impact of shock in oil or ethanol price on agricultural commodity prices is higher than vice versa.

4. Conclusion

The main purpose of this paper is to analyze the statistical relationship between fuel and food prices. In order to achieve our goal, we first collected weekly data for oil, bioethanol, corn, wheat and sugar prices from April, 2005 to August, 2010. In order to account for structural break we divide 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. The Granger causality tests suggest that there is a long run Granger causality from oil to agricultural commodity prices but not vice versa. There is also a bivariate causal relationship between ethanol and oil prices. After running an Impulse Response Function, we found out that all the agricultural commodities are affected by fuel prices. The impact of shock in oil or ethanol price on agricultural commodity is higher than vice versa.

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