Impact and competitiveness of EU biofuel market – First view of the prices of biofuel market in relation to the global players

Xing Liu

MTT Taloustutkimus, Luutnantintie 13, 04410, Helsinki, xing.liu@mtt.fi

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Abstract

The goal of this study is to investigate the price relationship of EU biofuel market with other main markets in both horizontal level and vertical level. We first carry out Granger causality between ethanol price of EU, USA and Brazil. Secondly, we use vecto error cointegration Mechnism (VECM) to test the relationship between three selected vegetable oil prices in EU to see the competive potential of EU rapeseed oil compared with imported crude palm oil and soybean oil as the feedstock of biodiesel. Evidence shows that there is a unidirectional Granger causation from both USA and Brazil to EU market. USA price of ethanol is the most influential among the three price series, and EU has the least influence on the contrary. It indicates that it is very necessary for EU to set up its own price indicator, for instance, futures prices in EURONEXT. However, in biodiesel market, production in EU has some potential in competing with outside of the world since rapeseed oil price show some potential in price competition with other vegetable oils

Keywords: ethanol, vegetable oils, feedstock, directives, VECM, Granger causality

Introduction

Using biofuels including bioethanol and biodiesel have potential advantages: less greenhouse gas emissions, increasing the sources of income employment in rural areas and most importantly diversifying fuel supply sources. Ethanol is a renewable biofuel produced from sugar crops such as sugar cane or sugar beet, or from cereals like wheat, barley and corn. Currently, the US and Brazil are the two dominant users and producers of ethanol. More than half of world production of ethanol came from them. The share of the European countries is rather small, only representing 15% of the total share. However, it has increased dramatically since 2004. In comparison, EU produces more biodiesel than ethanol using feedstock mainly local rapeseed oil and imported soybean oil and palm oil. Especially, the demand of imported palm oil has gone up dramatically during the last couple of year. The three major oils have similar end-uses in both the food industry and biodiesel industry. The main driver might come from two biofuel directives by the European Commission. One is the Directive 2003/30/EC[1], and the other is the one on taxation of energy products[2]

The global price of ethanol is mainly determined by two countries, Brazil and USA. The expanding trade volumes have created incentives to establish new marketing boards and hedging tools for increasing transparency and managing risks in the bio-fuels market.

An example of the new and emerging hedging tools is the new ethanol futures contract designed and quoted by the Chicago Board of Trade (CBOT). The trade for the new ethanol contract started in July 2005. Thereafter, the trading volumes have been increasing drastically and also the traditionally thought price parity between the fossil fuels and ethanol has broken down. The price of ethanol has continued to increase even if the price of fossil fuels has developed more steadily, though remaining at very high level in the historical perspective. No matter the technological process adopted for bio-diesel manufacturing, the largest share of production cost of bio-diesel is the feedstock cost. In this context, the feedstock cost is the major obstacle to the market feasibility of bio-diesel. Therefore, special emphasis of biodiesel is given to the analysis of costs of feedstocks

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[1] See Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003, on the promotion of the use of biofuels and other renewable fuels for transport

[2] See Directive 2003/96/EC of 27 Octobor 2003 (O.J.L283, 31/10/2003)

as a key raw material for biodiesel production. So far European marketing boards, such as the EURONEXT, have not launched new contracts for open trade and quotations for bio-fuels. Therefore, the bio-fuels market is not transparent from the Finnish traders' and ethanol processors' perspective. The reason is that the existing open quotations represent different market regimes and, in addition to the transportation costs, they are separated from the European market by different tariff regimes. Thus, it is not really known, what is the opportunity cost for the domestic, large scale ethanol production, and how competitive the domestic market is in the international context. Further, it is unclear how the bio-fuels markets are linked to the agricultural commodity markets and how the price movements in these markets reflect each others.

The study has two goals: first, it is to investigate the market integration of world ethanol market with focus on three main markets: EU, USA and Brazil. To what extent price shocks are transmitted between three ethanol markets, which are EU, USA and Brazil is also analysed. The extent to which a price shock at one market affects a price at another point can broadly indicate whether efficient arbitrage exists in the space that includes the two markets. A full transmission of price shocks can indicate the presence of a frictionless and well functioning market, while a total absence of transmission may make the very existence of a market questionable. Therefore, the degree of price transmission can provide at least a broad assessment of the extent to which markets are functioning in a predictable way, and price signals are passing-through consistently between different markets. Should different markets of ethanol prices be conitegrated, their relationship can be represented by an Error Correction Model (ECM) on the basis of which movements in any one of them can be used to predict movements in the other. Accordingly, the ECM associated with cointegrated ethanol price indexes provides traders and policy makers with valuable information regarding their investment decisions and for economic policy. Secondly, this study also examines the market potential and challenges of the European rapeseed oil industry in facing competition from other vegetable oils, which are soybean oil and palm oil. The vector error correction model (VECM) was used to distinguish the long and short term relationships between the vegetable oil price variables. In doing so, a price leader among the vegetable oils would be determined.

Data and Methodology

Data

For the ethanol data, monthly ethanol prices in EU, USA and Brazil are provided by Agronet[3]. European price is collected average price in Rotterdam, while Brazilian spot prices are FOB price collected from Santos in Brazil. USA price is average price collected from different harbours in United States. The data spans from January of 1998 to January of 2007 (Figures 1a). Both EU and USA price series include 109 observations, but price series of Brazil include only 101 data as the price of the first 8 month in 1998 was not available. We exchange the currency of USA and Brazilian price from the original US dollars to Euro accordingly.[4]

[3] The Data is provided by Agra Informa. The detailed information could be subscribed from www.agra-net.com
[4] The exchange rate is refered to xrate monthly average. Detaled information can be found at www.x-rates.com

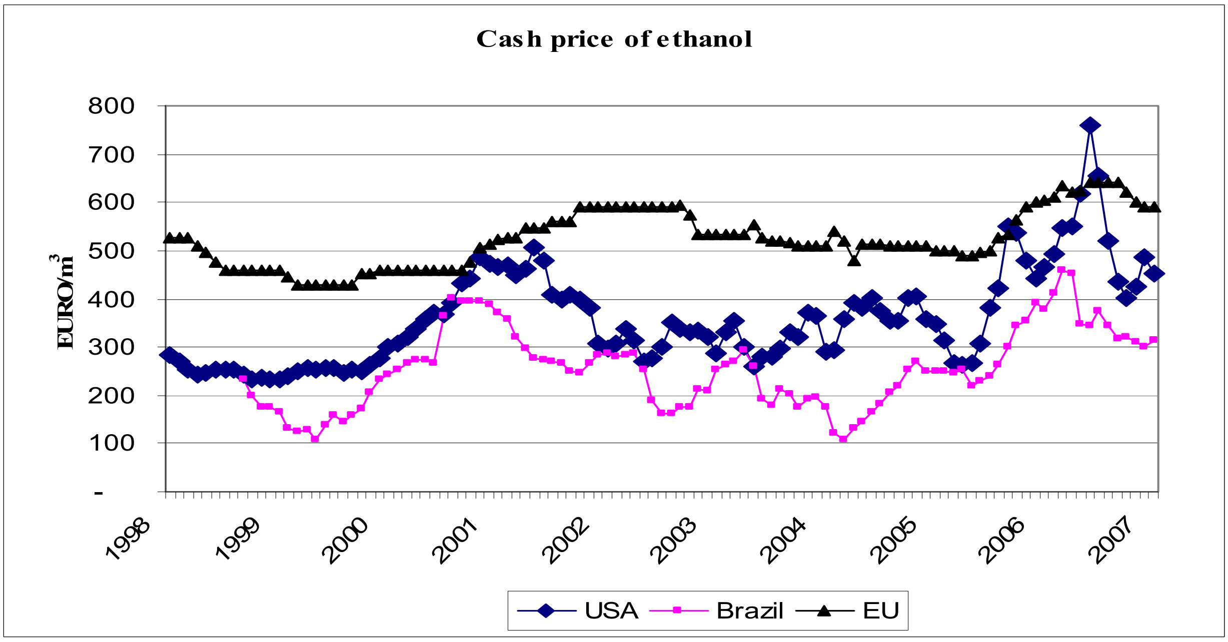

Figure 1a. Global ethanol wholesale prices in EU, USA and Brazil.

For vegetable oils, the lowest representative weekly asking FOB prices of rapeseed oil, soybean oil in Dutch and weekly crude palm oil (CPO) CIF price are used in the analysis (See Figure 1b.) The time varies between 2001 till 2007.

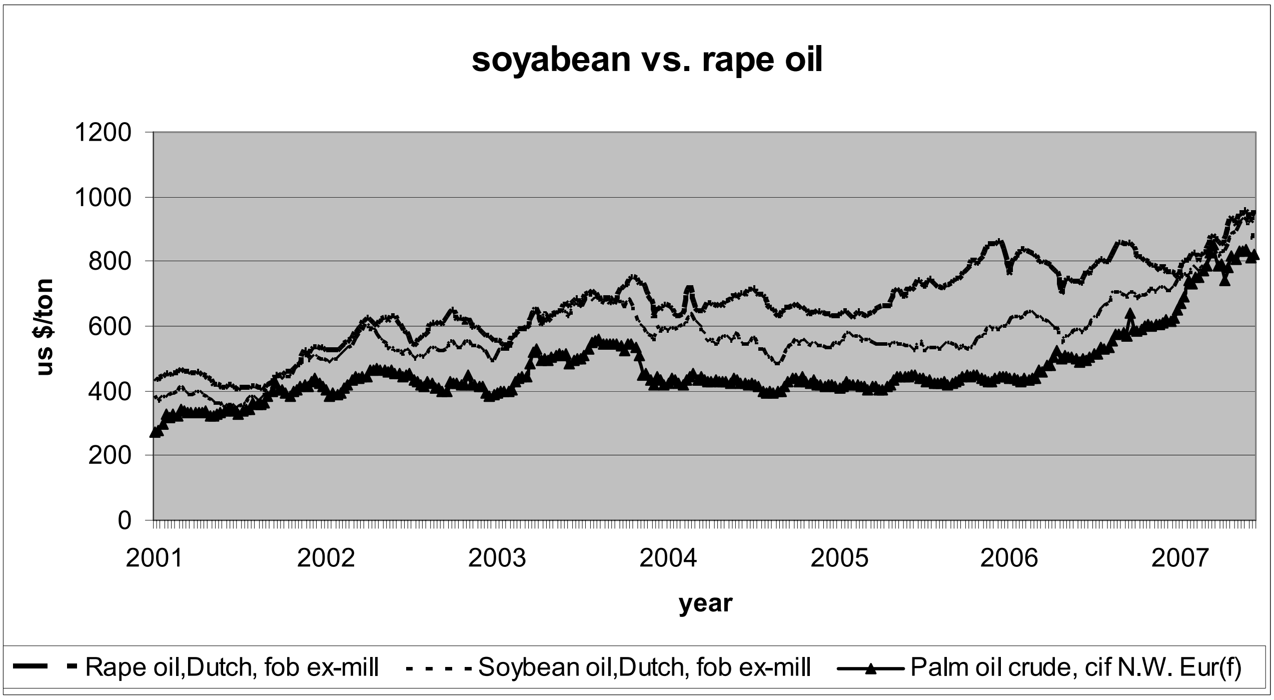

Figure 1b. Lowest representative weekly asking prices for nearest forward shipment in Bulk (excluding import duty, if any, US $/tonne)

The summary of statistics of ethanol monthly prices in three major markets is listed in Table1a; the summary of statistics of vegetable oils is listed in Table 1b. Obviously, European ethanol price has been highest among the three regions during the last decades, but turned most stable market. Comparatively, the average price of ethanol in USA stays between Europe and Brazil, but it has the biggest volatility figure among three regions. Also the high kurtosis and right skewness presents some evidence of a leptokurtic and asymmetric distribution. Brazilian price series, on the other hand, distribute as normal distribution. Among three vegetable oils, EU rapeseed oil is both the most expensive and volatile oil, and palm oil is both the least expensive and the most stable oil averagely. EU rapeseed oil is facing challenges from other vegetable oils that are substitutable. The supply and demand for vegetable oils in the world market play a significant role in determining the prices of vegetable oils. The substitutability between oils and fats, has increased through advancements, in technology that allow the oil characteristics to be modified so that they have become more versatile.(Amiruddin et. al. , 2005)

Table 1a. Summary of statistics of European, Americal and Brazilian ethanol price series

Descritives	Europe	USA	Brazil
Mean	524.30	358.36	253.9406
Median	520.00	337.0000	252.0000
Maximum	640.00	761.0000	461.0000
Minimum	430.00	231.0000	108.0000
Standard Deviation	57.73	101.4386	81.82112
Skewness	0.25	1.113112	0.361513
Kurtosis	2.14	4.509522	2.520680
Normality test (J-B test)	4.49	32.85775	3.166832
	0.11	0.000000	0.205273
Observations	109	109	101

Table 1b. Summary of statistics of the prices of vegetable oils in EU

Descritives	rapeseed oil	soybean oil	palm oil
Mean	660.47	573.36	466.58
Median	660	559	435
Maximum	960	932	850
Minimum	402	348	270
Standard Deviation	128.16	111.79	108.21
Skewness	-0.15	0.53	1.71
Kurtosis	2.55	3.98	6.11
Normality test (J-B test)	3.65	26.37	270.02
Probability	0.16	0.00	0.00
	303	303	303

Research method

Unit root test

The first step is to examine the stationarity properties of the univariate time series. Let $\ln p_t^{EU}$ $\ln p_t^{USA}$ and $\ln p_t^{Brazil}$ represent ethanol prices of European, USA and Brazilian respectively; $\ln p_t^{rapeoil}$, $\ln p_t^{soyoil}$ and $\ln p_t^{cpo}$ represent vegetable oils prices of rapeseed oil, soybean oil, and crude palm oil in EU market respectively with t = 1, 2, 3,…., T, where T is the sample size. Test for stationarity for price series, denoted by and the order of integration of the individual price series. The series is integrated of order d (denoted I(d) if it attains stationarity after differencing d times. If the series is I(1) it is deemed to have a unit root Stationarity of the price processes is tested using a group of unit roots which include the Augmented Dickey-Fuller (ADF) test (1976), Phillips-Perron test (PP) (1988), and a test developed by Kwiatkowski-Phillips-Schmidt-Shin (KPSS) (1992). While the ADF, PP tests state the null hypothesis of non-stationarity or the presence of a unit root, the KPSS test defines stationarity as the null. The Monte Carlo simulations by Schwert (1989) showed that the ADF tests have low power and are sensitive to the choice of lag-length. The unit root tests are known to have low power problems in small samples, particularly, if the series include structural breaks (Kwiatkowski et al.1992; Leybourne & Newbold 2000). The KPSS tests, on the other hand, have good power properties. PP test is an alternative (nonparametric) method of controlling for serial correlation when testing for a unit root. Since no single unit root test is without some statistical shortcomings, in terms of size and power properties, a group of unit root tests are applied to statistically determine the order of integration of the time-series used in cointegration analyses. The results of the ADF, PP and KPSS are summarized in Table 2a and Table 2b.

Shown in Table 1a, ADF tests indicate non-stationarity, and the KPSS tests confirm it for European and USA ethanol price. Thus, it was concluded that there is strong evidence that these two series are non-stationary. However, ADF and KPSS tests have different results in Brazilian ethanol price, but PP test supports the ADF tests, therefore, it is prudent to conclude that the series of Brazilian ethanol is also nonstationary. Table 2b displays the unit root tests for price series for the selected vegetable oils. The result indicates that all the selected vegetable oils uniformly tend to be non-stationary at 5% significant level. For the first difference series, the results of all these unit root tests indicate they are stationary and are not reported here, thus all three series are intergrated of order 1, designated as I(1).

Table 2a. Unit Root Tests for ethanol prices

Test	ethanol_EU	ethanol_USA	ethanol_Brazilian	Critical values
ADF (intercept and trend excluded)	0.46	0.45	0.21	-1.61* -1.94** -2.59***
ADF (intercept included)	0.83	-2.01	-2.37	-2.58* -2.89** -3.49***
ADF (intercept and trend included)	-1.88	-2.47	-2.51	-3.15* -3.45** -4.05***
KPSS (intercept included)	0.56	0.58	0.22	0.34* 0.46** 0.74***
Phillips-Perron (intercept included)	-1.28	-1.82	-2.13	-2.58* -2.88** -3.49***

Table 2b. Unit Root Tests for selected oil prices in EU market

Test	rapeseed oil_EU	Soy bean oil_EU	Palmoil_EU	Critical values
ADF (intercept and trend excluded)	1.74	1.88	2.21	-1.61* -1.94** -2.59***
ADF (intercept included)	-1.05	-0.69	-0.87	-2.58* -2.89** -3.49***
ADF (intercept and trend included)	-2.55	-1.48	-1.46	-3.15* -3.45** -4.05***
KPSS (intercept included)	1.79***	1.22***	1.12***	0.34* 0.46** 0.74***
Phillips-Perron (intercept included)	-1.05	-0.85	-1.02	-2.58* -2.88** -3.49***

Notes: ADF is Augmented Dickey-Fuller test, test statistics is according to MacKinnon (1996) critical values for rejection of hypothesis of a unit root. KPSS is the η-test of Kwiatkowski et al. (1992). Phillips-Perron test is Phillips and Perron (1988) nonparametric test of unit root. Asterisk (*), (**) and (***) denote significance level at 10 %, 5% and 1% respectively. [5]

Conintegration test

In the second step the conintegration analysis will be carried out. Conintegration analysis helps to identify long-run economic relationships between two or several variables and to avoid the risk of spurious regression (Hamilton, 1994). Cointegration analysis is important because if two non-stationary variables are cointegrated, a VAR model in the first difference is misspecified due to the effect of a common tend. If cointegration relationship is identified, the model should include residuals from the vectors (lagged one period) in the dynamic Vector Error Correcting Mechanism (VECM) system. In this stage, Johansen (1988) cointegration test is used to identify cointegrating relationship among the variables. Within the Johansen multivariate cointegrating framework, the following system is estimated:

$$\Delta y_t = \mu + \Pi y_{t-1} + \sum_{t=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t \tag{1}$$

where Δ is the first difference operator, **y** denotes vector of variables, which are $\ln p_t^{EU}$ $\ln p_t^{USA}$ and $\ln p_t^{Brazil}$, $\varepsilon_t \sim niid(0,\Sigma)$, μ is a drift parameter, and Π is a ($p \times p$) matrix of the form $\Pi = \alpha\beta'$, where α and β are both ($p \times r$) matrices of full rand, with β containing the r cointegrating relationships and α carrying the corresponding adjustment coefficients in each of the r vectors. Johansen (1988) proposed two tests statistics to determine the cointegration rank, which are trace statistic denoted by LR_{tr} and maximum eigenvalue statistic denoted by $\lambda_{\max}$. The trace statistics is shown in function (2)

$$LR_{tr}(r \mid k) = -T \sum_{i=r+1}^{k} \ln(1-\hat{\lambda}_i) \tag{2}$$

[5] Unit root testing and cointegration analysis are conducted using EVIEWS 5.1 (2004).

where $\hat{\lambda}_i$ denote the i-th largest Π eigenvalue of the matrix in function (1). The maximum eigenvalue statistic tests the null hypothesis of r cointegrating relations against the alternative of $r+1$ cointegrating relations. This test statistic is computed as function (3):

$$LR_{\max}(r \mid r+1) = -T\ln(1-\lambda_{r+1}) = LR_{tr}(r \mid k) - LR_{tr}(r+1 \mid k) \quad (3)$$

for r=0, 1, 2….., k-1.

Johansen and Juselius (1990) indicated that trace test might lack the power relative to the maximum eigenvalue test. Based on the power of the test, the maximum eigenvalue test statistic is often preferred. Johansen Cointegration test results are presented in Table 3a and Table 3b. Table 3a shows that only one trace statistic rejects the hypothesis of no cointegration at the 5% level, which implies that the evidence of cointegration among the prices of ethanol in three markets is very weak. Thus, the ethanol prices in Europe, USA and Brazil are very unlikely cointegrated. Table 3b shows the cointegration relationship among the selected vegetable oils in EU market. The result shows that with constant and linear trend included, the Johansen-Juselius cointegration test confirms that only one vector cointegration existed, indicating that the long-term relationship is found among the vegetable oil prices. Hence, the vegetable oil prices move in tandem in the long-term.

Table 3a. Johansen Cointegration Test for ethanol

(i) Constant included

Hypothesized No. of CEs	Max-Eigenvalue	5% max	Trace statistic	5% trace
r=0	14.56	22.3	30.40	35.19
r=1	11.27	15.89	15.84	20.26

(ii) Constant not included

Hypothesized No. of CEs	Max-Eigenvalue	5% max	Trace statistic	5% trace
r=0	13.75	17.80	25.08**	24.28
r=1	10.58	10.50	11.32	12.32

Table 3b. Johansen Cointegration Test for selected vegetable oils

(i) Constant and linear trend included

Hypothesized No. of CEs	Max-Eigenvalue	5% max	Trace statistic	5% trace
r=0	27.64**	24.25	39.09**	35.01
r=1	7.36	17.15	18.39	18.39

(ii) Constant not included

Hypothesized No. of CEs	Max-Eigenvalue	5% max	Trace statistic	5% trace
r=0	11.07	17.79	22.88	24.28
r=1	9.82	11.22	11.82	12.32

Note: Critical values based on MacKinnon-Haug-Michelis (1999) **denotes rejection of hypothesis at 5% level

Causality test and VECM approach

The causality or causation is the relationship between causes and effects. The causality of two variables describes the extent of one variable is caused by the other. When there is causality, there is a measure of predictability between the two variable. The fundamental Granger causality method is based on the hypothesis that compared series are stationary or I(0). In the Absence of cointegration vector, with I(1) series, valid results in Granger causality testing are obtained by simply first differentiating the VAR model. Hassapis et al. (1999) show that in the absence of cointegration, the direction of causality can be decided upon via standard F-tests in the first differenced VAR. The VAR in the first difference can be written as:

$$\Delta X_t = c_0 + \sum_{i=1}^{k} \alpha_{1i} \Delta X_{t-i} + \sum_{j=1}^{k} b_{1i} \Delta Y_{t-1} + \mu_{1t} \quad (4)$$

$$\Delta Y_t = c_1 + \sum_{i=1}^{k} \alpha_{2i} \Delta X_{t-i} + \sum_{j=1}^{k} b_{2i} \Delta Y_{t-1} + \mu_{2t} \quad (5)$$

where ΔX_t and ΔY_t represents a pair of ethanol prices among $\ln p_t^{EU}$ $\ln p_t^{USA}$ and $\ln p_t^{Brazil}$. F test is carried out for the null hypothesis of no Granger causality $H_0 : b_{i1} = b_{i2} = b_{ik} = 0$, $i = 1,2$ The pairwise Granger Causality test results are shown in Table 4. Results of Granger-causality tests show the following facts:

1. The USA Granger cause to both EU and Brazil, implying that the change of ethanol price in USA has dominant impact in global ethanol market.
2. Brazil, as the biggest producer of ethanol, its ethanol price difference has rather bigger impact on the EU market than in USA.
3. The price difference of EU market has very limited effect on either USA or Brazil market. Thus there is only a one-way casualty running from USA market or Brazil market to EU market.

Table 4. Granger causality test results

	F - Statistics			
Null hypothesis	Lag 1	Lag 2	Lag 3	Lag 4
USA does not granger cause EU	1.747	7.553***	4.942***	3.91***
EU does not granger cause USA	0.898	2.418	1.809	1.262
EU does not granger cause Brazil	0.08	0.429	0.5320	0.403
Brazil does not granger cause EU	5.363**	2.654*	2.525*	1.911
USA does not granger cause Brazil	12.87***	5.39***	4.04***	3.007**
Brazil does not granger cause USA	4.46**	0.777	1.115	1.455

Note: *, ** and *** represent rejection of the null hypothesis at the 10%, 5% and 1% respectively.

As the cointegration test is confirmed as vegetable oils, the VECM approach is utilized to distinguish between the short-term and long-term causality of vegetable oil prices. Causality or causation is the relationship between causes and effects.

Table 5. Testing for vector error correction model (VECM)

	$\Delta \ln p_t^{rapeoil}$	$\Delta \ln p_t^{soyoil}$	$\Delta \ln p_t^{cpo}$
$\Delta \ln p_t^{rapeoil}$ (1)	0.036*	-0.015*	0.105*
$\Delta \ln p_t^{rapoil}$ (2)	0.115*	0.025*	0.008*
$\Delta \ln p_t^{soyoil}$ (1)	-0.091*	-0.087*	0.049*
$\Delta \ln p_t^{soyoil}$ (2)	0.047*	0.126*	0.046*
$\Delta \ln p_t^{cpo}$ (1)	0.014**	0.044*	-0.07*
$\Delta \ln p_t^{cpo}$ (2)	-0.113**	-0.0118*	0.03*
ECT	-0.115***	-0.069***	-0.126***

Notes: All variables in first difference (denoted by Δ)except the lagged error correction term (ECT). ***, **, * denote the levels of significance at 1%, 5% and 10% respectively)

Generally, it is accepted that the price of a vegetable oil is dependent on the its own past prices and other vegetable oil in the previous month. The is in agreement with economic theory where the price of a product is determined by supply and demand, the price of the product in the previous period as well as the prices of substitutes. According to Table 5, clearly, the prices of the selected vegetable oils are significant factors influencing each other, which indicate that the prices of vegetable oils have bi-directional causality to each other. Especially, The VECM illustrates that the price of crude palm oil is the most significant factor influencing the price of rapeseed oil in EU in the short term. This means that CPO is a closer substitute to European rapeseed oil than soybean oil in the last two weeks.

Clearly, among the selected vegetable oils, there is not such a price leader that its oil price is independent and not influenced by other vegetable oils. However, crude palm oil shows some evidence that it might be the closer substitute to European rapeseed oil. It may explain the reason that EU has been increasingly imported CPO from other regions.

Conclusions

In rapid growth of ethanol demand in EU has caused ethanol price to fluctuate much more within recently two years. Meanwhile, the import of feedstock for biodiesel such as palm oil and soybean oil has been also increasing during the last couple of years. The dominant ethanol markets in the world, are located in USA and Brazil, where the most production and trading took place. A careful assessment of the relationship between ethanol prices in EU and the prices in USA and Brazil provides significant insights to the greatly expanded linkages among these markets. In comparison, EU is one of most import biodiesel producers and consumer in the world, mostly used locally produced rapeseed oil. Imported palm oil and soybean oil are two popular substitutes. This study used Johansson cointegration test and Granger Causality test to investigate the price trend and relationship among these three ethanol markets and among the vegetable oils. Our results for regarding to ethanol market indicate that the ethanol prices in EU, USA and Brazil do not follow the same pattern in the long-term. Thus, the futures market for commodity CBOT in USA may not be the best predictor for the expected price for EU ethanol spot market. However, the study finds there is obvious Granger causality between EU and other markets, which is one-way directional. That is, the ethanol price changes in both USA and Brazil will affect EU market significantly in the short term, but not the other way around. USA, as the major producer and trader for ethanol, its ethanol market has dominant impact in the global ethanol market. Brazil, the biggest producer of ethanol, its ethanol price change gives significant impact only to EU but not to USA market. The results of vegetable oil prices show that there is no a significant price leader for selected substitutes vegetable oils, even though the similar research from global perspective provides some different opinion (Amiruddin et al. 2005). The price competition among the vegetable oils in EU seemed quite tough, which give some potential for EU local rapeseed oil. However, the competitiveness of rapeseed oil compared to other vegetable oils for both food industry and biodiesel industry need to be further carefully studied.

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