EUROPEAN RAPESEED AND FOSSIL DIESEL: THRESHOLD COINTEGRATION ANALYSIS AND POSSIBLE IMPLICATIONS

Martin Ziegelbäck, Gregor Kastner

ziegelbaeck@farming.at

University of Natural Resources and Life Sciences, Vienna - BOKU
Department of Economics and Social Sciences

Institute for Statistics and Mathematics
Vienna University of Economics and Business, Austria

GEWISOLA

2011

Vortrag anlässlich der 51. Jahrestagung der GEWISOLA

„Unternehmerische Landwirtschaft zwischen Marktanforderungen und gesellschaftlichen Erwartungen“

Halle, 28. bis 30. September 2011

Content

Abstract..3

Zusammenfassung 3

1. Introduction 3

2. Theoretical issues 4

3. Empirical Analysis..5

4. Conclusion..8

References..8

List of Figures

Figure 1: Daily log-prices of Heating Oil and Rapeseed from 2005 until 2010

List of Tables

Table 1: ADF Test and PP Test for Heating Oil and Rapeseed

Abstract

In this paper we analyze the long-run relationships between Rapeseed prices at Euronext Paris and the conventional NYMEX diesel prices during the period 2005 to 2010. For the European operators of biofuels plants there are not many hedge vehicles available to hedge their input and output factors. Cross hedges for rape oil (with the rapeseed futures contract) and RME (with the NYMEX diesel futures contract) could be useful instruments. We use recent developments on threshold cointegration approaches to investigate if asymmetric dynamic adjusting processes exist among rapeseed and diesel prices. The results suggest that a three-regime threshold cointegration model suitably explains the dynamics of the data. We demonstrate with statistical significance that – in extreme situations where Rapeseed price is low compared to Heating Oil – Heating Oil adjusts Rapeseed to its long term equilibrium more strongly and faster than in the remaining periods. G140, Q140

KEY WORDS: Hedging, Rapeseed, Heating Oil, Threshold cointegration analysis

Zusammenfassung

In dieser Arbeit analysieren wir das langfristige Gleichgewicht zwischen den Preisen von Rapssaat an der Euronext Paris und Heizöl an der NYMEX für die Periode 2005 bis 2010. Für Europäische Biodieselproduzenten sind nur wenige Möglichkeiten vorhanden, um Input- und Outputfaktoren gegen Preisrisiken abzusichern. Cross-hedges für Rapsöl (mit dem Euronext Rapskontrakt) und RME (mit dem NYMEX Dieselkontrakt) könnten wirkungsvolle Instrumente dazu sein. Wir verwenden neuere Methoden der Schwellenwert-Kointegrationsanalyse um zu untersuchen, ob asymmetrische dynamische Anpassungen zwischen Rapssaat und Diesel existieren. Die Ergebnisse zeigen, dass ein Schwellenwert-Kointegrationsmodell mit drei Regimen die Dynamik in den Daten passend widerspiegelt. Nur für extreme Situationen – wenn der Preis von Rapssaat im Vergleich zu Heizöl niedrig ist – können wir mit statistischer Signifikanz nachweisen, dass Heizöl den Preis von Rapssaat in sein langfristiges Gleichgewicht korrigiert. Dies passiert schneller und stärker als in anderen Perioden. G140, Q140

SCHLÜSSELWÖRTER: Absicherung, Rapssaat, Heizöl, Schwellenwert-Kointegrationsanalyse

1. Introduction

Volatility in markets for biofuels proved to be high over the last years: Rising commodity and food prices (FLAMMINI, 2008; KANAMURA, 2008), oscillating demand for biofuels, over-supply of biofuels and increasing links between the energy and the commodity markets (CAESAR, RIESE & SEITZ, 2007:53ff) have resulted in increasing risk for producers of e.g., corn for corn-based ethanol production (WU & GUAN, 2009) or rapeseed for rapeseed-based production of biodiesel, but for the producer of biofuels as well. With increasing interconnectivity between energy and commodity markets, the risk for the biofuels producer and the commodity producer alike is linked to two markets (HARRI & HUDSON, 2009), i.e. volatility is amplified. Nevertheless, McKinsey (CAESAR, RIESE & SEITZ, 2007) recommends investments in biofuels as a reliable source of income and profit. The main driver might come from two biofuels 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].

Several studies in the past have analyzed vegetable oil price relationships, among others IN & INDER (1997) and OWEN, CHOWDHURY & GARRIDO (1997). In addition to the recent YU, BESSLER & FULLER (2006), CAMPICHE, BRYANT, RICHARDSON & OUTLAW (2007) and PERI & BALDI (2008) studies have considered the potential link between vegetable and mineral oil. Furthermore it is evident, that European biofuels producers suffer from a lack of tradable hedging vehicles, to manage their price risks. Already LIU (2008:2) has stated that the CBOT futures market for Ethanol is not a good predictor for the EU Biofuels spot market and also recommended setting up an own price indicator (futures contracts) for biodiesel. In consequence we examine the ability of comparable futures contracts, to serve as an efficient price and risk management tool for European plant operators. In other words: Can biodiesel producers lock in future operational margins, because of the indication of a long-run relationship between the markets? Hence, it is beneficial to investigate possible interactions. In so doing, we follow the assumption that there might be a no-arbitrage band, which is bounded by the installed output capacity – 12.5 billion liters in 2010, MOUSDALE (2011:8) – as well as by publicly stated and centrally directed objectives for biofuels consumption inside the European Union (EU). Off this range, markets should not experience price-linearity. With the aim to gain better insight into price behaviors, we applied a threshold vector error correction model (TVECM) to investigate if asymmetric dynamic adjusting processes exist between EU Rapeseed futures price and fossil fuel prices.

The next chapter (chapter 2) will briefly summarize what is understood as threshold cointegration analysis. Chapter 3 will explain the test procedure and outline evidence from cointegration analysis, while chapter 4 will summarize the results.

2. Theoretical issues

Integrated time series for which a linear combination exists which is stationary are said to be *cointegrated*. This linear combination can then be interpreted economically as the presence of a long-run equilibrium. As illustrated by STIGLER (2010), the cointegration concept gained a significant interest with the so-called Granger representation theorem, which states that cointegrated variables have a vector error correction model (VECM) representation, that can be seen as a VAR model including a variable representing the deviations from the long-run equilibrium.

This VECM representation is particularly interesting as it allows to estimate how the variables adjust deviations towards the long-run equilibrium, to test for Granger-causality as well as to determine the impacts of shocks to the variable using impulse response functions. However, it requires a linear dependence structure throughout the entire observation period, which is hard to justify in practice.

BALKE and FOMBY (1997) introduced the concept of threshold cointegration, which allows taking into consideration this main criticism raised against linear cointegration. In their

[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 October 2003 (O.J.L283, 31/10/2003)

framework, the adjustment need not to occur instantaneously but only once the deviations exceed some critical threshold, allowing thus the presence of an inaction, or no-arbitrage band (STIGLER, 2010:5).

Hence, for further analysis a threshold vector error correction (TVECM) model with three states is employed, accounting for the "no-arbitrage" state of the world as well as one exceptional state in each direction (see below for details and interpretation). A priori it is not clear (to us) how wide such a band might be, thus we employ a grid search for optimum threshold parameters minimizing RSS. Equation (1) shows such a model for two variables with three states (L, M, H) including a constant c, the error correction term and one lag.

$$\begin{bmatrix} \Delta X_t \\ \Delta Y_t \end{bmatrix} = \left\{ \begin{matrix} \begin{bmatrix} c_{1L} \\ c_{2L} \end{bmatrix} \\ \begin{bmatrix} c_{1M} \\ c_{2M} \end{bmatrix} \\ \begin{bmatrix} c_{1H} \\ c_{2H} \end{bmatrix} \end{matrix} + \begin{matrix} \begin{bmatrix} \alpha_{XL} \\ \alpha_{YL} \end{bmatrix} \\ \begin{bmatrix} \alpha_{XM} \\ \alpha_{YM} \end{bmatrix} \\ \begin{bmatrix} \alpha_{XH} \\ \alpha_{YH} \end{bmatrix} \end{matrix} \right\} ECT_{t-1} + \left\{ \begin{matrix} \begin{bmatrix} b_{11L} & b_{12L} \\ b_{21L} & b_{22L} \end{bmatrix} \\ \begin{bmatrix} b_{11M} & b_{12M} \\ b_{21M} & b_{22M} \end{bmatrix} \\ \begin{bmatrix} b_{11H} & b_{12H} \\ b_{21H} & b_{22H} \end{bmatrix} \end{matrix} \right\} \begin{bmatrix} \Delta X_{t-1} \\ \Delta Y_{t-1} \end{bmatrix} + \left\{ \begin{matrix} \begin{bmatrix} \varepsilon_t^{XL} \\ \varepsilon_t^{YL} \end{bmatrix} \\ \begin{bmatrix} \varepsilon_t^{XM} \\ \varepsilon_t^{YM} \end{bmatrix} \\ \begin{bmatrix} \varepsilon_t^{XH} \\ \varepsilon_t^{YH} \end{bmatrix} \end{matrix} \right\} \quad (1)$$

$$ECT_{t-1} = (1, -\beta) \begin{bmatrix} X_{t-1} \\ Y_{t-1} \end{bmatrix}$$

3. Empirical Analysis

For the analysis, we use daily data for Heating Oil futures contracts[3] and Rapeseed futures contracts[4] ranging from January 3, 2005 until December 30, 2010. Prices for Heating Oil are given in US dollars per 100 gallons and are transformed to Euros per 100 gallons via daily exchange rates; prices for Rapeseed are given in Euros per ton. All prices have been converted to natural logarithms for further exploration.

In agreement with the literature, we find that the raw (and thus also the log) time series are clearly non-stationary, while the returns are stationary. See Table 1 for results of Augmented-Dickey-Fuller (ADF) as well as Phillips & Perron (PP) Unit Root Tests. We conclude that there is strong evidence that the series are I(1).

[3] NYMEX HO futures contract, settlement prices, nearest delivery month, downloaded from www.nymex.com

[4] Euronext Paris ECO futures contract, settlement prices, nearest delivery month, downloaded from www.hgca.com

Table 1: ADF Test and PP Test for Heating Oil and Rapeseed

Series	ADF	PP
Oil	0.7459809	-2.6273*
DeltaOil	-28.95347***	-42.6581***
Rapeseed	1.819592	-0.2148
Delta Rapeseed	-28.2062***	-43.0279***

***, **, and * indicate the reject of the Null at 0.01, 0.05 and 0.1 significance level

The estimation of TVECM with three regimes is conducted using the R-package `tsDyn` by STIGLER (2010), which yields an estimated cointegration coefficient of $\beta = 0.876468$ by minimizing the SSR, thus we have an error correction term $ECT_t = Gas_t - 0.88 \times Rape_t$. Note that it is not necessary to estimate a constant here, as the individual regimes in (1) compensate for constants already; doing so would result in model-overspecification.

We can interpret the first regime, occurring when $ECT_t \leq -0.2953$ (4.7% of all cases), as times where Rapeseed Price is exceptionally high compared to Heating Oil. The second regime occurs when $-0.2953 < ECT_t < 0.1653$ (73.5% of all cases) and corresponds to the "usual" scenario that may interpreted as a no-arbitrage band. The third regime is of course defined when $ECT_t \geq 0.1653$ (21.8% of all cases), meaning that Rapeseed Price is exceptionally low compared to Heating Oil.

Figure 1 shows the distribution of scenarios along the time axis, indicated by black solid dots on the bottom of the graph. A "low" dot corresponds to the first regime, a "middle" dot corresponds to the second regime, and a "high" dot corresponds to the third regime. It can clearly be seen that the third regime only occurs in the beginning of 2009, where the price of Heating Oil dropped heavily. The first regime mainly happens in 2005 and 2006, with comparably high Heating Oil prices.

The estimated TVECMs are presented below with corresponding p-values in parentheses:

Regime 1 (Low, $ECT_t \leq -0.2953$; 4.7% of all cases)

$$\Delta Oil_t = -0.1243_{(3.8e-05)} - 0.3606_{(2.5e-05)}\,\mathrm{ECT}_{t-1} - 0.2425_{(0.0035)}\,\Delta Oil_{t-1} + 0.3781_{(0.0720)}\,\Delta Rape_{t-1} + \varepsilon_t$$

$$\Delta Rape_t = -0.0076_{(0.6509)} - 0.0213_{(0.6542)}\,\mathrm{ECT}_{t-1} - 0.0374_{(0.4187)}\,\Delta Oil_{t-1} + 0.0258_{(0.8254)}\,\Delta Rape_{t-1} + \varepsilon_t$$

Regime 2 (Middle, $-0.2953 < ECT_t < 0.1653$; 73.5% of all cases)

$$\Delta Oil_t = 0.0003_{(0.6631)} - 0.0093_{(0.1528)}\,\mathrm{ECT}_{t-1} - 0.0612_{(0.0615)}\,\Delta Oil_{t-1} + 0.0393_{(0.4983)}\,\Delta Rape_{t-1} + \varepsilon_t$$

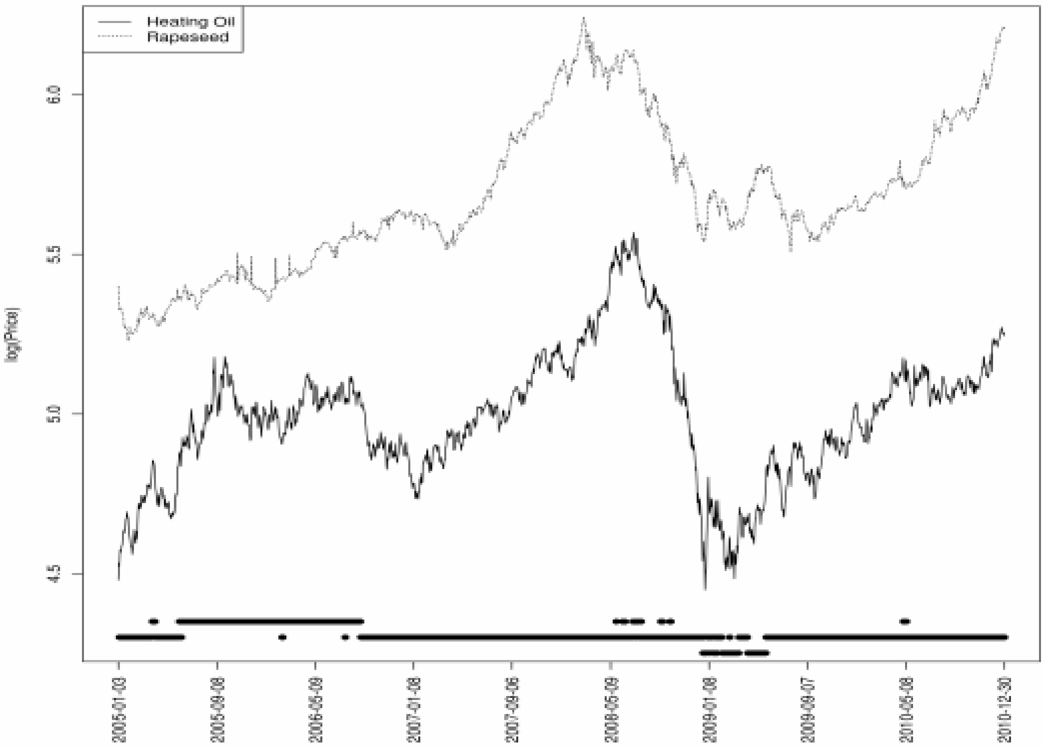
$$\Delta Rape_t = 0.0005_{(0.2183)} - 0.0032_{(0.3828)}\,\mathrm{ECT}_{t-1} + 0.0309_{(0.0905)}\,\Delta Oil_{t-1} + 0.0526_{(0.1038)}\,\Delta Rape_{t-1} + \varepsilon_t$$

Regime 3 (High, $ECT_t \geq 0.1653$, 21.8% of all cases)

$$\Delta Oil_t = 0.0082_{(0.1426)} - 0.0370_{(0.1000)}\,\mathrm{ECT}_{t-1} - 0.0578_{(0.2832)}\,\Delta Oil_{t-1} + 0.0332_{(0.6771)}\,\Delta Rape_{t-1} + \varepsilon_t$$

$$\Delta Rape_t = -0.0055_{(0.0784)} + 0.0249_{(0.0466)}\,\mathrm{ECT}_{t-1} + 0.0444_{(0.1386)}\,\Delta Oil_{t-1} - 0.4301_{(1.5e-21)}\,\Delta Rape_{t-1} + \varepsilon_t$$

Figure 1: Daily log-prices of Heating Oil and Rapeseed from 2005 until 2010 (T=1528).



Source: own illustration. Solid dots on the bottom of the figure indicate the current regime: “Low” dot means regime 1, “middle” dot corresponds to regime 2, “high” dot signifies regime 3.

Looking at the ECT-coefficient, we can see no statistically significant terms in either second regime. This can easily be interpreted as a “usual” state of the world, where the distance of the two time series at time $t-1$ does not play a role for the returns at time t. This is also true for the VAR-terms, showing that it is not possible to (linearly) predict future returns – a feature frequently observed for returns in general.

Observing the first regime, we notice significant negative dependence of ΔOil_t on ECT_{t-1}(which is negative itself in this regime) and ΔOil_{t-1} as well as a negative constant. This greatly differs from the values in the other regimes and shows that the beginning of 2009 was systematically different from other times: We see a tendency towards negative Oil returns in general, a strong mean reversion effect and a great deal of error correction, accompanied by high volatility. Clearly, great caution must be taken when interpreting these values, since there is only a rather limited number of data available in this regime and other influential variables may exist. Nevertheless, this regime shows strikingly different dynamics than the others and substantiates the use of thresholds.

In the third regime, where Rapeseed price is low compared to Heating Oil, thus ECT strongly positive, we can observe that both Heating Oil and Rapeseed prices are slightly pushed towards the long run equilibrium. Nevertheless, only the error correction coefficient for Rapeseed is statistically significant, showing that convergence of Rapeseed prices towards the long run equilibrium is only given if the deviation from that equilibrium exceeds the critical threshold.

4. Conclusion

The futures and option market for Rapeseed at Euronext Paris is capable to serve as a vehicle for European Biodiesel producers to hedge future input price risks. On the output side, the NYMEX heating oil futures contract is a proof instrument. Therefore, it is interesting to examine possible interactions between Rapeseed and fossil diesel prices. This can lead to the answer to the question whether future operational margins can be locked in. We have demonstrated that asymmetric movements occur between these two prices and that there is evidence of the presence of a threshold defining three different regimes. 73.5% of all states within a 6-year period can be understood as a "normal state of the world" where no interaction between prices is evident. In the two other regimes, (possibly non-causal) dependences can be shown. Only for extreme situations, where Rapeseed price is low compared to Heating Oil, can demonstrate with statistical significance that Rapeseed adjusts to its long run equilibrium more strongly and faster than in the remaining periods. This is in line with PERI & BALDI (2008), who pointed out similar coherences between Rape oil and Gasoil. Based on these results, we recognize Euronext Rapeseed futures and options contracts as reliable risk management tools for biodiesel operators.

References

CAESAR, W.K., RIESE, J. & SEITZ, T. (2007): Betting on Biofuels. McKinsey Quarterly 2: 53-63.

CAMPICHE, J.L., BRYANT, H.L., RICHARDSON, J.W. AND OUTLAW, J.L. (2007): Examining the evolving correspondence between petroleum prices and agricultural commodity prices, AAEA Proc. Portland, OR, July 29-August 1

FLAMMINI, ALESANDRO (2008): Biofuels and the Underlying Causes of High Food Prices. Rome: Global Bioenergy Partnership.

HARRI, A. & HUDSON, D. (2009): Mean and Variance between Agricultural Commodity Prices and Crude Oil Prices. Paper presented at the Economics of Alternative Energy Sources and Globalization: The Road Ahead. Orlando: November 15-17, 2009.

IN, F. AND INDER, B. (1997): Long-run relationships between world vegetable oil prices. Aust J Agr Resour Ec 41:455-70

KANAMURA, TAKASHI (2008): Monitoring the Upsurge of Biofuels in Commodity Futures Markets.

LIU, X. (2008): Impact and competitiveness of EU biofuel market – First view of the prices of biofuel market in relation to the global players: Paper prepared for presentation at the 107th EAAE Seminar "Modelling of Agricultural and Rural Development Policies". Spain, January 29th – February 1st, 2008

MOUSDALE, D., (2011): Can biofuels recover from the crunch?, Society of Chemical Industry and John Wiley & Sons, Ltd View online at Wiley Online Library (wileyonlinelibrary.com); DOI: 10.1002/bbb.268 Biofuels, Bioprod. Bioref. 5:7–9 (2011)

OWEN, A.D., CHOWDHURY, K. AND GARRIDO, J.R.R. (1997): Price interrelationship in the vegetable and tropical oils market. Appl Econ 29:119-24

Peri M., Baldi L. (2008): Biodiesel and vegetable oil market in European Union: some evidences from threshold cointegration analysis: 12th Congress of the European Association of Agricultural Economists – EAAE 2008

STIGLER, M. (2010): Threshold cointegration: overview and implementation in R: (Revision 4): paper downloaded from: http://cran.r-project.org/web/packages/tsDyn/vignettes/ThCointOverview.pdf on February 24th.

WU, F. & GUAN, Z. (2009): The Volatility Spillover Effects and Optimal Hedging Strategy in the Corn Market. Paper prepared for the Agricultural & Applied Economics Association Annual Meeting, Milwaukee, July 26-29, 2009.

YU, T.H., BESSLER, D.A. AND FULLER, S. (2006): Cointegration and causality analysis of world vegetable oil and crude oil prices, AAEA Proc. Long Beach, CA July 23-26