German Rapeseed Oil and Biodiesel Pricing under Changing Market Conditions:
A Markov-switching Vector Error Correction Model Approach

Stefan Busse and Rico Ihle

Georg-August-Universität Göttingen, Germany,
Department of Agricultural Economics and Rural Development,
Ihle is also member of the Center for Statistics of the Georg-August-Universität Göttingen,
Please address correspondence to sbusse1@gwdg.de

Contributed Paper prepared for presentation at the International Association of Agricultural Economists Conference, Beijing, China, August 16-22, 2009

Abstract

We analyze vertical price transmission in the German biodiesel market studying the relationship between rapeseed oil, soya oil and biodiesel prices. We focus on the period from summer 2002 to late 2007 during which the German biodiesel market developed into the largest market worldwide, mainly driven by political intervention. Tests on the adequacy of a traditional linear vector error correction model provide strong evidence against it and favor a regime-dependent model. We consider the Markov-switching vector error correction model which allows for parameter switching between regimes to be suitable for the question to be analyzed. We find two distinct regimes with differing error-correction behavior. Estimation results indicate that only rapeseed oil prices adjust deviations from the long-run equilibrium between the three prices. Error-correction is found to be strong until 2005; however, it substantially weakens in 2006 and 2007 due to market distorting policy measures such as blending obligations and norms requiring the use of rapeseed oil.

Keywords: Biodiesel, cointegration, nonlinear vector error-correction model, regime-dependent model, Markov-switching.

JEL: C22, Q11, Q18

Introduction

The analysis of market integration received broad attention in the agriculture economics literature, and especially the integration of energy markets with agricultural commodities has been increasingly investigated. A central feature of integrated markets is that shocks to prices in one market are transmitted to other markets (Barrett 1996). Rapsomanikis and Hallam (2006) and Balcombe and Rapsomanikis (2008) found nonlinear price adjustment in the Brazil ethanol market, using a threshold vector error correction model (TVECM). Serra et al. (2008) found cointegration in the US ethanol industry using smooth transition VECM (STVECM) and Peri and Baldi (2008) observed cointegration between rapeseed oil and gasoil prices in the European market using a TVECM.

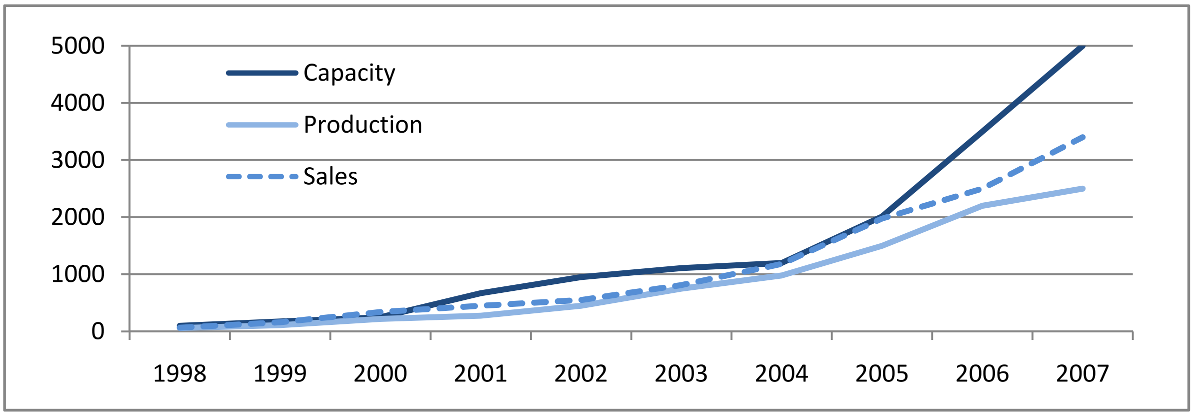
We focus on the largest biodiesel market worldwide, Germany, and simultaneously model the influence of biodiesel and soya oil prices on rapeseed oil prices. This is important since the substitutability of rapeseed and soya oil in food and fuel has to be considered when analyzing the impact of fuel prices. We apply a Markov-switching VECM (MS-VECM) to analyze this relationship what, to our knowledge, has not been done before. The pricing on the German biodiesel market is suspected to be heavily disturbed by changing policy interventions and market conditions, leading to regime-dependent behavior of the market which we expect to be able to detect with the MS-VECM.

The analysis of price transmission is problematic, as Goodwin (2006) argues, because the results can be consistent with a variety of different explanations. The understanding of the fundamental structure of the markets is essential for the proper interpretation of the results. The market development is therefore reviewed first in the following section presenting the necessary background information used later on for specifying the model and interpreting the estimation results. The econometric theory of the MS-VECM is explained in the third section which is followed by the description of the data. In the fifth section, the estimation results are presented. Section six discusses these results before, finally, conclusions are drawn.

The German biodiesel market

The market for biodiesel emerged in Germany in the late nineties and grew at high rates between 2004 and 2006 when the production capacity doubled annually (Figure 1). Since 2006 the industry suffered from strong overcapacity because sales, due to changes in market conditions, were not able to keep up with capacity increases. The main source of biodiesel is rapeseed oil, since the use of other vegetable oils is restricted through norms, which limit the use of soya oil to 20%. Despite an increase in the German rapeseed area to 1.5 million ha, yielding a harvest of more than 5 Mt, Germany became a net-importer of rapeseed oil as well as of rapeseed.

Figure 1: Production, capacity and sales of biodiesel in Germany in 1,000 t



Source: Own.

The growth of the German biodiesel market was mainly encouraged by tax exemptions granted since 2004. As the strong overcompensation of the biofuel industry due to this tax exemption was discovered, the exemption was partly withdrawn. An energy tax of 103 €/t biodiesel sold as B100 (pure biodiesel) and a full taxation (541 €/t) for biodiesel used in blends up to 5% (B5) was implemented in August 2006. A blending obligation of 5%

biodiesel in diesel by volume is applied since 2007, absorbing about 1.5 Mt biodiesel. A penalty of 690 €/t missing biodiesel is raised in case the target is not reached. In relationship to this penalty, the production costs are comparatively low. For plants without own crusher, which produce biodiesel from rapeseed oil, the production costs are estimated at 165 €/t (about 18% of the 2007 average biodiesel price).

Methodology

The basic idea of the traditional VECM is that variables, e.g. prices, are connected by a stable long-run equilibrium towards which they are attracted over time. The prices deviate from their equilibrium relationship in the short-run due to random shocks; however, these short-run deviations (the equilibrium errors) are corrected over time. The core assumption of the model is its linear character, i.e., that all parameters of the data generating process are constant. Parameter constancy is, however, problematic under frequent changes in market conditions (Krolzig 2002), as they occurred in the German biodiesel market. Besides strong political interventions, the quick growth of the biodiesel market and the increased usage of rapeseed oil for fuel production instead of food cast doubt on the assumption of constant parameters.

The inclusion of dummies would be a first choice to solve the problem but breakpoints are difficult, if at all, to determine since the market is characterized by substantial uncertainties about policy changes, and mainly driven by expectations based on, and towards policy changes. Price adjustment could hence take place before policy measures come into force, or could be delayed if investments were undertaken. The difficulty of identifying and quantifying potential regime switches in the structural relationship of the variables and the variables inducing them favors another modeling strategy.

The appropriate model should allow parameters to take different values depending on the regime of the data generating process, without requiring the *a priori* specification and measurement of the variables causing the switches and their occurrence date. If markets and trade processes were the main forces generating the data, a TVECM would be most suitable. If the price data is, however, subject to exogenous impacts such as the changing governmental legislation, a MS-VECM is more suitable, since it does not require a specification of the switching variable (Ihle and von Cramon-Taubadel 2008).

The MS-VECM is based on the idea of regime-dependent time series models of Hamilton (1989) and in detail investigated by Krolzig (1997). Regime-dependent models assume a non-linear data generating process as piecewise linear by modeling it as linear conditional on the regime switch, which is denoted by the regime variable s_t. Hence, key difference between the VECM and the MS-VECM is the assumption on the model parameters which are not anymore restricted to be constant but allowed to be regime-dependent. The parameters are allowed to take in each regime a constant value and to switch between the regimes (Krolzig 2003).

The model was used to investigate the integration of agricultural commodity markets along the marketing chain in Brümmer et al. (2008) who analyzed the transmission between wheat and flour prices in Ukraine. They found four regimes reflecting different market behavior in different market phases. Most notable was the estimation of a regime reflecting the uncertainty in times of drastic changes in the market.

For analyzing market integration in the German biodiesel market it seems plausible to allow the vector of intercepts a_o, the loading matrix α, containing the magnitudes at which deviations from the long-run equilibrium are corrected, and the short-run adjustment matrices Γ_1 and Γ_2 to be regime-dependent. Hence, we propose the following MS-VECM specification:

$$\Delta p_t = a(s_t) + \alpha(s_t)\,(\beta' p_{t-1}) + \Gamma_1\,(s_t)\Delta p_{t-1} + \Gamma_2(s_t)\,\Delta p_{t-2} + u_t \qquad (1)$$

where, $p_t = (p_t^{Ro} \quad p_t^{BD} \quad p_t^{So})'$ is the vector of market prices for the three commodities. β represents the cointegration vector quantifying the long-run equilibrium of the prices, Δ denotes the first difference operator and u_t the residuals.

The core characteristic of regime-dependence is represented by the variable s_t indicating which of the M regimes governs the system at time t. This variable causing the regime and their switches may be unobservable or even unknown resulting in that the regimes s_t may also not be observable. The particular strength of the MS-VECM consists in its ability and high flexibility in identifying the potentially latent regimes in the data. Model parameters are allowed to depend on the regime s_t and, hence, take the respective constant value in each regime:

$$a\,(s_t) \;=\; \begin{cases} a_1 & if\; s_t = 1 \\ \quad\vdots & \\ a_M & if\; s_t = M \end{cases} \quad . \qquad (2)$$

The stochastic process generating the regimes is assumed to be an ergodic, homogenous and irreducible Markov chain, characterized by its constant transition probabilities:

$$\pi_{ij} = \Pr(s_{t+1} = j | s_t = i)\;, \quad \pi_{ij} > 0 \qquad \forall\, i,j\; \in \{1, \dots, M\} \qquad (3)$$

which quantify the probability for switching from regime i in time t to regime j in time $t+1$. All M^2 probabilities are summarized in the quadratic, but usually not symmetric transition matrix Π containing the probability π_{ij} in the ith row and the jth column so that:

$$\sum_{j=1}^{M} \pi_{ij} = 1 \qquad \forall\, i = 1, \dots, M\,. \qquad (4)$$

The regime switches are not considered as singular deterministic events, but the unobservable regime is assumed to be governed by an exogenous stochastic process (Krolzig 2004).

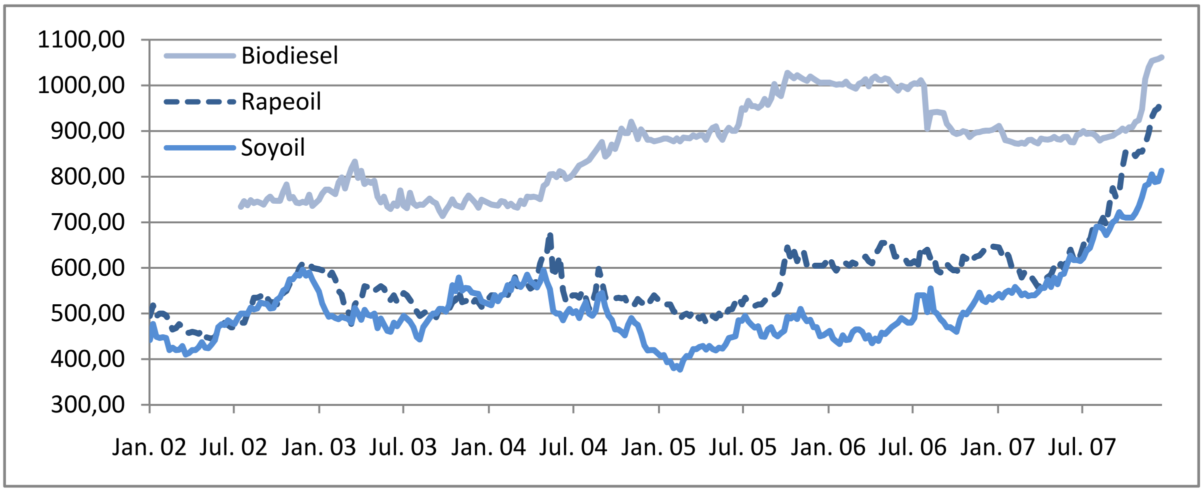
Hamilton (1989) characterizes them as “discrete shifts in regime-episodes across which the dynamic behavior of the series is markedly different”.

The regimes incidences can be reconstructed by inferring the probabilities of the occurrence of the unobserved regimes conditional on the available information in the sample (the so called smoothed probabilities). Deviations from the long-run equilibrium are corrected by the vector error correction mechanism in each regime. Since the regimes are generated by an ergodic and irreducible Markov chain, the errors arising from regime switches are corrected towards the stationary distribution of the regimes (Krolzig 2003).

The Data

The analysis is based on weekly observations from summer 2002 to the end of 2007 of rapeseed oil, soya oil and biodiesel prices (275 observations). All data are converted to € per ton and exclude VAT and other taxes. No adjustment for inflation was undertaken since the inflation rate in Germany is low (taking a maximum of 3% in 2007) and no deflator is available on weekly basis. Rapeseed and soya oil prices are German wholesale prices fob at the oil mill (ZMP 2008). Biodiesel prices reflect German consumer prices at the petrol station (UFOP 2008; Figure 2).

Figure 2: Development of German biodiesel, rapeseed and soya oil prices in €/t



Source: Own.

Expected values of the long-run elasticities

The prices are transformed into natural logarithms for the estimations, since the long-run coefficients can then be interpreted as long-run price transmission elasticities. The long-run elasticity of rapeseed oil prices with respect to soya oil prices ($\mathcal{E}_{Ro,So}$) can be expected to be close to one since rapeseed oil is a perfect substitute for soya oil in fuel and food, hence, price changes in soya oil should be fully transmitted to rapeseed oil prices.

When determining the long-run elasticity of rapeseed oil prices with respect to biodiesel prices, the possibility of substituting soya oil for rapeseed oil in biodiesel production has to be regarded. Following Wohlgenant (2001) the elasticity can be calculated using the marketing margins (*MM*). Assuming prices to be determined at the biodiesel level P_{BD}, with rapeseed oil prices P_{Ro} adjusting, *MM* has to be derived from P_{BD}. *MM* is assumed to consist of an absolute (α) and a relative (β) part ($MM = \alpha + \beta P_{BD}$). With fixed transformation rates between biodiesel and rapeseed oil, where λ is the input share of rapeseed oil, *MM* can be calculated by subtracting the rapeseed oil cost share from the biodiesel price ($MM = P_{BD} - \lambda P_{Ro}$). Bringing both assumptions together gives:

$$P_{BD} - \lambda P_{Ro} = \alpha + \beta P_{BD} \qquad (5)$$

which after reordering, differentiation with respect to P_{BD} and expansion by $\frac{P_{BD}}{P_{Ro}}$ yields the elasticity of P_{RO} with respect to changes in P_{BD}:

$$\mathcal{E}_{Ro,BD} = \frac{1-\beta}{\frac{P_{Ro}}{P_{BD}}\lambda} \quad . \qquad (6)$$

β is estimated to 0.587 by regressing the biodiesel price on the marketing margin. The average rapeseed oil price is estimated to $P_{Ro} = 586$ €/t and the average biodiesel price to

$P_{BD} = 867$ €/t. The share of rapeseed oil in biodiesel (λ) is presumed to be 80-90%. The expected long-run elasticity of rapeseed oil with respect to biodiesel ($\mathcal{E}_{Ro,BD}$) lies therefore between 0.68 and 0.76.

Empirical results

Unit root and cointegration tests

First, the three prices are tested for unit roots using the ADF and KPSS tests. Both tests give strong evidence for the presence of unit roots in all series[1]. Cointegration is then tested pairwise by the Johansen trace test, where the null hypothesis of no cointegration cannot be rejected for any of the pairs, which is confirmed by the Saikkonen and Lütkepohl test. Subsequently, all series are tested for joint cointegration. Applying the Johansen Trace test gives strong evidence for a single cointegration relationship, and, again, the Saikkonen-Lütkepohl test confirms this result.

VECM estimation results

First, we estimate a VECM with two lags for studying the fit of the linear model with constant parameters to the data. The long-run relationship of all three series, normalized with respect to rapeseed oil prices, yields (standard errors in parentheses):

$$\underset{}{ln\ P_t^{Ro}} = \underset{(1.0319)}{-4.8573} + \underset{(0.1140)}{0.7429}\, ln\, P_t^{BD} + \underset{(0.0933)}{0.9965}\, ln\, p_t^{So} + ect_t \quad . \qquad (7)$$

The estimated elasticity of rapeseed oil prices with respect to soya oil prices does, with a value of 0.997 (0.09), not significantly differ from one. The elasticity of rapeseed oil prices with respect to biodiesel prices lies with an estimate of 0.74 (0.11) in the expected range.

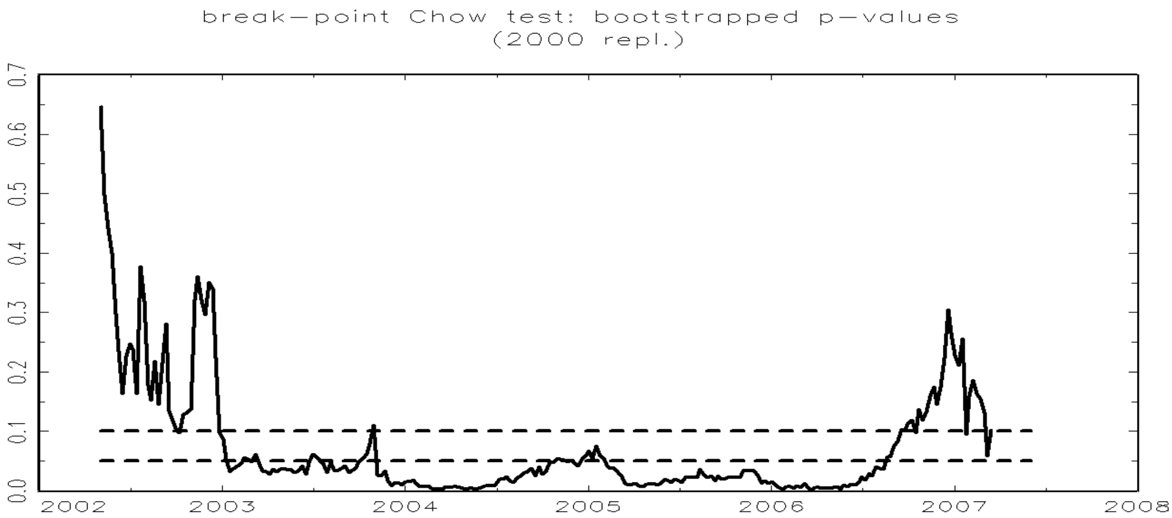
---

[1] Test statistics are available from the authors upon request

Rapeseed oil prices significantly error-correct towards the long-run equilibrium (α^{Ro} = -0.120 (0.024)) while the coefficients both for biodiesel (α^{BD}= -0.011 (0.014)) and soya oil prices (α^{So} = 0.001 (0.025)) are not statistically significant. Thus, correction of deviations from the long-run equilibrium is only shown by rapeseed oil prices.

The residual analysis of this model indicates problems of heteroskedasticity, autocorrelation and non-normality. In order to test for parameter stability, we conduct a break-point Chow test on all model parameters, except the cointegrating vector β, over each data point with 2,000 bootstrap replications. The parameter constancy null hypotheses can be rejected for almost all possible breakpoints between 2003 and 2007 at the 5% level (see Figure 3).

Figure 3: P-values of the bootstrapped break-point Chow test



Source: Own.
Note: A value below the lower dotted line indicates the rejection of the parameter constancy hypothesis at the 5% level of significance.

Both the residual as well as the stability analysis strongly suggest that a linear VECM does not fit the data and, furthermore, the assumption of constant parameters cannot be justified. Hence, a non-linear modeling strategy has to be preferred. We estimate the regime-dependent MS-VECM since we consider it as most appropriate because the German biodiesel market was subject to changing complex economic and political influences.

MS-VECM estimation results

We estimate a MSIAH(2)-VECM, which allows for Markov-switching in the error-correction coefficients, the intercept (I), autoregressive parameters (A), and in the standard errors of the equations (heteroscedasticity, H) between the two regimes (2). This specification is suggested by the Hannan-Quinn and the Schwarz information criteria and yields consistent results (Table 1), which are interpreted in detail below. The model is estimated using one lag for biodiesel and two lags for soya oil prices. The diagnostic tests indicate a normal distribution of the residuals of the MSIAH(2)-VECM and the absence of autocorrelation and heteroskedasticity; hence, the model seems to be appropriate for the data.

Table 1: Estimation results of the MSIAH(2)-VECM

Variable	Regime 1 (adjustment regime)			Regime 2 (biodiesel regime)		
	Δp^{Ro}	Δp^{BD}	Δp^{So}	Δp^{Ro}	Δp^{BD}	Δp^{So}
Const	-1.202***	0.066	-0.062	-0.309***	-0.045	0.031
	(0.316)	(0.202)	(0.297)	(0.113)	(0.049)	(0.127)
Δp^{BD}_{t-1}	-0.201	-0.092	0.044	0.263*	-0.184***	-0.509***
	(0.185)	(0.125)	(0.180)	(0.136)	(0.064)	(0.166)
Δp^{So}_{t-1}	-0.110	0.079	0.142	-0.089	-0.032	-0.163**
	(0.131)	(0.085)	(0.126)	(0.072)	(0.035)	(0.083)
Δp^{So}_{t-2}	-0.167	0.013	-0.034	-0.013	-0.001	0.203***
	(0.136)	(0.089)	(0.135)	(0.064)	(0.031)	(0.076)
ECT_{t-1}	-0.247***	0.013	-0.013	-0.064***	-0.009	0.006
	(0.065)	(0.041)	(0.061)	(0.023)	(0.010)	(0.026)
SE	0.035	0.024	0.034	0.020	0.009	0.022
Constant restricted in the ECT	4.861			4.847		

Source: Own calculations.
Note: Standard deviation in parentheses; asterisks denote significance at the 1%(***), 5%(**) and 10%(*) level

Interestingly, the constant does not significantly change between the two regimes if it is restricted to the cointegration vector, and is therefore not considered a suitable parameter to distinguish the regimes. The error-correction behavior varies between the regimes and is the main characteristic to discriminate them from each other. The adjustment speed of rapeseed oil prices is almost of the fourfold magnitude in the first regime ($a^{Ro} = -0.247$) compared with the second one ($a^{Ro} = -0.064$), corresponding to half lives, i.e., the times needed for correcting 50% of a deviation from the long-run equilibrium, of almost 2.5 weeks and 10.5 weeks, respectively. Another distinction between the regimes is the short-run adjustment behavior. Only in the second regime, a significant adjustment in rapeseed oil prices to changes in biodiesel prices is found.

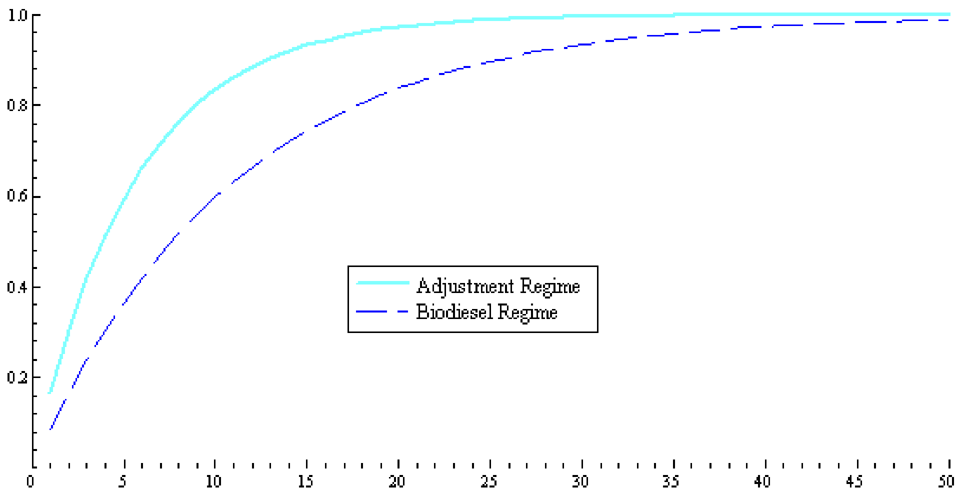
Based on these differences between the regimes, the first regime is labeled "adjustment regime" in the following, since a strong adjustment towards the long-run equilibrium occurs here and the second regime is labeled "biodiesel regime" due to the short-run impact of changes in biodiesel prices. The estimated transition probabilities are given in Table 2. Assuming the Markov-chain is in the biodiesel regime, it has a 91.3% probability to stay in and a 9.7% probability to leave it and switch to the adjustment regime.

Table 2: Transition matrix for the MSIAH(2)-VECM

to… / from...	Adjustment regime	Biodiesel regime
Adjustment regime	0.8347	0.1653
Biodiesel regime	0.0869	0.9131

Source: Own calculations.

Figure 4: Cumulated probability of leaving the regimes



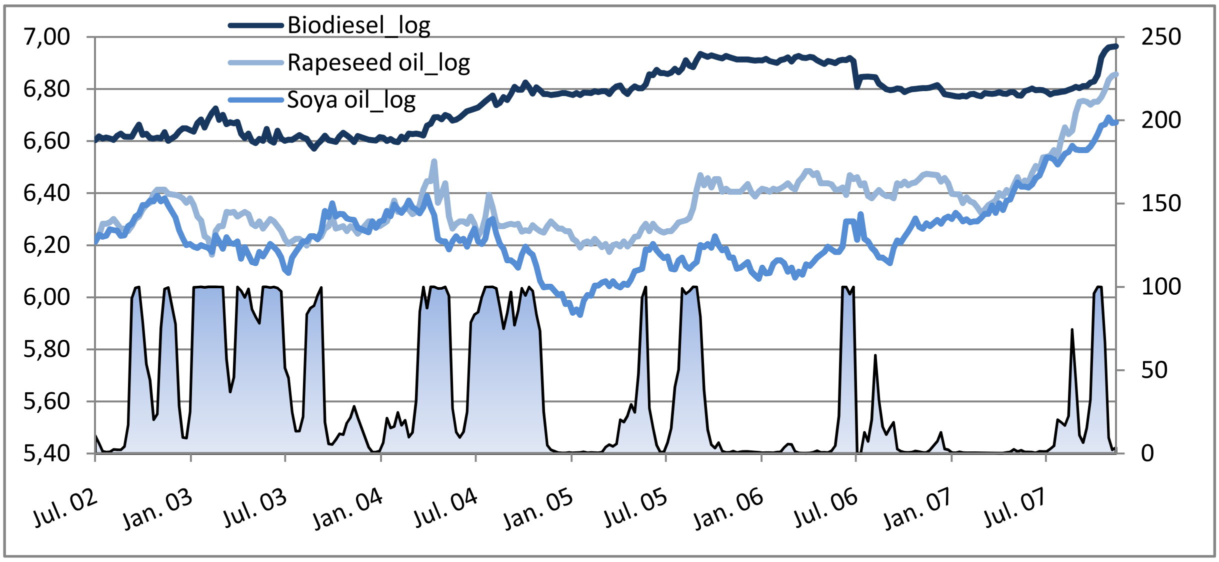
Source: Own calculations.

The biodiesel regime appears to be even more persistent than the adjustment regime. The system lasts on average for more than eleven weeks in the biodiesel regime compared to only six weeks in the adjustment regime. Even though the regime probabilities do not change over time, the cumulated probability of leaving the regime increases (Figure 4). The adjustment regime is exited with a probability of 95% after approximately 17 weeks, whereas the biodiesel regime is exited with the same probability after 33 weeks.

Discussion

In the following, the statistical results are interpreted based on the market development discussed before. Until autumn 2003 the adjustment regime with strong error-correction was almost continuously present (Figure 5). The first continuous presence of the biodiesel regime began in October 2003, following a strong increase in soya oil prices. The error-correction ensured by rapeseed oil prices was low as the difference towards biodiesel prices diminished (Figure 7). Meanwhile, the importance of the biodiesel industry as sales market for rapeseed oil grew. The error correction term (ECT; Figure 6) remained negative until April 2004.

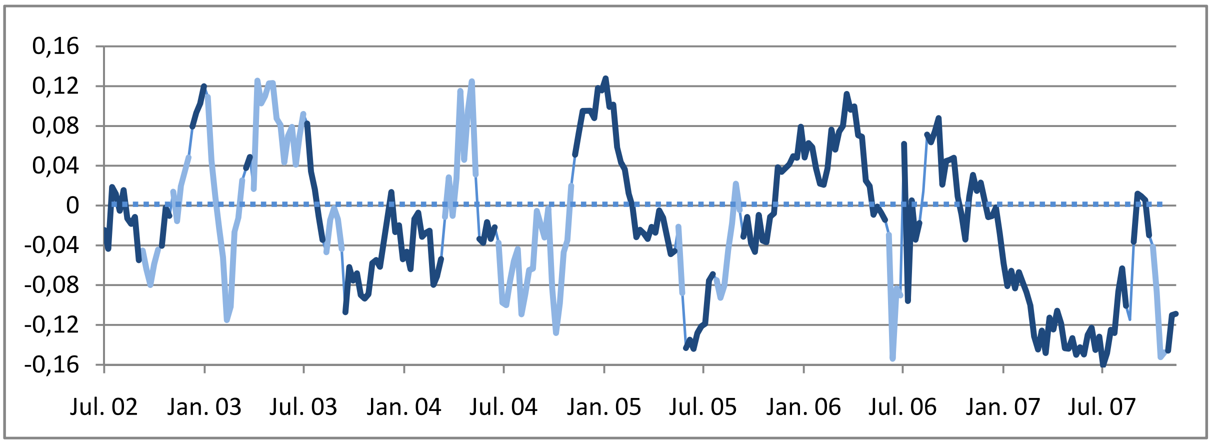
Figure 5: Biodiesel, soya oil and rapeseed oil prices in logs and smoothed probabilities of the adjustment regime



Source: Own calculations.

After a slump in soya oil prices in May 2004, rapeseed oil prices were quickly brought back into equilibrium in the adjustment regime. The equilibrium was binding in June/ July 2004 and the adjustment regime was present until November 2004. Negative peaks in the ECT ruled from increases in biodiesel prices and fluctuation in soya oil prices. Furthermore, the German rapeseed harvest brought a record yield of 4.13 t/ha and prices dropped within four weeks by 31%. All these effects pushing the ECT away from equilibrium were quickly corrected by the strong adjustment of rapeseed oil prices in the adjustment regime.

Figure 6: Error correction term with regime assignment

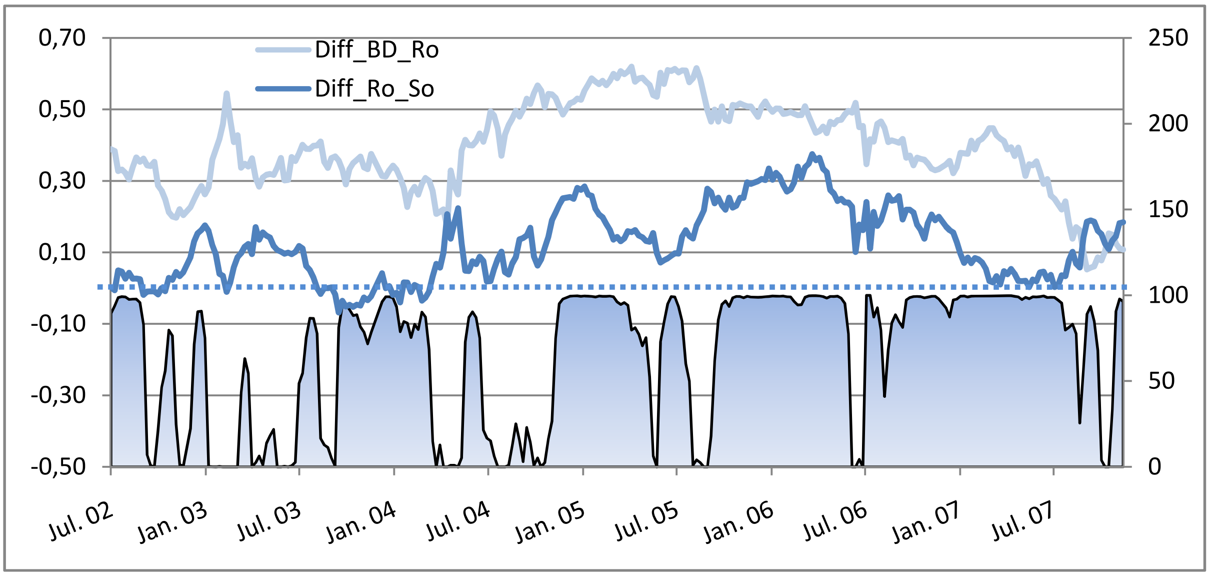


Source: Own calculations.

In February 2005 soya oil prices reached a trough but rapeseed oil prices were unaffected and orientated at stable biodiesel prices. The biodiesel regime was present until May 2005. The ECT was strongly positive and the weak error-correction needed several months to bring it back to equilibrium. The stronger influence of the biofuel industry with sales of two million tons biodiesel mainly produced of rapeseed oil, showed effect now.

The ECT became strongly negative after a rise in biodiesel and soya oil prices in June 2005 but the respective adjustment of rapeseed oil prices towards the equilibrium did not follow until September. With the switch into the adjustment regime, rapeseed oil prices caught up and the deviations from long-run equilibrium were corrected within six weeks. The reason for the late adjustment of rapeseed oil prices might have been expectations of a high rapeseed harvest. The total rapeseed harvest dropped despite an increase in rapeseed area, while demand from the biodiesel industry increased.

Figure 7: Differences between logged biodiesel, soya oil and rapeseed oil prices and smoothed probabilities of the biodiesel regime[2]



Source: Own calculations.

During the following nine months, the biodiesel regime was present, and the ECT grew steadily, as did the difference between rapeseed and soya oil prices (Figure 7). The prices were not brought into equilibrium until June 2006. The main driving force of this imbalance can be found in the strong overcapacity in biodiesel production and strict norms requiring the use of rapeseed oil. Rapeseed (-oil) became the limiting factor. Despite increased rapeseed production (5.3 Mt), Germany became a net-importer of rapeseed (1 Mt) and rapeseed oil (0.4 Mt).

After the announcement of the taxation of biodiesel starting in August 2006, the market came back into equilibrium in June 2006. The adjustment regime lasted until end of July, and deviations from the equilibrium were corrected within few weeks. The massive exogenous

[2] Note that the smoothed probabilities of the biodiesel regime are calculated as one minus the smoothed probabilities of the adjustment regime.

shock to the market from taxation made an adjustment of biodiesel production necessary and comparably cheap soya oil was increasingly used for biodiesel production. With very slow error correction in the biodiesel regime, rapeseed oil prices needed until October to move towards the equilibrium.

With the overall increase in vegetable oil prices in 2007, the difference between rapeseed and soya oil prices vanished. This effect outweighed the effect of overcapacity, and the ECT became strongly negative in spring 2007 so that the equilibrium was not reached until October. The German harvest in July brought the lowest yield in five years (3.44 t/ha), and rapeseed prices increased from 240 €/t in April to 380 €/t in December 2007. The net imports of rapeseed (1.5 Mt) and rapeseed oil (0.9 Mt) increased further in 2007, while the use of rapeseed oil for food fell below 0.5 Mt. The margin between rapeseed oil and biodiesel prices fell under the production costs in late 2007. The market situation was not stable and the biodiesel price increased strongly to ensure cost recovery yielding in a strongly negative ECT.

This instability might be explained by various market disturbing factors but especially by policy failures which inhibited price adjustment. In 2006 rapeseed oil prices profited from overcapacity, resulting from exaggerated expectations of biodiesel producers, which limited error-correction through decreasing rapeseed oil prices. The tax introduction might have been unexpected to some market actors but was a rational reaction to at that time detected overcompensation. Since the prices came back into equilibrium after the tax introduction, it cannot said to be harmful.

The gap between rapeseed and soya oil prices resulted from strict norms for biodiesel which inhibited the use of soya oil for biodiesel production. This was partly balanced by the industry itself through application of maximum allowed shares of soya oil in biodiesel since late 2006. The need of fulfilling the blending obligations made even unprofitable biodiesel production necessary and did not allow the market to settle. A loosening of the biodiesel norms to allow for stronger usage of other vegetable oils besides rapeseed oil and an abolishment of the blending obligation might have circumvented this situation.

It is most interesting to observe from the estimation results that the adjustment regime got lost over time while the biodiesel regime became dominant. Both regimes in this MS-VECM mainly reflect different phases of the market development and different market behavior under changing market conditions.

Conclusions

In this paper we assess vertical price relationships within the German biodiesel market. Weekly prices for biodiesel, rapeseed oil and soya oil over the main development period of the biodiesel industry from 2002 to 2007 are analyzed. Strong evidence against a linear VECM is found so that a MS-VECM is preferred. A single long-run relationship between all three prices exists; however, the adjustment towards this equilibrium appears to be regime-dependent since market conditions change substantially. The strength of the MS-VECM consists in its enormous flexibility in detecting latent regimes in the data. It does neither require *a priori* identification of the variable (*s*) causing the regime switches, nor the *a priori* dating of the regime switches, but also allows plausible interpretation of estimation results. Furthermore the German biodiesel market during the period studied was characterized on the one hand by rapid development and on the other hand by strong political intervention which advocates the use of the MS-VECM model. Both the fit of the model and the intuitive interpretability with respect to the market development show the suitability of this approach, which to our knowledge has not been used before to analyze market integration between agricultural and energy prices.

The main finding of our research are two regimes in the German biodiesel market; the first one characterized by strong error-correction of rapeseed oil prices and the second by considerably weaker error-correction and significant impact of changes in biodiesel prices. The market situation is stable with strong error-correction until 2005 but becomes increasingly instable in 2006 and 2007. In the latter years, the system is dominated by the regime with weak error correction of rapeseed oil prices but short-run adjustments towards changes in biodiesel prices. Strong overcapacity and norms requiring rapeseed oil use in biodiesel production are the main reasons for weak adjustment in rapeseed oil prices in 2006. In 2007, these effects are outweighed by overall price increases and substitution of rapeseed oil by soya oil in biodiesel production. The market distortion due to policy intervention is still present, while the impact of increased commodity prices should phase-out with falling prices observed in the second half of 2008. It can be shown that the prices do react quickly under free market conditions and the request towards policy maker would, thus, be the abolishment of market distorting measures as quotas and biased norms, rather than the intended further regulation of the market.

References

Balcombe, K. and G. Rapsomanikis (2008): Bayesian Estimation and Selection of Nonlinear Vector Error Correction Models: the Case of the Sugar-Ethanol-Oil Nexus in Brazil, *American Journal of Agricultural Economics*, August 2008.

Barett, C. B. (1996): Market analysis methods: are our enriched toolkits well suited to enlivened markets? *American Journal of Agricultural Economics*, August 1996.

Brümmer, B., S. von Cramon-Taubadel and S. Zorya (2008): Vertical price transmission between wheat and flour in Ukraine: A Markov-switching vector error correction approach, under revision for the *European Review of Agricultural Economics*.

Goodwin, B. K. (2006): Spatial and Vertical Price Transmission in Meat Markets, paper presented at the Market Integration and Vertical and Spatial Price Transmission in Agricultural Markets Workshop, University of Kentucky, April 2006.

Hamilton, J. D. (1989): A New Approach to the Economic Analysis of Nonstationary Time Series and the Business Cycle, *Econometrica*.

Ihle, R. and S. von Cramon-Taubadel (2008): A Comparison of Threshold Cointegration and Markov-Switching Vector Error Correction Models in Price Transmission Analysis. 2008 NCCC-134 Conference on Applied Commodity Price Analysis, Forecasting and Market Risk Management, St. Louis, USA, April 21-22.

Krolzig, H.-M. (1997): Markov-Switching Vector Autoregression Modelling, Statistical Inference, and Application to Business Cycle Analysis, March 1997, Oxford.

Krolzig, H.-M. (2002): Regime-Switching Models, Department of Economics and Nuffield College, University of Oxford 2002.

Krolzig, H.-M. (2003): Constructing Turning Point Chronologies with Markov-Switching Vector Autoregressive Models: the EU-Zone Business Cycle. Paper prepared for the Colloquium on modern tools for business cycle analysis, Eurostat, Luxemburg 2002.

Krolzig, H.-M. (2004): MSVAR – an Ox package designed for the econometric modeling of univariate and multiple time series subject to shifts in regime. Version 1.31k: http://www.economics.ox.ac.uk/research/hendry/krolzig/msvar.html.

Peri, M. and L. Baldi (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.

Rapsomanikis, G. and D. Hallam (2006): Threshold cointegration in the sugar-ethanol-oil price system in Brazil: evidence from nonlinear vector error correction models, FAO commodity and trade policy research working paper No.22, September 2006.

Serra, T., D. Zilberman, J. M. Gil and B. K. Goodwin (2008): Nonlinearities in the US corn-ethanol-oil price system, Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Orlando, FL, July 27-29, 2008.

UFOP (2008): Union of the promotion of oil products e.V., URL: http://www.ufop.de/.

Wohlgenant, M. (2001): Marketing Margins: Empirical Analysis, in Handbooks in economics 18, *Handbook of agricultural economics*, volume 1b, marketing, distribution and consumers, 2001.

ZMP (2008): ZMP-Marktbilanz Getreide, Ölsaaten Futtermittel 2008, ZMP Zentrale Markt- und Preisberichtsstelle GmbH, Bonn.