Interdependencies between Rapeseed and Biodiesel in Europe – Empirical Results and Policy Implications

Dissertation

zur Erlangung des Doktorgrades

der Fakultät für Agrarwissenschaften

der Georg-August-Universität Göttingen

vorgelegt von

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geboren in Dannenberg (Elbe)

Göttingen, 20. Mai 2010

D7

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Tag der mündlichen Prüfung: 12. Mai 2010

Busse, S. (2010): *Interdependencies between Rapeseed and Biodiesel in Europe – Empirical Results and Policy Implications.* Dissertation at the Department of Agricultural Economics and Rural Development, Georg-August University of Göttingen.

And at the end of the Stone Age there were still stones left.

Contents

Abbreviations[1]

ADF	Augmented Dickey-Fuller Test
Art.	Article / Artikel
B5	5 % blend of biodiesel to fossil diesel
B100	Pure biodiesel
BLE	Bundesanstalt für Landwirtschaft und Ernährung (Federal Agency for Agriculture and Food, Germany)
BMELV/ BMVEL	Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz (Federal Ministry of Consumer Protection, Food and Agriculture, Germany)
Bn	Billion (1,000 Million)
BtL	Biomass to Liquid
CFPP	Cold Filter Plugging Point
CO_2	Carbon dioxide
ct	(Euro) Cent
DCC	Dynamic Conditional Correlation (Model)
E85	Ethanol with a 85 % share ethanol and a 15 % share petrol
ECT	Error Correction Term
EG	Europäische Gemeinschaft
EU	European Union
EMA	Expectation Maximization Algorithm
ETBE	Ethyl tert-butyl ether
FAO	Food and Agriculture Organization of the United Nations, Italy
GARCH	General Autoregressive Conditional Heteroskedasticity
GATT	General Agreement on Tariffs and Trade

[1] The list comprises English as well as German abbreviations since parts of this thesis are written in German.

GHG	Green House Gas
ha	Hectare (= 10,000 m²)
IEA	International Energy Agency
KPSS	Kwiatkowski, Phillips, Schmidt & Shin Test
l	Litre
MATIF	Marché A Terme International de France, Paris (commodity forward exchange)
Mil	Million
Mio.	Million
MGARCH	Multivariate General Autoregressive Conditional Heteroskedasticity (Model)
Mrd.	Milliarde
MS-VECM	Markov-switching Vector Error Correction Model
MS-VFKM	Markov-sprung Vektor Fehlerkorrektur Model
Mha	Million ha
Mt	Megatons
MwSt.	Mehrwertsteuer
NGO	Non-governmental organisation
NPR-PPM	Non-Product Related Process and Production Methods
p	Price
P100	Pure vegetable oil used as fuel
SD	Standard deviation
t	Ton (= 1,000 kg)
TBT	Technical Barriers to Trade
THG	Treibhausgas
TVECM	Threshold Vector Error Correction Model

UFOP	Union zur Förderung von Oel- und Proteinpflanzen (Union for the Promotion of Oil and Protein Plants, Germany)
US/ USA	United States of America
VAT	Value added tax
VECM	Vector Error Correction Model
VFKM	Vektor Fehlerkorrektur Model
WTO	World Trade Organization
ZMP	Zentrale Markt- und Preisberichtsstelle GmbH (Centre for Market and Price Reports, Germany)

Acknowledgements

This PhD thesis was compiled during my time as a research assistant at the Chair of Agricultural Market Analysis at the University of Göttingen. I am very grateful to my advisor Prof. Dr. Bernhard Brümmer. Under his supervision I was able to conduct research independently. At the same time, he was always open for guidance and discussion. His assistance and feedback contributed to the success of my work. Without his support, the compilation of this thesis would have been a much greater challenge.

Furthermore, he encouraged me and gave me the possibility to follow several work related activities. During my time at his chair, I visited several conferences, organized international student excursions and participated in teaching. I thereby met many interesting persons from all over the world. I would like to thank all of them for their contribution to my work and for making my time as a PhD student a very interesting experience.

I would like to thank the discussants of my progress reports who contributed to my advancement with their feedback and experience; Prof. Dr. Stephan von Cramon-Taubadel not only gave hints on how to structure and focus the research but also valuable advice on how to write a good paper; Prof. Dr. Jens-Peter Loy contributed with his comments and remarks during seminars and conferences to the further qualitative improvement of my research.

I am very thankful to my colleagues who provided valuable feedback and interesting discussions on my progress reports and conference talks. A special thank goes to Rico Ihle who co-authored two of the papers and furthermore contributed to my work with important remarks, especially in the area of model specification and the interpretation of statistical results. Sebastian Lakner, Tinoush Jamali Jaghdani, Linde Götz, Martin Pfeuffer, Oleg Nivyevskiy and Sören Prehn also contributed with valuable feedback during internal presentations and meetings of the working group of Applied Econometrics at the Department of Agricultural Economics and Rural Development. For proofreading, correction and valuable tips I would like to thank Therese Lindfors, Rico Ihle, Sören Prehn, Sebastian Lakner and Abena Poku-Blaeschke.

Moreover, I have to thank the Edmund Rehwinkel foundation for their support which enabled us to carry out a study on consequences of the EU's Renewable Energy Directive.

Most of all I would like to thank my beloved Therese who always supported me during these years. She was my backing in difficult phases and accepted long working days as well as frequent conference travels and seminar weekends.

Einen herzlichen Dank auch an meine Eltern, die mich während meines Studiums und der Promotion stets unterstützt haben.

1 Introduction

This PhD thesis comprises four articles which focus on the analysis of recent developments in the European rapeseed and rapeseed oil markets. These developments took place under the impacts of growing biofuel demand, changing biofuel policies and temporary price increases of agricultural commodities. Rapeseed production grew in the beginning of the new millennium with the rise of the biodiesel industry. The importance of the biodiesel industry for the rapeseed sector is nowadays large with 60 % of EU rapeseed oil and 80 % of German rapeseed oil being processed for industrial use in 2008 (ZMP, 2008). On the global scale, the EU owns about 70 % of global biodiesel production facilities with one quarter of that located in Germany (EBB, 2010). However, growth in biodiesel production and consumption was politically induced, rather than market related. Rapeseed-based biodiesel is, up to now, not competitive with fossil fuel. Hence, biodiesel consumption depends strongly on political goodwill.

A lot of research was devoted to analysing the implications of the growing demand for bioenergy, which has been observed worldwide for several years. The methods used to analyse the developments are as manifold as the characteristics of the individual markets. While large scale industrial biofuel production takes place primarily in Europe, the US and in a number of South American countries, small scale local production of bioenergy can be observed in African countries e.g. based on jatropha or cassava. In the latter case, these are even promoted in development projects. Furthermore, sectors such as e.g. biogas production in Germany, which show strong regional impacts have, up to now, rather limited global effects. The largest bioenergy source worldwide is still woody biomass which is used directly for heating or cooking.

This research focuses on the impact of large scale biofuel use on agricultural markets. The market chosen is the rapeseed-based biodiesel market in Europe. It has developed more recently than the commercially established ethanol market in the US or Brazil and shows special characteristics which will be discussed in this thesis. Furthermore, little research has been carried out till date analysing the European biodiesel sector and its influence on the markets for oilseeds and vegetable oils. In the past years, the use of biodiesel has also been rising in other regions of the world.

Results and conclusions regarding the effects of biodiesel promotion and usage in the EU can, hence, not only guide policy makers in European countries but also serve those in other countries for their own promotion strategies.

A number of methods and models have been frequently applied to analyse the economic impacts of biofuel promotion, production and usage. Among them are general and partial equilibrium models and econometric models. This thesis is based on econometric time series models. Such a model type can yield information about the integration of markets[2] and the behaviour and interrelationships of prices. Under perfect market conditions, prices should contain and mirror all information available in the market. Price data are in many cases the only reliable data available at high frequency. This feature enables the analysis of changing market conditions or volatile prices and quantities since any research based on temporarily aggregated data would disregard such market dynamics.

The focus of this thesis lies on commodity price developments in the biodiesel and oilseed markets. Regarding the physical flows in the oilseed market, it becomes obvious that the biodiesel market grew in its importance for the oilseed market during the past decade. A theoretical discussion on price effects and the effects of different promotion strategies for biofuels on agricultural markets can be found e.g. for the US corn-based ethanol market in Gardner (2003). More recent work on this topic has been carried out by De Gorter and Just (2009, 2008). A fundamental discussion on the support for biofuel emerged already before the food crisis. Articles from Doornbosch and Steenblik (2007) of the OECD or Kutas et al. (2007) from the Global Subsidies Initiative attracted a wide audience. In the course of the food crisis, the World Bank report of Mitchell (2008) found particular attention: it estimated that 70-75 % of the increase in food prices was attributed to biofuels and related factors. A detailed discussion on biofuel policies and the contribution of biofuel demand to the rise in food prices can be found in FAO (2008).

[2] When we use the term market integration in this thesis, we refer to the definition of Barrett (1996) who states that “If two markets are integrated, a shock to the price in one market should be manifest in the other market’s price as well. Among perfectly segmented markets, price series should be independent.”

A detailed and comprehensive study on the developments in biofuel markets was carried out by Rajagopal and Zilberman (2007) for the World Bank. They argue on page 77 that:

"*From a formal modelling perspective, the dynamic relationship of food price in relation to energy price as they become increasingly correlated is an area of future research. Most of the models that exist today are simulation based but, as the time series of biofuels grows, econometric verification of the impacts should also be accorded priority*."

The econometric estimation of the integration of fuel and agricultural commodity markets using time series models attracted increasing interest during the past years, with a focus lying on ethanol markets. The integration in the US market could be shown by Serra et al. (2009). For the Brazilian market, Balcombe and Rapsomanikis (2008), and Rapsomanikis and Hallam (2006) found evidence for the integration of crude oil and ethanol prices and also for changing behaviour in the price adjustment process. The biodiesel market on the other side grew until now primarily within the EU, and more recently also in India, Brazil and Argentina. One of the few existing studies of this subject is Peri and Baldi (2008) who found evidence for threshold cointegration between EU diesel and vegetable oil prices. All these studies focus on price level effects and adjustments in price levels. On the other hand, the behaviour of price volatilities in agricultural markets and the connection between agricultural and energy markets found little attention up to now. The work by Serra and Zilberman (2009) is one of the few attempts in analysing this topic.

This thesis contributes to the literature by providing a detailed analysis of price developments in the EU biodiesel market. It consists of four studies, each of which aims to answer specific questions concerning the EU oilseed and biodiesel markets by applying suitable methods. The first two studies are based on Markov-switching Vector Error Correction Models. The third paper uses a Multivariate General Autoregressive Conditional Heteroskedasticity Model and the fourth paper is designed as a policy impact assessment. This non-econometric approach is used to answer questions concerning the sustainability criteria for bioenergy and their consequences for rapeseed-based biodiesel and the biofuel sector in general.

Concerns regarding the (missing) sustainability of biofuel production already rose in 2006. The topic gained public awareness especially in the course of the food crisis in 2007/08. With the implementation of sustainability criteria for biofuels, measures are used whose impact on the affected markets is difficult to determine in quantitative terms at present. The article “Die Biokraftstoff-Nachhaltigkeitsverordnung: Ein erster Schritt in eine nachhaltige Bioenergiepolitik oder ein weiteres Stück Bürokratie?“ aims to provide a basis for discussion on whether the EU Renewable Energy Directive (COM, 2009) helps to achieve a sustainable biofuel production.

The article “Price Formation in the German Biodiesel Supply Chain: A Markov-switching Vector Error Correction Modelling Approach” is in line with the above cited research undertaken on the integration of ethanol markets. Following evidence for the integration of biodiesel and vegetable oil markets, the impacts of different policy measures are assessed. The period covered in this article is the time from the rise in biodiesel demand in 2002 until its first decline in 2007. The analysis provides insights into the effects of tax credits, blending mandates and rapeseed oil oriented norms on price formation in fuel and vegetable oil markets.

In the course of the food crisis 2007/08, biofuels came under discussion as a possible cause of the extreme agricultural commodity price increase (e.g. Mitchell, 2008, FAO, 2008). During this period, German rapeseed prices, as did prices for many other agricultural commodities, increased strongly and high volatilities occurred. The articles „Bestimmungen der Determinanten der Rapspreisentwicklung in der Hochpreisphase auf Basis von Markovzeitreihenmodellen“ and “Investigating Rapeseed Price Volatilities in the course of the Food Crisis” particularly focus on this period. Price dynamics in the oilseed market and price interactions between related markets are analysed in order to gain insight into the market behaviour during this period, to find explanations for the price development experienced and to discuss whether such events are likely to reoccur. While the price level effects are analysed in the former article, the latter focuses on the volatility of prices. Both discuss the role of fuel markets with regard to this price development.

In chapter 2, an overview of all four articles is provided. Chapters 3 to 6 present the individual articles. In chapter 7, results of the studies are summarized, bioenergy objectives are discussed and overall policy implications are derived. Finally, open questions concerning biofuel policies are raised and potential areas for further research are revealed.

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2 Overview of research papers

This chapter provides an overview of the four articles, emphasising the core results and conclusions.

2.1 Price Formation in the German Biodiesel Supply Chain: A Markov-switching Vector Error Correction Modelling Approach

(Jointly with Bernhard Brümmer and Rico Ihle)

The article is under revision for the Journal of Energy Economics and was first submitted in July, 2009. Parts of the article were presented at the XXVII International Conference on Agricultural Economics in Beijing (China) which took place from August 16-22, 2009, under the title "German Rapeseed Oil and Biodiesel Pricing under Changing Market Conditions: A Markov-switching Vector Error Correction Model Approach" and the IAMO Forum in Halle (Germany, June 17-19 2009) under the title "Price Formation in the German Diesel - Biodiesel - Rapeseed - Soy Oil System: A Markov-switching VECM Approach".

The article focuses on price developments in the German biodiesel and oilseed markets between 2002 and 2007. During this period the German biodiesel sector made its way from a niche market to the largest national biodiesel market worldwide. As a consequence of this development, the rapeseed and rapeseed oil markets were transformed from food markets to energy feedstock markets. Given these rapidly changing market conditions, questions arise concerning the pricing processes in these markets. It is likely that such a fast rise of a new market has a strong impact on price relations between various commodities in these markets and price adjustment processes[3]. Besides the growth of vegetable oil demand for biodiesel, the biodiesel market itself underwent structural changes, and modifications in the legal framework additionally occurred.

The Markov-switching Vector Error Correction Model applied, revealed changes in the price adjustment behaviour. While one would expect that especially the relationship between the rapeseed oil and the biodiesel market should have tightened

[3] The term "price adjustment" refers to the error-correction behaviour of cointegrated prices and the short-run price behaviour to price changes estimated by a Vector Error Correction Model. It indicates in which form and how quickly price changes are corrected towards the long-run equilibrium. The terms will be discussed in detail in Chapter 3 and 4.

due to the strong link in physical trade flows, the opposite was observed in 2006 and 2007. In particular the response of rapeseed oil prices to disequilibria between both prices was reduced in 2006 and 2007. This observation is related to the fundamental changes, the industry had to undergo. After a strong growth in production capacity and sales until 2006, the increase in tax depressed the competitiveness of biodiesel relative to diesel and strong overcapacity arose. Furthermore, soy oil was increasingly used for biodiesel from this year onwards, while biodiesel was almost exclusively based on rapeseed oil until 2006.

A third factor was the introduction of the blending mandate. While most of the biodiesel was sold in pure form (B100) until 2006, an increasing share was used for blends with fossil diesel (B5). Here, the pricing behaviour is different from the B100 market and contracts play a much more important role. However, the B100 market still presented the marginal revenues for biodiesel sales and, thus, determined its price. The changes observed can, as such, not be explained by market processes alone but are rather the consequence of unpredictable and comparatively sudden changes in the promotion framework for the biodiesel market.

2.2 Bestimmungen der Determinanten der Rapspreisentwicklung in der Hochpreisphase auf Basis von Markovzeitreihenmodellen

(Jointly with Bernhard Brümmer)

The article was prepared for the 49. Jahrestagung der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues e.V. (GEWISOLA/ Annual Meeting of the German Association of Agricultural Economists) and presented at the conference which took place from 30 September to 2 October 2009 in Kiel (Germany). The article is to be published in the forthcoming conference proceedings.

In 2007, the prices of many agricultural commodities started to rise, reaching a maximum in late 2007 or the beginning of 2008. The German rapeseed price reached its peak in the beginning of 2008 at 500 €/t, which represents a reduplication within 12 months. The price increase also coincided with rising volatility in many markets which caused additional concern for many interest groups. The causes for the increase in rapeseed prices were unclear and the question arose whether these are reoccurring events or whether this was a singular phenomenon.

The article reviews the development of the German rapeseed prices in the course of the price boom in 2007/08 and identifies the determinants of the price development. A Markov-switching Vector Error Correction Model is employed since it is highly flexible and can detect latent regimes in time series and identify reoccurring abrupt changes between them. Wheat, soya, rapeseed oil and rapeseed meal prices can be determined as driving factors of the rapeseed prices in 2007/08. Evidence is found that the strong influence of all these prices on the rapeseed price development was not a singular event but had occurred already in 2003/04. The difference between this event and the event from the earlier period lies, however, in the structure and persistency of the adjustment behaviour of rapeseed prices. Early impulses for rapeseed price increases can be attributed to changes in wheat prices. The wheat price is seen as an indicator for the grain market and is widely assumed to form its base price. Furthermore, the cereal harvest starts some weeks earlier than the rapeseed harvest and gives some indication regarding the overall price development. Consequently, strong adjustments in rapeseed prices in response to changes in wheat prices have to be interpreted to reflect expectations towards future price increases rather than as reaction towards market changes.

Oilseed market actors determined the development and especially the level of rapeseed prices in 2008. In particular the strong error-correction[4] of rapeseed prices towards the long-run equilibrium with rapeseed oil and meal played a key role. Additionally, strong adjustment towards past changes in soybean prices with a delay of four to seven weeks was observed. These two findings support the assumption that the development in rapeseed prices was primarily driven by vegetable oil price increases. Even though rapeseed meal is, in quantitative terms, the larger part of the rapeseed (58 % mass fraction), it is outperformed by rapeseed oil in value terms (75 % value share) since rapeseed oil prices rose substantially with the boom of the biodiesel sector. The strong time lag of adjustment in rapeseed prices towards changes in soybean prices indicates that adaption processes in the industry take place very slowly and that price signals are transmitted via soy oil and rapeseed oil

[4] Error-correction describes the process of price movements towards the long-run equilibrium between two or more price series, i.e. the correction of price disequilibria. The term will be discussed in detail in Chapter 3 and 4.

markets. Furthermore, the development of German rapeseed prices in 2007/08 was shown to be a non-singular event.

2.3 Investigating Rapeseed Price Volatilities in the course of the Food Crisis

(Jointly with Bernhard Brümmer and Rico Ihle)

The article was submitted to the 50. Jahrestagung der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues e.V. (GEWISOLA, Annual meeting of the German Association of Agricultural Economists). The conference takes place from 29 September to 1 October, 2010 in Braunschweig (Germany).

Between 2007 and 2009 agricultural commodity prices underwent strong increases and returned afterwards to their previous levels. The price increases were accompanied by strong fluctuation which raised additional concerns among politicians, researchers and NGOs. The price changes within a week in 2007/08 were in some cases higher than those observed over a period of one year in the previous years. The article addresses specific questions regarding the dynamics of rapeseed price volatilities. The structure of its volatility behaviour and its connection to other markets are analysed, and consequences for future developments are discussed.

A Dynamic Conditional Correlation model is used to analyse the volatility behaviour. This model belongs to the class of Multivariate General Autoregressive Conditional Heteroskedasticiy models. This model class is suitable for analysing the correlation in price volatilities. Due to its huge data requirement, it has primarily been used in financial market analysis. Reliable price data on agricultural commodities are usually only available on weekly or monthly frequency. In order to meet the data requirements, we used daily rapeseed prices from the agricultural stock exchange, MATIF, and spot market prices from the most important trading place Rotterdam (rapeseed oil, soybeans and soya oil).

The results indicate an increased volatility in rapeseed prices during the food crisis but also in 2008/09. The rapeseed prices appear to be sensitive to shocks and bear the risk of overreacting in volatile phases. Furthermore, we find an increased and persistent correlation in the volatilities of rapeseed and crude oil prices. This is not observed for correlation with commodity spot market prices. This indicates that rapeseed prices react increasingly to the same market signals as crude oil prices. The market signals that guide agricultural spot market prices, which should usually be demand and supply changes, seem to play a much smaller role for rapeseed prices. Since the crude oil prices showed more pronounced volatility than rapeseed prices throughout the past decade, the increased correlation bears the potential for stronger rapeseed price fluctuations in the future. The prices were on a significantly lower level in 2008/09 in comparison to the previous year. The effects will become more evident when prices start increasing again. Since market signals are difficult to interpret during volatile phases, production systems and trading strategies are difficult to set up. Consequently, short-run volatilities could lead to even more pronounced price level changes than those observed in the past.

2.4 Die Biokraftstoff-Nachhaltigkeitsverordnung: Ein erster Schritt in eine nachhaltige Bioenergiepolitik oder ein weiteres Stück Bürokratie?

(Jointly with Bernhard Brümmer)

The article was submitted to the German Journal of Agricultural Economics in September 2009. The article is based on a study conducted with support from the Edmund Rehwinkel Foundation in 2008 and was published in Schriftenreihe der Rentenbank under the title "Zertifizierung von Biokraftstoffen zur Sicherung der *Nachhaltigkeit" in 2009.*

The article analyses the consequences of the German biomass sustainability directive for the German and EU biofuel and agriculture sectors. The German directive comes into force in 2010 and implements the requirements set out by EU directive 2009/28/EC. The EU directive defines requirements for biomass used for energy generation. These have to be met when energy generated from biomass is to account for the fulfilment of national obligations of biofuel use or when biofuels should be eligible for tax credits. Since this is the first time that sustainability criteria are defined and the potential for strong impacts on the agricultural sector is high, the directive is likely to determine the path the EU biofuel production will take during the next decade.

Today, biofuels are mainly produced from agricultural products such as rapeseed, sugar or corn. Different measures are implemented in order to promote the use of domestically grown crops. The technical norm for biodiesel, which imply that mainly rapeseed oil has to be used, is the most important rule. The largest rapeseed producer worldwide is currently the EU. For ethanol the US and Brazil appear to be the largest producers. High import tariffs are applied in the EU. Brazil appears to be the most competitive producer.

The EU has set the target of a 10 % biofuel share in fuel sales by 2020. This target seems rather ambitious, with current sales being far away from the 2010 target of 5.75 %. The targets came under serious discussion during the food crisis in 2007/08. The aim of the directive is to provide an answer to the increasing criticism on biofuels regarding their environmental side effects.

Main criteria for sustainability are the requirement of a certain amount of GHG savings of biofuels and the exclusion of areas with specific natural characteristics from the production of biomass. Since these restrictions only apply to biomass used for biofuels in the EU, positive impacts on a global scale beyond the rapeseed market are presumably low. For most agricultural commodities, the alternative use to biofuels is food and feed, which is still much more important than the energy use. Since the food and non-EU bioenergy markets remain initially unregulated, the most likely outcome of the regulation is a segmentation of agricultural markets with a limited impact on global production systems. Furthermore, under current biofuel production structures, EU rapeseed farmers and the EU (bio-) fuel consumers are likely to be the losers when the new regulations are implemented. The first group is very dependent on the biofuel market; the latter has to bear any additional costs arising from stronger regulations either at the petrol pump or through taxes.

3 Price Formation in the German Biodiesel Supply Chain: A Markov-switching Vector Error Correction Modelling Approach

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Abstract

Vertical price transmission in the German biodiesel supply chain is analysed by looking at the relationship between diesel and biodiesel prices, and between rapeseed oil, soy oil and biodiesel prices. The sample period goes from summer 2002 to late 2007. Incidentally, the German biodiesel market developed round this time, mainly driven by political interventions, into the largest biodiesel market worldwide. Because of the frequent policy changes, a regime-dependent Markov-switching vector error correction model is applied. This indicates that regimes with differing error correction behaviour govern the transmission process among the various prices. Strong error correction is found until 2005; however, it has been less prevalent since 2006. Reasons for this include changing market conditions, caused by political decisions, as well as the implementation of the blending mandate. Furthermore, excess capacity was incurred due to overconfidence in political support. Additionally, rapeseed oil oriented biodiesel norms might have been the main reason for low price adjustment.

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

JEL: C22, Q11, Q18

3.1 Introduction

The development of prices has been of interest to agricultural researchers for a long time, and various methods have been applied to analyse the dynamics in price formation on related markets. The central feature of integrated markets is that shocks to prices in one market are transmitted to other markets (Barrett, 1996). During the past years, a rising influence of energy markets on agricultural commodity markets was observed, and the integration of the two markets has been increasingly investigated. The use of agricultural goods as energy feedstock re-opened a market which had been long forgotten during the past century since the switch to fossil-based energy supply. This, however, introduced a new factor influencing the price formation on agricultural markets. The revived link between these two markets is of particular importance for the much smaller agricultural market, because it not only implies a potential for higher agricultural prices, but also the risk of volatility transmission from the crude oil market. De Groter and Just (2008) analysed the effects of policy measures, implemented to promote biofuels, on energy and agricultural markets. The results vary depending on the measure, or combination of measures, implemented in the market. While the welfare effects are exhaustively discussed, the impact of these measures on the integration of both markets is not.

The integration of agricultural and energy markets, in terms of price transmission changes between the markets, and the existence of long-run price relations, was however analysed for different commodities in various countries using price time series. Rapsomanikis and Hallam (2006), and Balcombe and Rapsomanikis (2008) found non-linear price adjustment in the Brazilian ethanol market using a threshold vector error correction model (TVECM). Serra et al. (2008) found cointegration in the US ethanol industry using a smooth transition VECM. Peri and Baldi (2008) also found cointegration between rapeseed oil and gasoil prices in the European market using a TVECM. All authors found evidence for cointegration in both markets and determined that change in energy price also causes changes in agricultural prices. The impact of different policy measures and the market structure was thereby only briefly discussed.

With this paper, we provide the first quantitative investigation of vertical price transmission in the biodiesel supply chain in Germany, nowadays the largest national biodiesel market worldwide. The relationship between diesel and biodiesel is analysed in the first stage. This is followed by the analysis of the influence of biodiesel and soy oil prices on rapeseed oil prices. The motivation for this procedure originates from the substitutability of rapeseed oil for soy oil in food and fuel, which can be expected to have a distinct impact on price formation. The pricing on the German biodiesel market is suspected to be strongly affected by changing policies and changes in market conditions as the structure of the biodiesel industry, is mainly influenced by policy expectations. The Markov-switching VECM (MS-VECM) is used to analyse these effects, which has, to our knowledge, not been done before. Since policy changes led to recurring changes in the market situation, regime-dependent models, such as the MS-VECM, are a natural modelling choice.

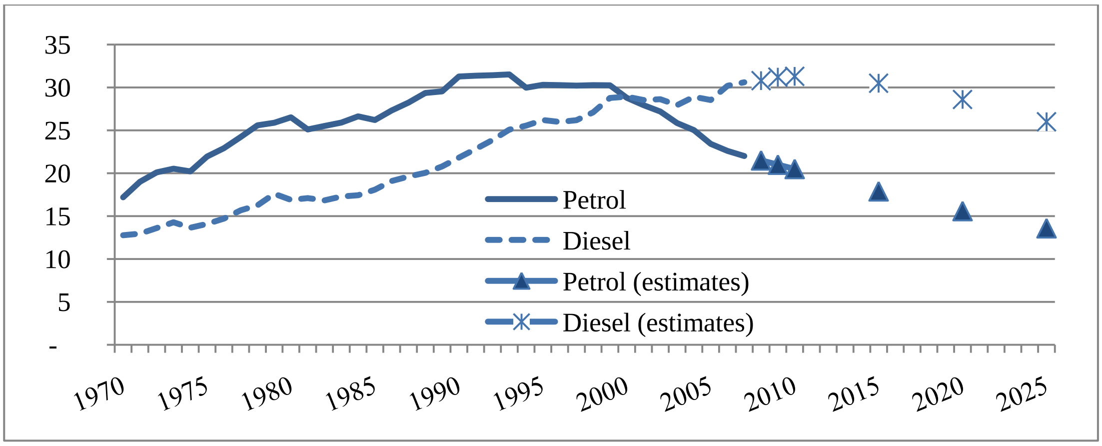
This study not only aims to provide evidence for the integration of energy and agricultural markets; but to also link the different policy measures to changes in price transmission behaviour. The analysis of price transmission is challenging, as Goodwin and Vara (2009) argue, because the results can be consistent with a variety of different explanations. Without a prior understanding of the economic phenomena being modelled, it is unclear what definitive information can be gleaned from test results alone. The understanding of the fundamental structure of the markets is therefore essential to the proper interpretation of the results (Goodwin and Vara, 2009). Consequently, we first review the main market developments by presenting the most important background information. Following the description of the market structure, the impacts of the different policy measures are analysed graphically, and hypotheses about their effects on the extent of market integration are discussed. Subsequently, we specify Markov-Switching vector error correction models, which form the basis for the estimation results in the fourth section. The next section discusses these results in detail, after which some concluding remarks and policy implications close the paper.

3.2 The German biodiesel market

Market developments

The reasons for European countries, and in particular Germany, to focus their efforts in promoting biofuels, primarily on biodiesel, are manifold. One major reason was probably the search for an alternative outlet for vegetable oil, mainly rapeseed oil. The prices of domestically grown rapeseed were under constant pressure from cheap soybean imports from the US and South America, against which the Common Agricultural Policy provided no external protection. One alternative use for rapeseed was seen in biodiesel. Furthermore, with low rapeseed oil prices and relatively high diesel prices (due to taxation), rapeseed oil based fuel became increasingly competitive (condition on receiving a tax exemption) at the end of the nineties. Another reason is the rather untypical ratio between diesel and petrol sales in Europe in comparison to international markets. In 2007, more than twice as much diesel than petrol was sold within the European Union (MWV, 2008). The situation in Germany is similar, with increasing diesel sales already exceeding petrol sales (Figure 1).

Figure 1: Petrol and diesel sales in Mt, Germany for 1970-2007 as well as estimates for 2008-2025

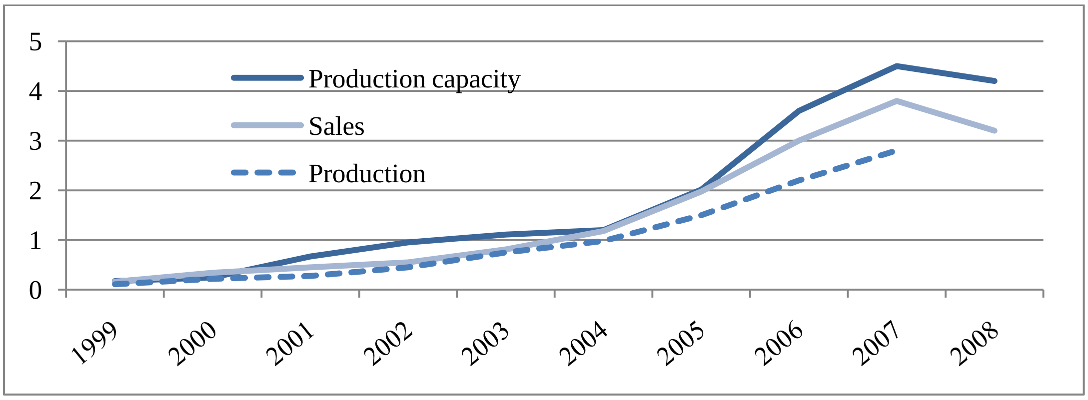


Source: Own elaboration based on MWV (2006).

The EU has set an indicative target that 5.75% of all fuels placed on the market by 2010 must be biofuels. Member states are responsible for ensuring that a minimum proportion of biofuels is placed on the market (D2003/30/EG). In Germany, the growth of the biodiesel industry was mainly encouraged by capital assistance and tax exemptions granted from 2004. Until 2003, the use of vegetable oil as fuel was unregulated and therefore, tax free. As excess profits of the biofuel industry due to this tax exemption were discovered, the tax credit was reduced. An energy tax of 103 €/t of 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 full taxation of B100 is intended for 2012. Since 2007, diesel must be blended with 5% (by volume) biodiesel, which requires about 1.5 million tons of biodiesel. In case the target is not reached, a penalty of 690 € is charged for each ton of biodiesel required to reach the blending target. In comparison to this penalty, the production costs are comparatively low.

The European biodiesel market is today the largest in the world and within this market, Germany takes a dominant position. About half of the EU biodiesel production capacity was installed here in 2006 (Strategié Grains, 2008). Highest growth rates occurred especially between 2004 and 2006 (Figure 2) and a large gap between domestic production and production capacity emerged. Given the excess capacity in combination with increased import pressure, the capacity growth slowed down in 2007 and even turned negative in 2008. 49 plants are dedicated to biodiesel production with individual production capacities in the range from 2 kt to 500 kt (Stratégie grains, 2008).

Figure 2: Production, production capacity and sales of biodiesel in Mt, Germany, 1999-2008

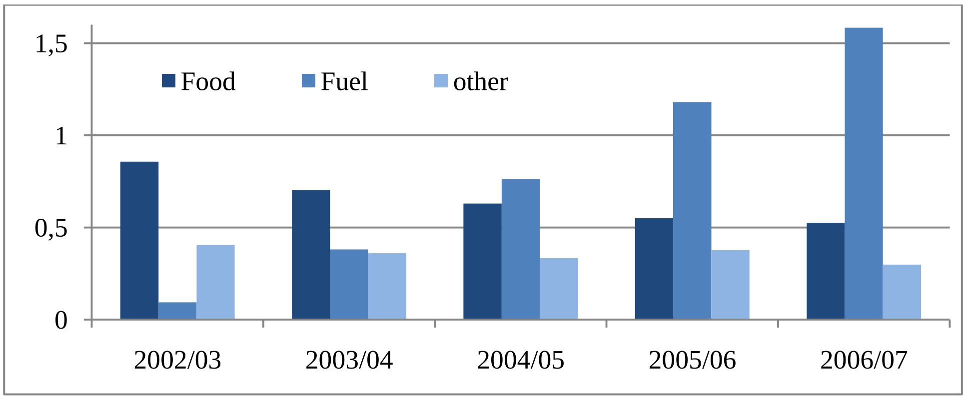


Source: Own elaboration, based on UFOP (2008a), VDO (2008), Biokraftstoffbericht (2008).

While mainly B100 was sold until 2005, the sales of B5 gained importance from 2006 when the market was challenged with taxation and increasing raw material costs. In 2007, the B5 market grew further and exceeded the B100 market resulting from the need to fulfil the blending mandate (UFOP, 2008a). The raw material basis was initially almost exclusively rapeseed oil as the use of other vegetable oils is restricted through technical norms. Soy oil shares of 20% and above is possible and has been used since 2006. This, however, requires the use of additives and is most suitable during the summer months where a lower Cold Filter Plugging Point (CFPP) is required. The CFPP requirement applies for B100 as well as B5 and virtually excludes palm oil from biodiesel use.

With the development of the biodiesel market, the food and nutrition market lost its importance for rapeseed oil use. In 2006/07, two thirds of the domestically produced rapeseed oil sold in Germany was used for biodiesel (Figure 3). Despite an increase in the German rapeseed area to 1.5 million ha, yielding more than 5 Mt, Germany became a net-importer of rapeseed. The net-imports of rapeseed oil rose to 0.9 Mt in 2006/07, whereas Germany was a net-exporter of 0.6 Mt only five years before (ZMP, 2008a).

Figure 3: Rapeseed oil sales in Mt, Germany

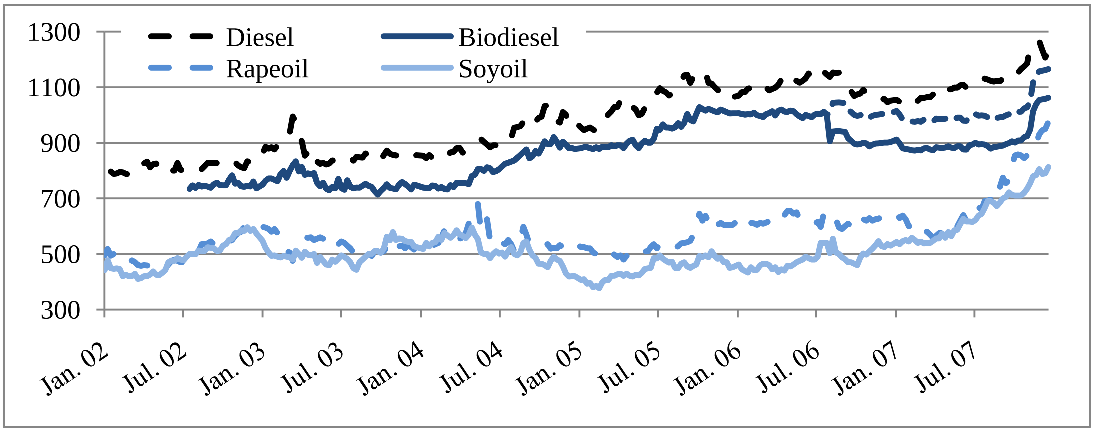


Source: Own elaboration based on ZMP (2008a).

Price developments

The development of diesel, biodiesel, rapeseed oil and soy oil prices between July 2002 and December 2007 is given in Figure 4. Due to its high nutrition value, sunflower oil is not used for biodiesel and will therefore not be considered in the analysis. Each series is based on weekly observations so that 275 observations are available for the empirical analysis. The prices are given in € per ton without VAT. Rapeseed and soy oil prices are German wholesale prices fob at the oil mill (ZMP, 2008b). The biodiesel prices are German consumer prices at the petrol station (UFOP, 2008b). Since a petroleum tax was implemented in August 2006, the prices used are without this tax for comparison with agricultural commodities. The tax is however included when investigating its relationship with diesel prices (the distinction is also shown in Figure 4). The diesel prices are obtained from the Chamber for Agriculture of the region Lower Saxony and represent average wholesale prices for 3000 l in bulk including petrol tax (LWK, 2008).

Figure 4: Prices of diesel (including energy tax), biodiesel (with and without energy tax), rapeseed, and soy oil in €/ton, Germany (in current prices)



Source: Own figure, based on data from ZMP (2008b), LWK (2008) and UFOP (2008b).

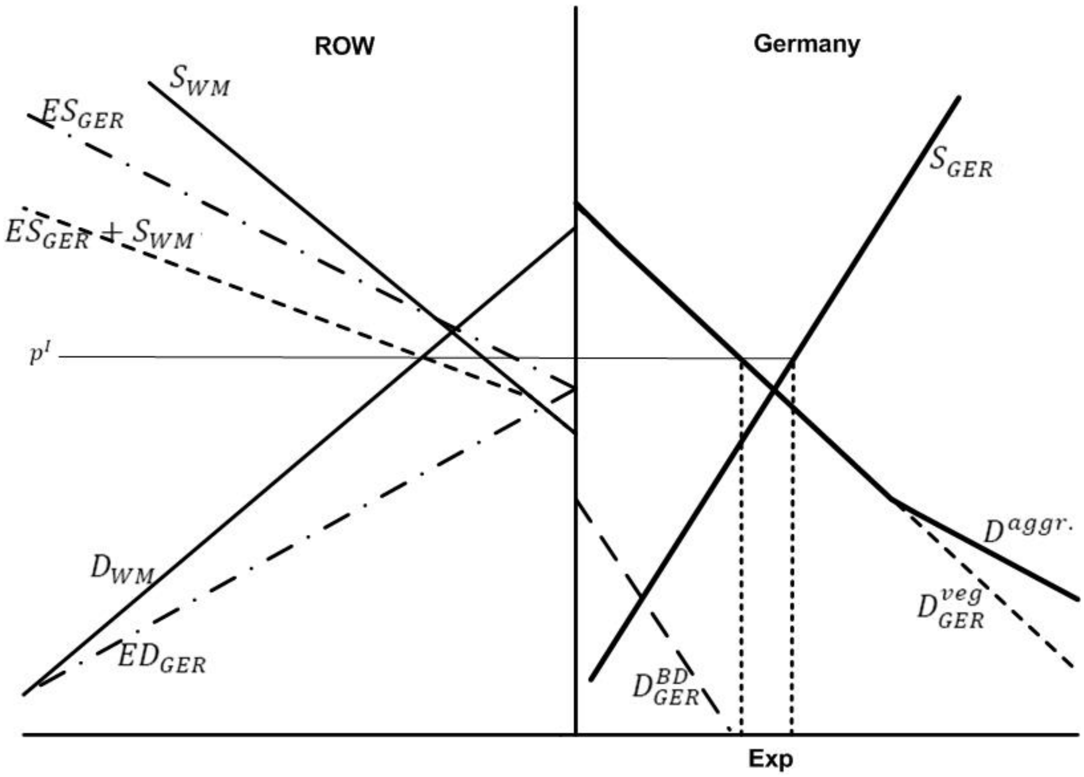
The widening gap between the prices on food (soy oil) and fuel (biodiesel) markets is remarkable. However, this trend stops in August 2006 and even reverses in 2007. The impact on the rapeseed oil price is clearly visible, too. The gap towards soy oil prices reached a maximum at 200 €/t in spring 2006. The rapeseed oil price was, hence, up to 45% above the soy oil price, while parity between the two prices had been observed in earlier years.

The bulk prices for diesel might slightly underestimate the diesel price at the petrol station. This, however, should happen in a systematic way and therefore deliver a good approximation for diesel consumer prices. Strong co-movement between diesel and biodiesel prices can be observed here until 2005. Thereafter, the co-movement appears to have weakened. This gives indications for a strong price linkage towards diesel during the first years of the development of the biodiesel market.

Theoretical background

The impact of the different policy interventions in the German biodiesel market on the price formation, as well as the degree of market integration, is expanded upon. The reference scenario is depicted in Figure 5. At the international price level p^I, domestic supply of rapeseed oil (S_{GER}) exceeds the demand (D_{GER}). Without any tax credit for biofuels, no rapeseed oil will be used for biofuels since the willingness to pay of the biofuel industry is bounded by low fossil fuel prices. The biodiesel demand (D_{GER}^{BD}) lies, hence, below the international price level (p^I). The international price level (p^I) itself, is determined by the intersection of the demand curve of the rest of the world (D_{WM}) and the aggregate world supply curve, as given by the sum of the excess supply curve for Germany (ES_{GER}) and the world supply curve (S_{WM})).

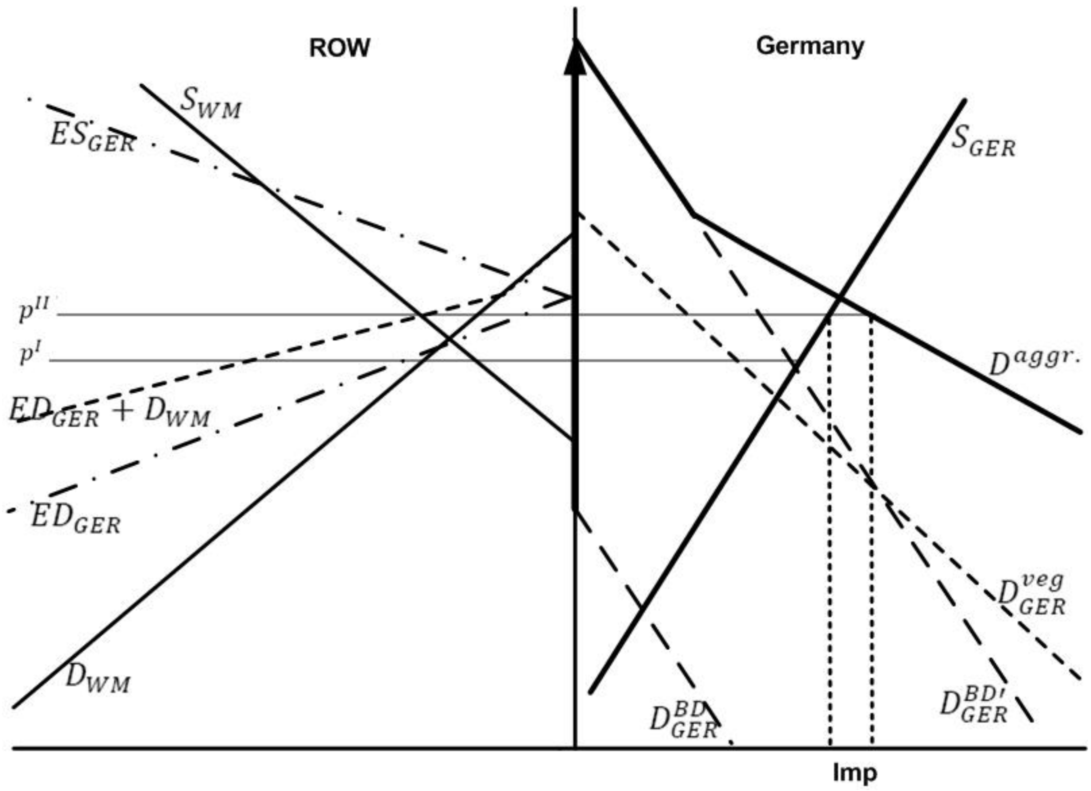
Figure 5: Reference scenario for the rapeseed oil market



Source: Own elaboration.

Figure 6 shows the impact of the introduction of a tax exemption for biodiesel based on the reference case. The demand curve for rapeseed oil from the biodiesel sector ($D_{GER}^{BD'}$) shifts upwards as indicated by the arrow. Hence, a higher aggregated domestic demand curve ($D^{aggr.}$) results as the sum of the two demand functions. These changes translate into new excess supply and excess demand curves. Thus the equilibrium price increases to p^{II}. Germany changes its trade position on the rapeseed oil market from a net exporter to a net importer. The use of rapeseed oil for food decreases due to higher prices. Thus, budget costs due to tax losses arise. These amount to roughly one billion Euros, based on sales of around 2 Mt at a tax credit of 541 €/t.

Figure 6: Tax exemption for biodiesel



Source: Own elaboration.

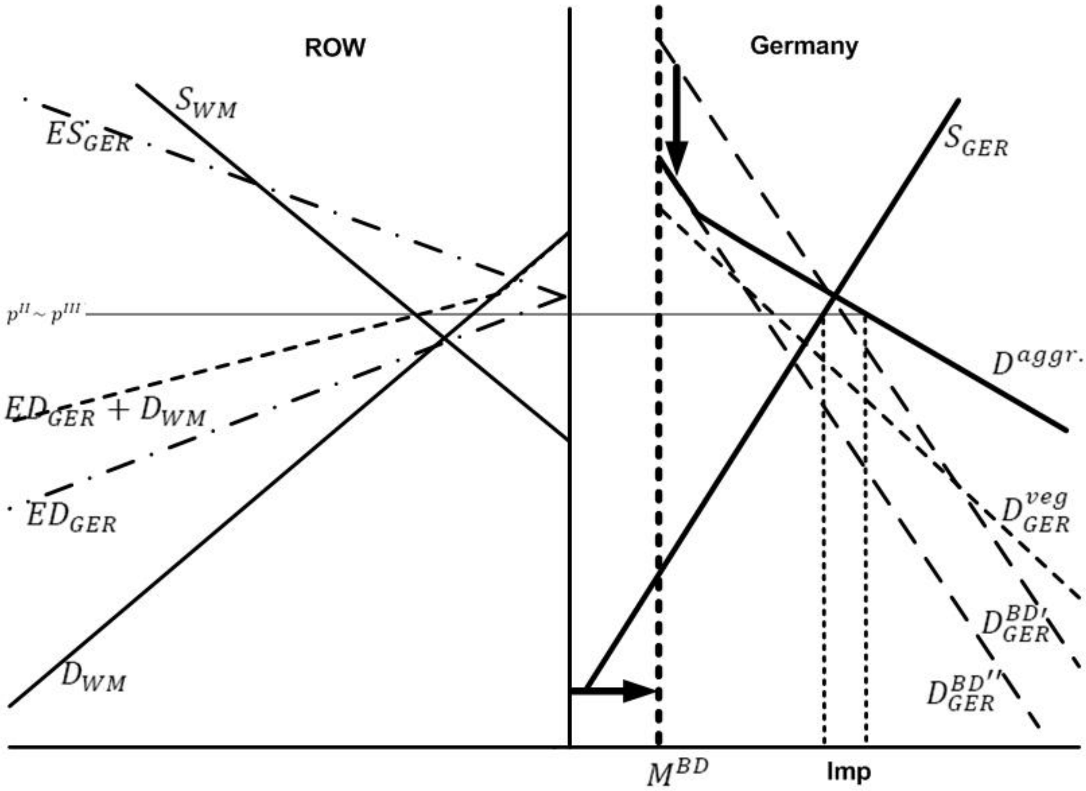
One problematic aspect of the tax exemption is the amount of "water" in the system (De Gorter and Just, 2008): Since biodiesel production is far from being competitive relative to fossil fuel, a substantial amount of the tax credit gets lost in order to achieve production incentives, i.e. to bridge the gap in production costs. The rest of tax payers' money goes to producers of biodiesel and, assuming perfect market integration, rapeseed and rapeseed oil producers, since rapeseed is the essential feedstock for biodiesel.

In 2007, a blending mandate (M^{BD}) was implemented as a compensation for the reduction in tax credit (from $D_{GER}^{BD'}$ to $D_{GER}^{BD''}$ in Figure 7). This led to an inelastic demand for about 1.5 Mt biodiesel[5]. From a welfare economic viewpoint, it has to be

[5] To retain readability, the demand for B100 ($D_{GER}^{BD''}$) and food oil (D_{GER}^{veg}) are shifted to the right and the aggregated domestic demand ($D^{aggr.}$) results as a sum of the three demand functions. For the sake of simplicity, the excess supply (ES_{GER}) and demand function (ED_{GER}) are kept unchanged in the relevant area to keep the imports unchanged.

noted that even though direct budgetary losses are reduced, welfare transfers remain more or less unchanged. Since the sales of B100 represent the marginal revenues for biodiesel producers, and the same norms apply for both markets, the price for biodiesel used in blends should not deviate substantially from this. Consequently, the price of biodiesel used in blends is still substantially higher than for fossil diesel; the additional costs have to be borne by consumers.

Figure 7: Blending mandate and reduction in tax credit



Source: Own elaboration.

Consequences for the pricing

Several hypotheses about the price behavior can be stated, based on the market development discussed. First of all, a strong connection between biodiesel and diesel prices should exist. The reason is a price distance of biodiesel to diesel, which has to be kept to set buying incentives. Since the biodiesel market was niche until 2004, diesel prices should determine biodiesel prices. Afterwards, the industry started to grow rapidly, and the gap between production capacity and domestic production rose. A ‘battle’ for market share between a rapidly increasing number of biodiesel producers occurred. The intense competition ensured strong price linkages. The ongoing diesel price increase up to summer 2005 enhanced the competitiveness of biodiesel and mitigated the pressure on the biodiesel market. Since a strong price linkage is assumed, the biodiesel prices should increase correspondingly.

In late 2005, diesel prices started to decrease while the production capacity for biodiesel still rose. Rapeseed oil prices should especially profit here since the feedstock basis for biodiesel production tightened and an import demand appeared. Biodiesel was now increasingly used in blends with diesel. The reduction in tax credit from August 2006 can be regarded as the strongest policy change in the biodiesel market up to now. In this situation with overcapacity and decreasing margins, comparatively cheap soy oil was increasingly used. The implementation of the blending mandate in 2007 led, as discussed, to a fixed demand for biodiesel from the petrol industry. Half of the biodiesel was now purchased by the petrol industry, typically under contracts, and the ratio of production capacity and sales on the spot market increased sharply, leading to a reduction in production capacity.

Besides the energy market, the markets of agricultural raw products have an impact on the pricing of vegetable oils. Shocks from the markets for raw products, i.e., rapeseed and soybeans, were mainly supply-side based and occurred especially at harvest time. E.g., the two extreme rapeseed harvests in Germany in July 2003, with an exceptionally low yield, and in July 2004, with an all-time record yield, are reflected in the price series. Soy oil is additionally influenced by the feed market since it is a by-product of soy meal. Given that rapeseed oil is influenced by these two comparatively large markets, i.e., the international energy and soy markets, rapeseed oil is likely to be a price follower, hence, adjusting to price changes in those two markets.

From late 2004, the biodiesel market gained importance for rapeseed oil sales. At the same time, the price gap between rapeseed oil and (decreasing) soy oil prices widened. The below average rapeseed yield in 2005 was followed by a jump in rapeseed oil prices. The reduction in tax credit in 2006 brought a new situation: increasing usage of soy oil for biodiesel. Hence, the soy oil market regained importance for the rapeseed oil price. The share of soy oil in biodiesel increased steadily, with higher proportions used over the summer months than during periods with low temperatures. The adjustment process from rapeseed to soy oil as feedstock is, however, a slow process since a modification of production facilities and logistics is necessary. Additionally, additives have increasingly been used to increase the usability of soy oil for biodiesel and, hence, increase the share of soy oil in biodiesel. The perfect substitutability between the vegetable oils in fuel is, however, still not possible. Concurrent with these adjustment processes and low profits, emerged the overall increase in commodity prices. This led to the revival of the food oil market as an attractive sales market for rapeseed oil.

In summary, the situation in the biodiesel and rapeseed oil markets changed substantially over the course of the sample period. Most of the driving factors are somehow directly or indirectly linked to policy changes and expectations towards these, rather than to the behavior of economic agents in a competitive market. With several years' length as the typical planning horizons for the industry, as well as complex adjustment processes in production, changes in the legal framework are perceived as comparatively sudden. Hence, the market development is often based more on long-run expectations than on short-run, immediate market signals.

3.3 Methodology

The basic idea of the traditional VECM is that variables, e.g., prices, are connected by a long-run relationship 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. If no more short-run shocks would occur, the variables tend towards their equilibrium values which they would reach after some time. One of the core assumptions of the model is structural stability, i.e., that all parameters of the data generating process are constant. Parameter constancy is, however, unlikely 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 dummy variables for periods of changed policies would be a first choice to solve this problem. However, the timing of such breaks is difficult to determine since the market is characterized by substantial uncertainties about policy changes. Furthermore, it is mainly driven by expectations based on implemented policies and is geared towards expected policy changes. Economic agents change their behaviour according to their expectations before policy measures come into force. They may also maintain certain behaviour due to investments undertaken, or based upon implemented policy measures, which may create and strengthen incentives. Thus, changes in dynamics and interactions of price behaviour do not necessarily have to coincide with the timing of policy changes. The difficulty of identifying and quantifying potential changes in the structural relationship of the variables (regime switches) and the factors inducing them, favours a modelling strategy alternative to the traditional VECM. An appropriate model should allow parameters to take different values depending on the regime of the price behaviour, i.e. the underlying economic relationships. This should take place without requiring the *a priori* identification and measurement of the factors causing the switches and their occurrence dates.

A variety of regime-dependent models are available, e.g., the TVECM (Balke and Fomby, 1997; Lo and Zivot, 2001), smooth transition VECM (Teräsvirta, 1994) or the parity bounds model (Baulch, 1997). None of them, however, seems appropriate in the given context of markets as they are driven by strong changes in expectations of economic agents and of the political environment. Hence, they yield regime changes induced by factors which can hardly be measured. The two former model classes require the identification and measurement of the factors inducing the regime changes. Additionally, the latter class, among others, leaves the switching mechanism completely unexplained and also disregards the time series properties of the data. The MS-VECM appears to be an alternative to these modelling strategies since it does not require the specification of the switching variables; but nevertheless models the switching mechanism in a meaningful way. Moreover, the development of the markets studied is determined by a number of exogenous factors discussed above. This corresponds closely to the basic idea of the MS-VECM - regime switches are induced by an exogenous stochastic process (Ihle and von Cramon-Taubadel, 2008).

The MS-VECM, as a regime-dependent time series model, was developed by Hamilton (1989). Krolzig (1997) gives a detailed account of the usage of the model in economic analysis. Regime-dependent models allow for a non-linear data generating process which is modelled in the case of Markov-switching time series models as piecewise linear, i.e., the linearity assumption is conditional on each regime. Hence, the key difference between the VECM and the MS-VECM is the assumption of the model parameters. Of note, these are restricted to be invariant across regimes in the former case but allowed to be regime-dependent in the latter. The particular strength of the MS-VECM lays in it its ability to identify potentially latent regimes in the data and its enormous flexibility in model specification.

The model has been used throughout socio-economic research although Markov-switching time series models are most frequently used in business cycle and finance research. Notable examples include Jackman (1995), who analyses presidential approval in the US. Hall et al. (1997) study house prices in the UK using a MS-VECM. Additionally, Morais and Portugal (2004) study regimes in the Brazilian import demand while Brümmer et al. (2009) investigate the integration of wheat and flour prices in Ukraine.

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

$$\Delta p_t = a(s_t) + \alpha(s_t)\,(\beta' p_{t-1}) + \sum_{i=1}^{k} \Gamma_i\,(s_t)\Delta p_{t-i} + u_t \qquad (1)$$

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

Regime-dependence is represented by the variable $s_t \in \{1, \dots, M\}$ indicating which of the M regimes governs the system at time t. This regime variable is not observed so that the current state of the system might be unknown a priori. The model assumes piecewise linearity, hence, its parameters, e.g. the intercept vector a, are allowed to take a different constant value in each regime s_t:

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

The stochastic process generating the regimes is assumed to follow a Markov chain. Thus, the probability of switching between two regimes in subsequent periods is independent of the history of the process before these periods, i.e., "the past should have no influence on the future except through the present" (Chung, 1960). The Markov chain is assumed to be ergodic, which ensures a stationary distribution of the regimes, and irreducible, which ensures that any regime can be reached from any other regime, i.e. no absorbing regimes exist. Furthermore, we assume the Markov chain to be homogenous, i.e., having constant transition probabilities:

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

These transition probabilities quantify the probability for switching from regime i at time t to regime j at time $t+1$. All M^2 probabilities are summarized in the transition matrix Π, containing the probability π_{ij} in the ith row and the jth column.

Due to the two stochastic processes, the time-series and the regime process in the model, two types of adjustment exist. Deviations from the long-run equilibrium are corrected by the vector error correction mechanism towards the long-run price equilibria in each regime. The errors arising from regime switches are corrected towards the stationary distribution of the regimes (Krolzig, 2003). Based on (3), it becomes obvious that the regime switches are not considered to be singular deterministic events (this would correspond to absorbing regimes). They are rather thought of as recurring structural changes which occur in a stochastic fashion and lead to alternating regimes which last for a limited period. Hamilton (1989) characterizes this switching mechanism as "discrete shifts in regime-episodes across which the dynamic behaviour of the series is markedly different". Hamilton and Raj (2002) argue that "normal behaviour of economies is occasionally disrupted by dramatic events that seem to produce quite different dynamics for the variables that economists study".

This class of models is usually, as in this article, estimated by the expectation maximization algorithm (EMA) developed by Dempster et al. (1977) and Hamilton (1990). EMA consists of two steps, which in turn evaluate the probabilities of the regime occurrence and the parameter estimates up to convergence. Details of the calculation are provided in Krolzig (1997, chapter 6). In recent years, the model class has been increasingly estimated with Bayesian methods (see Balke and Wohar, 2009 or Frei, 2008, among others).

The regime incidences can be reconstructed by inferring the probabilities of the occurrence of the unobserved regimes conditional on the total information available in the sample. These so called smoothed probabilities provide the likelihood of occurrence of each regime at time *t*. Such probabilistic, instead of deterministic statements, reflect hence, the uncertainty in the regime assignment. Hamilton (1989) suggested using 0.5 as the probability for regime classification. The closer the smoothed probabilities are to either zero or one, the higher the classification sharpness (see Tastan and Yildirim, 2008).

Expected values for the long-run elasticities

For the estimation, natural logarithms of the prices are used since the long-run coefficients can then be interpreted as long-run price transmission elasticities. No fixed linkage between diesel and biodiesel in the form of conversion costs exists. However, a minimum price difference between both prices seems to be regarded as necessary from the viewpoint of consumers. This difference between both prices is estimated to 100 €/t and the average diesel prices to be 1000 €/t (excluding VAT). Assuming an absolute margin is kept with increasing and decreasing diesel prices, the elasticity of changes in biodiesel prices with respect to changes in diesel prices ($\mathcal{E}_{BD,D}$) should be around 1.1.

The long-run cross price elasticity of rapeseed oil prices with respect to soy oil prices ($\mathcal{E}_{Ro,So}$) can be expected to lie close to one since rapeseed oil is a perfect substitute for soy oil. When determining the long-run elasticity of rapeseed oil prices with respect to biodiesel prices, the possibility of substituting soy oil for rapeseed oil in biodiesel production has to be taken into account. Following Wohlgenant (2001), the elasticity can be calculated using the marketing margins (*MM*). Assuming prices are to be determined at the level of the biodiesel price P_{BD}, with rapeseed oil prices P_{Ro} adjusting to changes in biodiesel prices. *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 ($MM = P_{BD} - \lambda P_{Ro}$). Hence, it follows that:

$$P_{BD} - \lambda P_{Ro} = \alpha + \beta P_{BD} \qquad (4)$$

After reordering and differentiating with respect to P_{BD} , and thereafter expanding by $\frac{P_{BD}}{P_{Ro}}$, the elasticity of P_{RO} with respect to changes in P_{BD} is obtained

$$\mathcal{E}_{Ro,BD} = \frac{1-\beta}{\frac{P_{Ro}}{P_{BD}}\lambda} \quad . \qquad (5)$$

β is estimated to 0.587. The average rapeseed oil price P_{Ro} is estimated to be 586 €/t, while the average biodiesel price P_{BD} arrived at, is 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.

3.4 Empirical results

Unit root and cointegration tests

Diesel, biodiesel, rapeseed, soy and palm oil prices are initially tested for unit roots using the Augmented Dickey-Fuller Test (ADF) and the Kwiatkowski, Phillips, Schmidt & Shin Test (KPSS). Both tests give strong evidence for the presence of unit roots in all series[6]. Cointegration is tested using the Johansen trace test and the Saikkonen-Lütkepohl (2000) test. Strong evidence is found for bivariate cointegration between diesel and biodiesel prices and also between rapeseed oil, soy oil and biodiesel prices. Cointegration of biodiesel, rapeseed or soy oil prices with palm oil prices is not found. In the next step, three series at a time are tested for joint cointegration. The Johansen trace test provides evidence for a single cointegration relationship between biodiesel, rapeseed and soy oil prices. This is also confirmed by the Saikkonen-Lütkepohl test. The tests are repeated for cointegration between diesel, rapeseed and soy oil prices. However, no cointegration is found. Hence, two groups are chosen for further analysis. First, the price pair diesel and biodiesel is investigated to link biodiesel prices to energy prices. Secondly, the relationship

[6] Test statistics are available from the authors upon request.

between biodiesel, rapeseed and soy oil prices is investigated, thus, analyzing the market relationships between biodiesel and its raw materials.

VECM estimation results for biodiesel and diesel prices

First, we estimate a VECM with two lags to derive the long-run relationship of biodiesel and diesel prices (standard errors in parentheses):

$$\ln P_t^{BD} = \underset{(0.3060)}{-1.0355} + \underset{(0.0444)}{1.1355} \ln P_t^{D} + ect_t . \qquad (7)$$

The estimated elasticity of biodiesel prices with respect to diesel prices (1.14) has the expected magnitude. Significant error correction only takes place by adjusting biodiesel prices to deviations from the long run equilibrium. Residual tests of this model indicate problems with heteroskedasticity and excess kurtosis. In order to test for parameter stability, we conduct a break-point Chow test on all model parameters (including the covariance matrix of the residuals, but maintaining regime invariance for the cointegrating vector β). This searches over each data point based on 2,000 bootstrap replications. The null hypotheses of parameter constancy can be rejected at any point in time between 2003 and 2006 at the 5% level (see Figure 8). When applying the recursive eigenvalue test, the null hypothesis of stability α and β vector over time, cannot be rejected at a distinct point in time. Hence, no suitable breakpoints can be determined. Thus, there is no clear indication for a change in the long-run behaviour but strong support for the existence of a stable long-run equilibrium is found. Both the residual as well as the stability analysis strongly suggest that a linear VECM does not fit the data. Furthermore, the assumption of constant parameters cannot be justified.

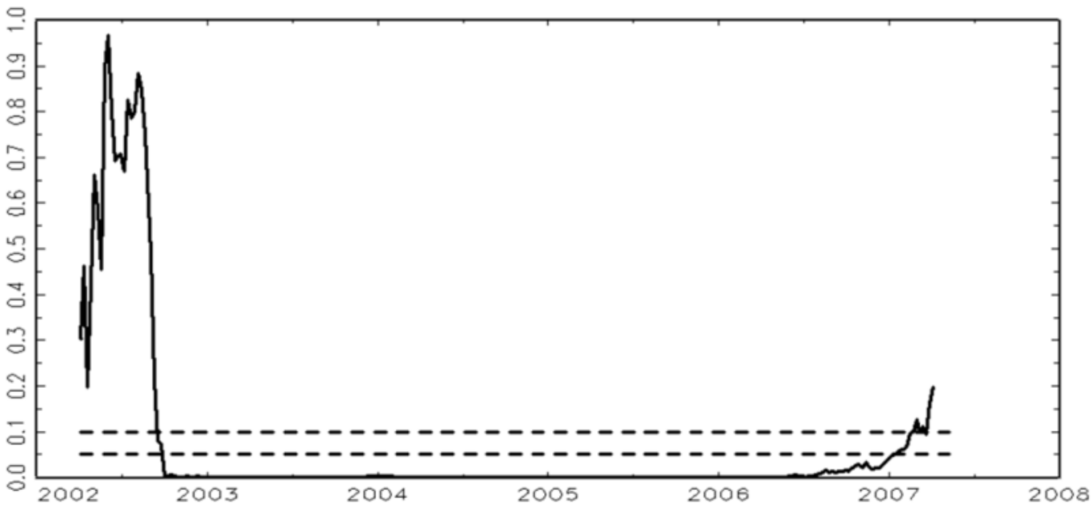
VECM estimation results for biodiesel, rapeseed and soy oil prices

The second long-run relationship of biodiesel with rapeseed and soy oil prices is estimated as follows (standard errors in parentheses):

$$\ln P_t^{Ro} = \underset{(1.0319)}{-4.8573} + \underset{(0.1140)}{0.7429} \ln P_t^{BD} + \underset{(0.0933)}{0.9965} \ln p_t^{So} + ect_t . \qquad (8)$$

The estimated elasticity of rapeseed oil prices with respect to soy 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 is estimated at 0.74 (0.11), which is within the expected range. Correction of deviations from the long-run equilibrium is only shown by rapeseed oil prices. The residual analysis of this model indicates, once more, problems with heteroskedasticity and non-normality. The null hypotheses of parameter constancy of the break-point Chow test can be rejected for most of the possible breakpoints between 2003 and 2007 at the 5% level (Figure 9). The recursive eigenvalue test again, does not indicate instability in the long-run relationship.

Figure 8: P-values of the bootstrapped break-point Chow test (biodiesel – diesel)



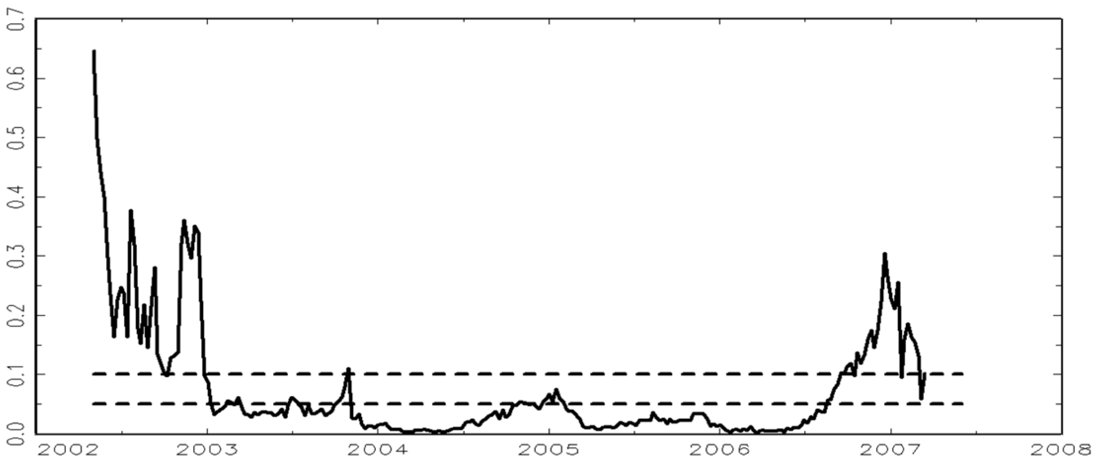
Source: Own calculations.
Note: A value below the lower dotted line indicates the rejection of the parameter constancy hypothesis at the 5% level of significance.

MS-VECM estimation results for biodiesel and diesel

A more flexible modelling strategy is required due to the instability in the adjustment behaviour. We estimate a regime-dependent Markov-switching VECM because we consider it as most appropriate since the German biodiesel market was subject to changing complex economic and political influences. For estimation, the MSVAR-package Version 1.31k for Ox is used (Krolzig, 2004). For the biodiesel and diesel pair we estimate a MSIAH(2)-VECM. This allows for Markov-switching in the error correction coefficients, the intercept (I), autoregressive parameters (A), and in the standard errors of the equations (heteroskedasticity, H) between the two regimes (2).

This specification is suggested by the Hannan-Quinn (HQ) and the Schwarz information criteria (SC) in comparison to alternative specifications with more regimes, and with additional restrictions on parameter invariance. The model is estimated using one lag for diesel and two lags for biodiesel prices, based on exclusion tests for higher order lag coefficients. The diagnostic tests indicate normally distributed residuals, and absence of autocorrelation and heteroskedasticity; hence, the model seems appropriate for the data. The parameter estimates are shown in Table 1.

Figure 9: P-values of the bootstrapped break-point Chow test, biodiesel – vegetable oils



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

The error correction behaviour varies between the regimes and is the main characteristic to discriminate them from each other. The adjustment speed of biodiesel prices is low in the first regime ($a^{BD} = -0.034$) compared with the second one ($a^{BD} = -0.242$). When ignoring any short-run adjustment, half a unit deviation would be reduced in the second regime within 2.5 weeks. It however needs 20 weeks in the first regime. The first regime is characterized by a low α for biodiesel prices and the variance is about 63% higher than in the second regime. Hence, the behaviour of the equilibrium errors tends not to be dominated by the error correction towards equilibrium but instead by the randomly occurring shocks in each period. This regime will therefore be labelled, 'weak regime'. In contrast, the second regime shows highly significant parameters in the biodiesel equation and is therefore labelled, 'complex regime'. The speed of adjustment in biodiesel prices is high and significant. The adjustment coefficient for diesel prices does not become significant in any of the regimes and is, therefore, assumed to be exogenous. Interestingly, the constant does not significantly change between the two regimes if it is restricted to the cointegration vector. It is thus, not considered a suitable parameter to distinguish the regimes.

Table 1: Estimated coefficients of the MSIAH(2)-VECM for diesel and biodiesel

	Weak regime		Complex regime	
	Δp^{BD}	Δp^{D}	Δp^{BD}	Δp^{D}
Const	-0.0355*	0.0121	-0.2508***	0.0217
	(0.0209)	(0.0300)	(0.0518)	(0.0543)
Δp^{BD}_{t-1}	-0.2179	-0.0557	-0.2635***	-0.0324
	(0.1488)	(0.1585)	(0.0750)	(0.0838)
Δp^{BD}_{t-2}	-0.1188	-0.1821	-0.2406***	-0.1637**
	(0.1001)	(0.1616)	(0.0713)	(0.0809)
Δp^{D}_{t-1}	0.0314	0.1473	0.2661***	0.2079**
	(0.0802)	(0.1068)	(0.0904)	(0.1000)
α	-0.0343*	0.0098	-0.2423***	0.0193
	(0.0201)	(0.0289)	(0.0495)	(0.0517)
SE	0.0065	0.0093	0.0153	0.0172
Constant restricted	1.0350		1.0351	

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

The estimated transition probabilities are given in Table 2. Assuming the Markov-chain is in the weak regime, it has a 94% probability to stay in and a 6% probability to leave it and switch to the complex regime. While the weak regime lasts for 18 weeks on average, the complex regime is more persistent with an expected duration of more than 23 weeks.

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

	to…	
from...	Weak regime	Complex regime
Weak regime	0.944	0.056
Complex regime	0.043	0.957

Source: Own calculations.

MS-VECM estimation results for biodiesel, rapeseed and soy oil

For investigating the relationship between biodiesel, rapeseed and soy oil prices, we estimate a MSIAH(2)-VECM, based on HQ and SC information criteria (Table 3). The model is reduced to one lag for biodiesel and two lags for soy oil prices, according to the significance levels. The diagnostic tests indicate a normal distribution of the residuals and the absence of autocorrelation and heteroskedasticity. Hence, the model seems to describe the data adequately.

Again, the error correction behaviour changes strongly across the regimes. 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, of almost 2.5 weeks and 10.5 weeks, respectively. Another distinction between the regimes is the short-run adjustment behaviour, where only the second regime shows a significant adjustment in rapeseed oil prices to changes in biodiesel prices. The constant does not significantly change between the two regimes when restricted to the cointegration vector.

Based on these differences between the regimes, the first regime appears to be an ‘adjustment regime’, since a strong error correction towards the long-run equilibrium occurs. The second regime is labelled ‘biodiesel regime’ due to the significant short-run impact of changes in biodiesel prices. The estimated transition probabilities are given in Table 4. While the adjustment regime lasts on average for 6 weeks, the biodiesel regime exceeds 11 weeks. The main characteristics of the four regimes are summarized in Table 5.

Table 3: Estimated coefficients of the MSIAH(2)-VECM for biodiesel, rapeseed and soy oil

Variable	Adjustment regime			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)
α	-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	4.861			4.847		

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

Table 4: Transition matrix for the MSIAH(2)-VECM for biodiesel, rapeseed and soy oil

to…		
from...	Adjustment regime	Biodiesel regime
Adjustment regime	0.835	0.165
Biodiesel regime	0.087	0.913

Source: Own calculations.

Table 5: Overview of regime characteristics

Parameter	Diesel- biodiesel		Biodiesel- rapeseed oil- soy oil	
	Weak regime	Complex regime	Adjustment regime	Biodiesel regime
Expected elast.	$\mathcal{E}_{BD,D}$= 1.10		$\mathcal{E}_{Ro,BD}$= 0.68- 0.76 ; $\mathcal{E}_{Ro,So}$= 1.00	
Estimated elast.	$\mathcal{E}_{BD,D}$= 1.14		$\mathcal{E}_{Ro,BD}$= 0.74 ; $\mathcal{E}_{Ro,So}$= 1.00	
Regime duration	18	23	6	11.5
Half lives	20	2.5	10.5	2.5
Significant short-run parameter	none	varies	none	Lagged biodiesel prices, for soy oil own lags

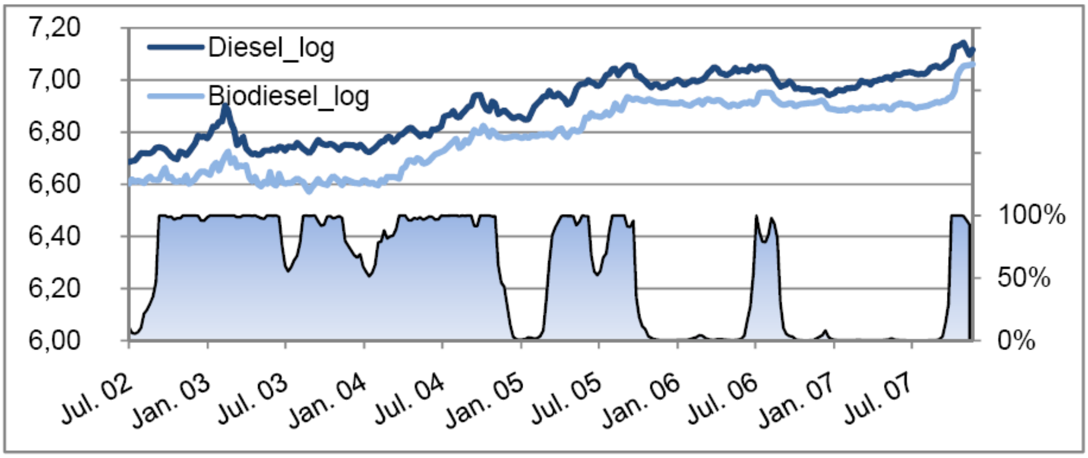
Source: Own calculations.

3.5 Discussion

The probabilities of the occurrence of the complex regime, quantified by smoothed probabilities, are plotted in Figure 10. They indicate that this regime, characterized by strong error correction, occurred until 2004, exclusively coinciding with the period during which the German biodiesel market started growing. In December 2004, the first regime switch towards the weak regime occurred. This lasted for a few weeks before the complex regime returned. At the end of 2005, another regime switch occurred. The industry developed rapidly during this time leading to several changes in the market structure, e.g. large overcapacities in 2006.

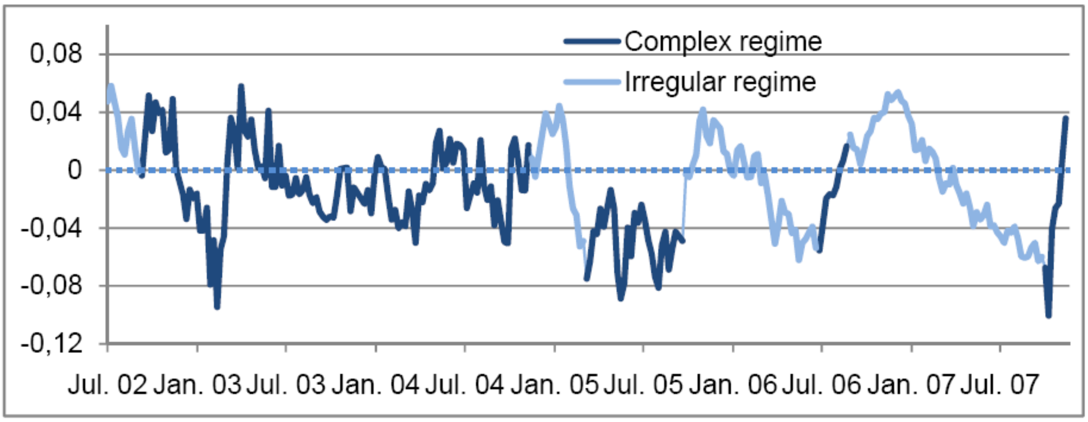
Strong error correction occurred only temporarily with the implementation of the petrol tax on biodiesel in August 2006. During most of 2006 and 2007, the biodiesel regime was predominantly present. The weak adjustment here might be caused by structural problems in the biodiesel industry. The consequences can be seen when inspecting the ECT (Figure 11). While deviations from the long-run equilibrium (ECT) were corrected quickly during the first years, this behaviour is found to be increasingly rare afterward, so that prices tend to exhibit stronger deviations from the equilibrium for a longer period of time.

Figure 10: Prices of biodiesel and diesel (left scale) and smoothed probabilities of the 'complex' regime (right scale)



Source: Own calculations.

Figure 11: Error correction term by regime, diesel-biodiesel

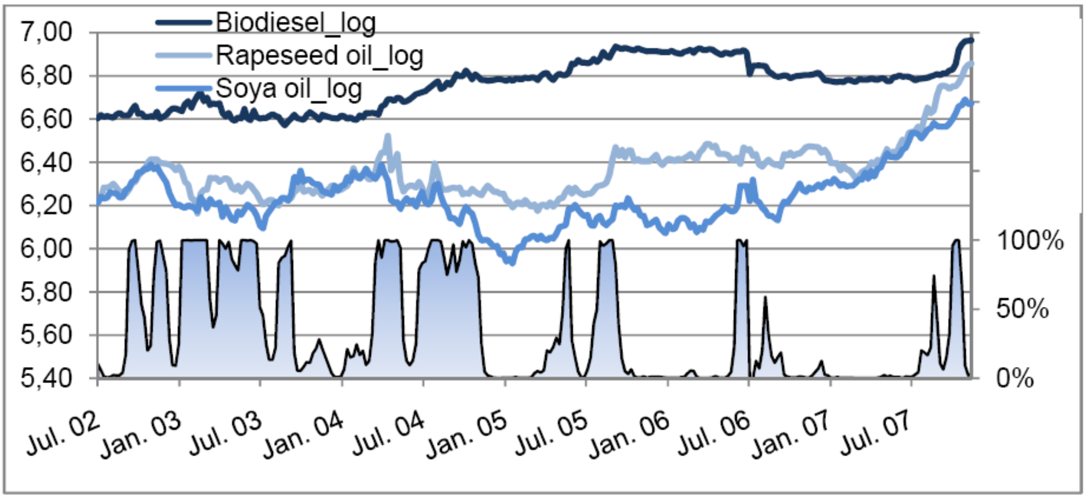


Source: Own calculations.

The adjustment regime in the relationship of biodiesel and its raw products occurred until October 2003 (Figure 12), before the biodiesel regime appeared for several weeks. With a growing importance of the biodiesel industry as the sales market for rapeseed oil in 2004, a strong adjustment towards the equilibrium, with increasing biodiesel and decreasing soy oil prices, took place. With further increasing demand from the biodiesel sector, the price adjustment towards falling soy oil prices weakened in late 2004.

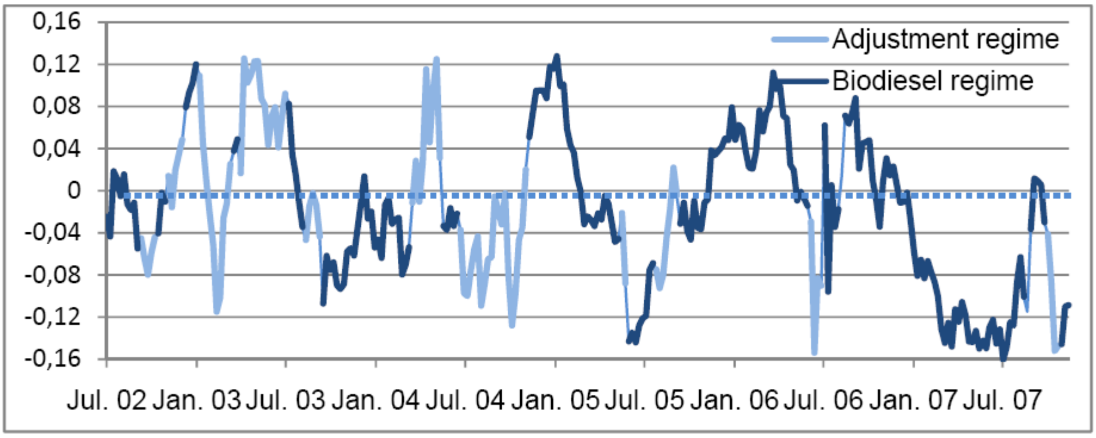
The ECT (Figure 13) became strongly negative after a rise in biodiesel and soy oil prices in June 2005, where an error correction of rapeseed oil prices did not follow before the end of the harvest in August. With growth in demand from the biodiesel sector, the error correction thereafter, remained low. The rapeseed oil price diverged from the equilibrium in times of relative scarcity of domestic rapeseed oil, high overcapacity in biodiesel production, and restricted soy oil use. After some turbulence due to tax implementation on biodiesel in August 2006, new market adjustment took place. The share of soy oil in biodiesel was slowly raised but this cost reduction strategy was outpaced by the overall increase in agricultural commodity prices in 2007. Strong error correction no longer occurred. Despite high vegetable oil prices, the production of biodiesel was still ongoing since the blending mandate had to be fulfilled.

Figure 12: Prices of biodiesel, soy oil, and rapeseed oil (left scale) and smoothed probabilities of the 'adjustment' regime (right scale)



Source: Own calculations.

Figure 13: Error correction term by regime: biodiesel-vegetable oils



Source: Own calculations.

The weak adjustment in both relationships can, as discussed, be primarily linked to the political development in Germany. The hypothesised effects of the tax credit, the blending mandate and the restrictive biodiesel norms can be shown. The first one led to exaggerated expectations of biodiesel producers and, hence, politically induced overcapacity. The blending mandate intensified the competition on the spot market by setting an inelastic demand for biodiesel. Stronger price adjustment was, however, not observed. The strict norms are especially problematic, since these severely limit the use of other vegetable oils beside rapeseed oil for biodiesel. Whether they are necessary from a technical viewpoint, especially in the case of blended biodiesel, remains questionable. Nonetheless, this is an issue which cannot be addressed by an economic study.

3.6 Conclusions

This paper assesses vertical price relationships in the German biodiesel market, in particular, the link to energy markets on the one hand and to its raw products markets on the other. Weekly prices for diesel, biodiesel, rapeseed oil and soy oil over the main development period of the biodiesel industry from 2002 to 2007 are analysed. A linear vector error correction model appears inadequate for the data analyzed; a regime-dependent Markov-switching vector error correction model which relaxes the limitation of constant parameters, describes the data appropriately instead. Stable long-run relationships between biodiesel and diesel and between biodiesel, rapeseed and soy oil prices are found.

The Markov-switching vector error correction model is capable of detecting latent regimes in the data. It neither requires *a priori* identification of determinants nor the timings of the regime switches. Furthermore, the German biodiesel market is characterized on the one hand by rapid development and on the other hand by strong political intervention during the period studied. Such features favour a modelling strategy which allows for regime-dependent behaviour. Both the fit of the models and the implications with respect to the market development, underline the suitability of this approach, which to our knowledge has not been used before to analyse market integration between agricultural and energy prices.

We find two different regimes describing the relationship between biodiesel and diesel prices. The first one is characterized by slow error correction of biodiesel prices and occurred predominantly in 2006 and 2007 when the market underwent ongoing changes caused by policy changes. The second regime shows strong error correction of biodiesel prices and complex short-run adjustment behaviour, hence, indicating functioning markets. This regime was prevalent until 2005. It was however seldom observed in the later years, and persistent deviations from the long-run equilibrium occurred.

In the relationship between biodiesel prices and its raw products, we find similar regimes and similar regime occurrence with weak error correction in 2006 and 2007. Several reasons for this can be found, but most important are again market distortions. Large overcapacity in biodiesel production occurred from 2006 due to investments undertaken in trust of political support and subsidies through capital assistance. Strong norms for both the pure biodiesel and biodiesel used in blends, limited the use of vegetable oils besides rapeseed oil. This led to a situation where even the strong production increase in German rapeseed production was no longer able to feed the demand for biodiesel.

The welfare gains of the change from full tax exemption towards a system with tax credit for B100 and a blending mandate under full taxation are, however, not of the magnitude which is often pretended by policy makers. Furthermore, with vegetable oils adjusting to changes in biodiesel prices, reductions in the tax credit do not require increasing diesel prices. They should however, be balanced by decreasing vegetable oil prices, as long as the market functions. Hence, further reductions in tax credit, as long as they follow a long-term plan, do not have to be compensated for, nor should they by increased blending mandates.

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4 Bestimmung der Determinanten der Rapspreisentwicklung in der Hochpreisphase auf Basis von Markovzeitreihenmodellen

Stefan Busse und Bernhard Brümmer

Zusammenfassung

Der Einfluss der Entwicklungen auf verschiedenen Agrarmärkten auf den deutschen Rapsmarkt wird im vorliegenden Beitrag anhand von multivariaten Zeitreihenmodellen für die Produktpreise untersucht. Da sich in Hochpreisphasen die Preisanpassungsprozesse möglicherweise im Vergleich zu Phasen niedriger Preise ändern, wird auf ein nichtlineares Vektor-Fehlerkorrektur-Modell (VFKM) zurückgegriffen, das regimeabhängige Anpassungen zulässt. Die Spezifikation des Modells als Markovsprung-VFKM erweist sich hier als vorteilhaft, da es keiner a priori Regimespezifizierung und -abgrenzung bedarf. Die Analyse zeigt, dass in den Jahren 2007/08 signifikante Änderungen in den Anpassungsprozessen der Rapspreise im Verhältnis zu anderen Agrargütern auftraten, wobei sowohl Weizen- als auch Sojapreise einen signifikanten Einfluss ausübten. Als entscheidend für das Ausmaß und die Nachhaltigkeit des Rapspreisanstiegs kann hingegen der Abbau von Abweichungen vom langfristigen Gleichgewicht zu Rapsöl- und Rapsschrotpreis determiniert werden.

Keywords: Markovsprung-Vektor-Fehlerkorrektur-Modell, regimeabhängiges Verhalten, Rapsmarkt, Hochpreisphase

4.1 Einleitung

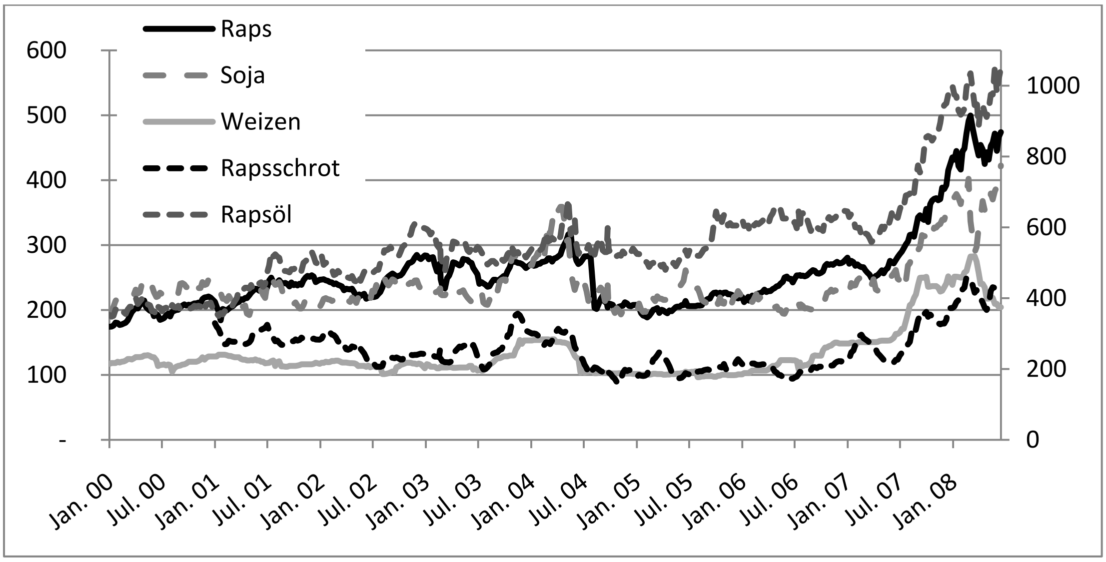
Raps hat sich in Deutschland in den letzten Jahren zu einer der Leitkulturen entwickelt und wird mit 1,5 Mio. ha auf über 9% der landwirtschaftlich genutzten Fläche angebaut (ZMP, 2008). Der Flächenanteil von Raps übersteigt damit bereits seit 2007 dem von Wintergerste, liegt aber noch deutlich hinter Weizen zurück. Die Entwicklung ist maßgeblich durch die Biotreibstoffpolitik begründet. Diese brachte den Raps in eine günstige Position gegenüber anderer Ölsaaten, da deren Verwendung für Biodiesel nur bedingt möglich ist, und führte, zumindest zeitweise, zu nicht unerheblichen Preisaufschlägen für Rapsöl. Im Zuge des Anstiegs der Agrarpreise im Herbst 2007 verdoppelte sich der deutschen Rapspreis innerhalb von Jahresfrist und erreichte einen Höhepunkt von 500 €/t im März 2008. Dabei kam es zu erhöhten Volatilitäten und Preissprüngen von über 25 €/t in Wochenfrist (Vgl. Abb. 1).

Als Ursachen des Preisanstiegs 2007/08 auf den Weltagrarmärkten und im deutschen Markt werden in der Literatur verschiedene Gründe genannt, und deren Implikationen für zukünftige Preisentwicklungen werden sehr unterschiedlich bewertet (vgl. Brümmer et al., 2008, v. Witzke et al., 2008). Zu den meistgenannten Ursachen zählt die Entwicklung der Weltbevölkerung, sowie die Änderung ihrer Ernährungsgewohnheiten, die steigende Nachfrage aus dem Bioenergiesektor, das Verhalten von Spekulanten, sowie unterdurchschnittliche Ernten bei tendenziell abnehmenden Lagerbeständen. Schon heute wird dabei deutlich, dass es sich bei den Preisanstiegen 2007/08 um eine Blase und nicht um eine grundlegende Umkehrung der langfristigen Preisentwicklung zu handeln scheint. Bei den Ölsaaten sehen Schumacher und Chilla (2009) den Grund in den engen Bilanzen, die Weltproduktion lag erstmals seit 2003/04 wieder unter dem Verbrauch, und den extremen Anstiegen der Rohölpreise.

Werden die Ursachen der allgemeinen Preissteigerungen als vielgestaltig akzeptiert, stellt sich die Frage nach den Dynamiken der Preise und der Wechselwirkung verschiedener Preise miteinander, die hier anhand der Preisentwicklung im deutschen Rapsmarkt analysiert werden sollen. Es wird generell angenommen, dass Produktmärkte, die in vertikalen Wertschöpfungsketten miteinander verknüpft sind oder in horizontalen Verbindungen mit anderen Produkten um Faktoren oder

Absatzmärkte konkurrieren, miteinander integriert sind. Grundlegendes Merkmal von Marktintegration ist dabei, dass Preisschocks in einem Markt auf einen anderen übertragen werden (Barret, 1996). Im Folgenden soll nun der Einfluss verschiedener Agrarpreise auf die Entwicklung im deutschen Rapsmarkt analysiert werden. Hierzu wird zunächst eine kurze Übersicht über die Entwicklung auf dem deutschen Ölsaatenmarkt gegeben, bevor wichtige Einflussfaktoren auf die Rapspreisentwicklung diskutiert werden. Im dritten Kapitel werden die theoretischen Grundlagen des Markovsprung-Vektor-Fehlerkorrektur-Modells (MS-VFKM) erläutert, woran sich die statistischen Auswertungen anschließen. Im fünften Kapitel werden die Schätzergebnisse diskutiert, bevor die Analyse mit Schlussfolgerungen schließt.

Abb. 1: Entwicklung der Agrarpreise in €/t (Rapsöl rechte Skala)



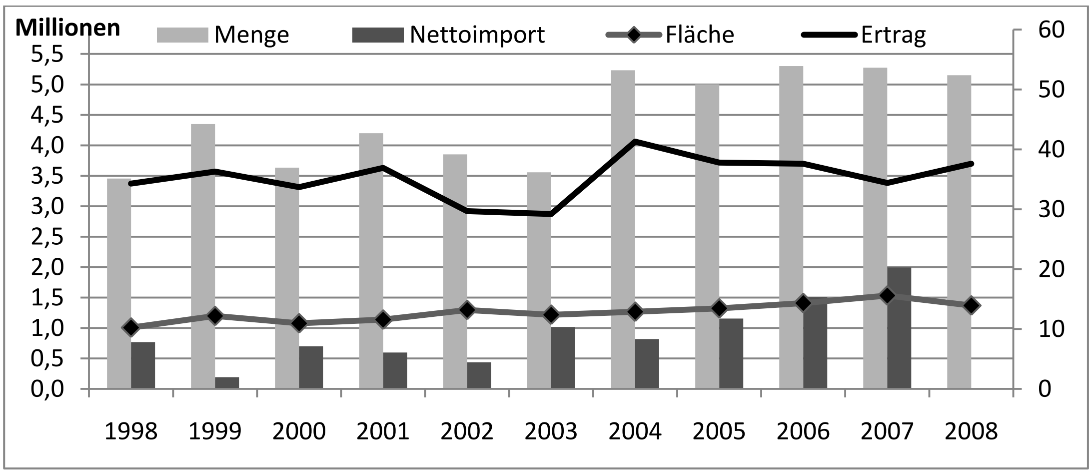
Quelle: Eigene Darstellung aus Daten der ZMP (2008) und LWK (2008).

4.2 Marktüberblick

Einfluss des Biodieselmarktes

Der Rapsanbau gewann in Deutschland, insbesondere durch eine sehr einseitige Biokraftstoffpolitik, in den letzten Jahren immer mehr an Bedeutung und Attraktivität. Die vorwiegende Nutzung von Raps für Biodiesel kann dabei weniger als zufällige Entwicklung, sondern muss als gezielte politische Maßnahme zur Marktentlastung angesehen werden. Die Förderung war so effektiv, dass nicht nur der Rapsanbau und -nettoimport stieg (Abb.2), sondern Deutschland sich auch von einem Nettoexporteur zu einem Nettoimporteur von Rapsöl entwickelte. Neue Analgenkapazitäten für die Biodieselproduktion aus Raps wurden geschaffen und es kam zu Umwidmungen von Ölmühlen von der Soja- zur Rapsverarbeitung. Zwischen 2004 und 2006 verdoppelte sich die Anlagenkapazität jährlich und erreichte in 2007 ihren Höhepunkt bei 5 Mio. t Biodiesel (UFOP, 2008), was einer Verarbeitungsleistung, bei ausschließlicher Verwendung von Raps, von rund 12 Mio. t Raps entsprechen würde. Diese Kapazität wurde allerdings nie ausgenutzt und bereits 2008 kam es zu einem Rückbau. Die Produktion von Biodiesel basierte bis 2006 fast ausschließlich auf Raps, bevor es zur zunehmenden Nutzung von Sojaöl, in Einzelfällen auch Palmöl, kam. Grund für die vornehmlich Nutzung von Rapsöl sind die Biokraftstoffnormen. So schließt der CFPP die Nutzung von Palmöl in den Wintermonaten aus und begrenzt die Nutzung von Sojaöl. Zudem liegt beispielsweise der Jodgehalt von Sojaöl über dem geforderten Höchstwert und verhindert die ausschließliche Nutzung von Sojaöl.

Abb. 2: Entwicklung der Rapsmengen und –fläche (linke Skala), sowie Erträge (dt/ha; rechte Skala) in Deutschland 1998 bis 2008



Quelle: Eigene Darstellung aus Daten der ZMP (2008).

Die Entwicklung im Biodieselmarkt führte zu einem Auftrieb des Rapsölpreises, der nach 2005 den Sojaölpreis um bis zu 200 €/t überstieg. Auch wenn Rapsschrot, bei einem Ölgehalt von 42%, den mengenmäßig größeren Anteil ausmacht, so ist doch seine wertmäßige Bedeutung nur zweitrangig. Die Nutzung von Rapsöl in der Ernährung ging leicht zurück und verlor im Vergleich zur industriellen Nutzung stark an Bedeutung. Diese Lücke wurde überwiegend durch Palmöl geschlossen (ZMP, 2008).

Einfluss der Soja- und Weizenpreise

Der Anbau von Sojabohnen findet überwiegend in Süd- und Nordamerika statt. In Europa finden sich nur einzelne Anbaugebiete, vor allem in Italien (130 000 ha) und Rumänien (114 000 ha) (ZMP, 2008). Mit einem Ölgehalt von etwa 17% kommt bei Soja, im Gegensatz zum Raps, der Schrotverwertung die vornehmliche Rolle zu. Die Konkurrenz zum Raps findet dabei in Deutschland auch weniger auf dem Speiseölmarkt, als vielmehr auf dem Futtermittelmarkt statt. Bei Soja ist Deutschland Nettoimporteur von Sojabohnen (3,7 Mio. t) und Sojaschrot (1,7 Mio. t) und gleichzeitig Nettoexporteur von Sojaöl (0,2 Mio. t), was die Bedeutung der einzelnen Komponenten deutlich unterstreicht. Unter der Entwicklung des Biodieselmarktes verlor Sojaöl zunächst Anteile im deutschen Markt, seine Nutzung stieg aber seit 2005 wieder an (ZMP, 2008). Eine Integration der deutschen Märkte für Raps und Soja scheint naheliegend, da beide Produkte über die Absatzmärkte ihrer Inhaltsstoffe in teilweise direkter Konkurrenz stehen. Als Preisgeber in der Beziehung sollte der Sojapreis auftreten, da dieser vom Weltmarkt bestimmt wird. Allerdings wird der deutsche Markt vom Raps dominiert und die Sojaverarbeitung findet nur statt, wenn sich diese gegenüber der Rapsverarbeitung als vorteilhaft erweist.

Langfristig haben für den Rapspreis im deutschen Markt auch die Preise konkurrierender Feldfrüchte, insbesondere Weizen und Gerste, Bedeutung. Die starke Ausdehnung des Rapsanbaus seit 2000 ging vornehmlich zu Lasten des Weizenanbaus (ZMP, 2008), was auf eine relative Vorzüglichkeit des Rapsanbaus hinweist. Limitierende Faktoren beim Rapsanbau sind dabei Klima- und Bodenfaktoren, sowie Fruchtfolgerestriktionen. Eine Erhöhung des Rapsanteils an Gunststandorten war problemlos möglich und stellte die Bewirtschafter in regelmäßigen Zyklen vor die direkte Wahl. Neben den sicheren Absatzmöglichkeiten gewann der Raps insbesondere durch starke Ertragszuwächse an Konkurrenzkraft. Ein direkter Einfluss der Weizen- auf die Rapspreise kann somit in der langfristigen Betrachtung nicht verneint werden, dürfte aber in der kurzfristigen Preisentwicklung nur eine untergeordnete Rolle spielen.

4.3 Methoden

Probleme linearer Modelle

Die Grundidee traditioneller Vektor-Fehlerkorrektur-Modelle (VFKMs) ist, dass Variablen, beispielsweise Preise, durch ein stabiles Langfristgleichgewicht miteinander verbunden, d.h. kointegriert, sind, von welchem sie auf lange Frist angezogen werden. Die einzelnen Preise können von diesem Gleichgewicht auf Grund von Schocks, also Zufallseinflüssen, kurzfristig abweichen (Gleichgewichtsfehler), werden jedoch langfristig durch die dem Gleichgewicht innewohnenden Wechselmechanismen immer wieder korrigiert. Kernannahme dieser Modelle ist ihr linearer Charakter im Sinne ihrer strukturellen Stabilität, also die Konstanz der Parameter im datengenerierenden Prozess. Die Annahme der Parameterkonstanz erscheint jedoch unter sich tiefgreifend ändernden Marktbedingungen, wie sie auch in den Jahren 2007/08 auftraten, als problematisch (vgl. Krolzig, 2002). Die raschen Preisanstiege bei Raps und anderen Agrarprodukten lassen Zweifel an der Annahme konstanter Parameter aufkommen und vermuten, dass der datengenerierende Prozess, zumindest vorübergehend, einer anderen Dynamik folgt. Ein geeignetes empirisches Untersuchungsmodell sollte diese Eigenschaft widerspiegeln, indem es seinen Parametern ermöglicht, verschiedene Werte anzunehmen (Regime) und zwischen diesen zu wechseln.

Da der genaue Zeitpunkt und der Grund des Regimewechsels schwer, wenn überhaupt, zu bestimmen sind, sollte das Modell weder die a priori Identifizierung und Messung der den Sprung verursachenden Variable, noch der Sprungzeitpunkte erfordern. Solange Markt- und Handelsprozesse die Hauptkräfte für Preisentwicklungen darstellen, kann ein Schwellen-VFKM als das geeignetste Modell angesehen werden. Da die Preisentwicklung hier aber möglicherweise weniger auf normalen Handelsprozessen, als vielmehr auf exogenen Einflussgrößen wie Spekulationen und Erwartungen beruhte, wird in solchen Fällen von Ihle und von Cramon-Taubadel (2008) die Nutzung des MS-VFKM als geeigneter angesehen.

Das MS-VFKM

Das MS-VFKM basiert auf regimeabhängigen Zeitreihenmodellen, die in dieser Form erstmals von Hamilton (1989) vorgeschlagen und dann ausführlich von Krolzig

(1997) untersucht wurden. Allgemein ermöglichen regimeabhängige Modelle die Identifizierung eines potentiell nichtlinearen datengenerierenden Prozesses, welcher als stückweise linear[7] innerhalb der Regime angenommen wird. Die Regimesprünge werden im Folgenden durch eine Zustandsvariable s_t gekennzeichnet. Der Hauptunterschied des MS-VFKM zum linearen VFKM liegt in der wesentlich höheren Flexibilität des Modells, da die Parameter nicht länger als global konstant, sondern als regimeabhängig angenommen werden (Krolzig, 2003). Dieses Modell wurde beispielsweise von Brümmer et al. (2009) genutzt, um Preistransmission entlang der Wertschöpfungskette im ukrainischen Weizenmarkt und abweichende Marktverhältnisse in verschiedenen Phasen der Marktentwicklung zu analysieren.

Für die Analyse von Marktintegration im deutschen Ölsaatenmarkt scheint es plausibel, den Parametermatrizen der Ladungen α (Geschwindigkeit der Gleichgewichtsfehlerkorrektur) und der Kurzfristanpassungen Γ_i Regimeabhängigkeit zu erlauben. Die folgende Spezifizierung des MS-VFKM wird daher verwendet:

(1) $$\Delta p_t = a + \alpha(s_t)\,(\beta'\,p_{t-1}) + \sum_{i=1}^{p-1} \Gamma_i\,(s_t)\Delta p_{t-i} + u_t$$

wobei p_t der Vektor der Marktpreise der verschiedenen Güter darstellt. a ist der Vektor der Konstanten und β ist der Kointegrationsvektor, der das Langfristgleichgewicht der Preise quantifiziert. Δ ist der Operator für die Differenz erster Ordnung, u_t der Vektor der Residuen.

Die Kerncharakteristik der Regimeabhängigkeit wird durch die Variable s_t widergespiegelt, die angibt, in welchem der M Regime sich das System zum Zeitpunkt t befindet. Diese Variable kann unbeobachtet oder unbeobachtbar sein, wodurch der gegenwärtige Zustand des Systems unbekannt bleibt. Die besondere Stärke des MS-VFKMs ist seine Fähigkeit und hohe Flexibilität, potentiell latente Regime in den Daten zu identifizieren. Die entsprechenden Modellparameter stehen in Abhängigkeit vom Regime s_t und nehmen in jedem Regime je einen konstanten Wert an:

(2) $$a\,(s_t) = \begin{cases} a_1 & \text{falls } s_t = 1 \\ \vdots & \\ a_M & \text{falls } s_t = M \end{cases}.$$

[7] Damit wird eine Konstanz der Parameter innerhalb jedes Regimes impliziert.

Der stochastische Prozess, der die Regime generiert, wird als ergodische, homogene und nichtreduzierbare Markovkette angenommen, die durch ihre konstanten Übergangswahrscheinlichkeiten charakterisiert ist:

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

Die Übergangswahrscheinlichkeiten quantifizieren die Wahrscheinlichkeit des Sprungs von Regime i zum Zeitpunkt t zum Regime j im Folgezeitpunkt. Die Regimesprünge werden im Allgemeinen nicht als singuläre, deterministische Ereignisse angenommen, sondern als vielfach wiederkehrende, von einem exogenen stochastischen Prozess geleitete, unbeobachtbare Regimeentwicklungen (Krolzig, 2003). Hamilton (1989) charakterisiert diese als „diskrete Änderungen in Regimeabschnitten in welchen sich das dynamische Verhalten der Zeitreihen merklich unterscheidet“. Abweichungen vom Langfristgleichgewicht werden von den Fehlerkorrekturmechanismen in jedem einzelnen Regime korrigiert. Das Regimeauftreten kann durch die Ableitung der Auftrittswahrscheinlichkeiten der unbeobachteten Regime aus den verfügbaren Informationen in der Stichprobe rekonstruiert werden (sog. geglättete Wahrscheinlichkeiten) (Krolzig, 2003).

4.4 Empirische Ergebnisse

Zeitreiheneigenschaften

Für die Analyse wurden Preise für Raps, Rapsöl, Rapsschrot, Soja und Weizen verwendet, die jeweils Großhandelspreise ohne MwSt. widerspiegeln. Die Preise sind auf Wochenbasis mit 51 Beobachtungen pro Jahr für den Zeitraum Januar 2000 bis Juli 2008 (Rapsschrot ab Januar 2001). Die Daten für die Ölsaaten und ihre Endprodukte wurden von der ZMP zur Verfügung gestellt, die Weizenpreise wurden von der Landwirtschaftskammer Niedersachsen erhoben und entsprechen der Qualitätsstufe B. Die Eigenschaften der einzelnen Preisreihen sind in Tabelle 1 aufgeführt.

Tab. 1: Statistische Eigenschaften der Preisreihen

	Raps	Rapsöl	Rapsschrot	Soja	Weizen
Mittel	254,88	559,07	139,69	240,89	132,92
Min	174,10	347,70	86,42	189,32	96,25
Max	499,60	1050,00	250,83	422,40	282,70
SD	62,48	146,40	33,65	44,35	40,42
# Obs.	433	433	382	433	433

Quelle: Eigene Darstellung

Die Einheitswurzeltests zeigen bei allen Zeitreihen starke Hinweise auf das Vorhandensein von Einheitswurzeln[8]. In keinem Fall kann der ADF-Einheitswurzeltest auf dem 5% Signifikanzniveau abgelehnt werden, beim KPSS-Test wird die Nullhypothese der Stationarität in allen Fällen auf dem 1% Niveau abgelehnt. Die Cointegration von Raps mit Soja, Weizen, sowie mit Rapsöl und Rapsschrot, wird mit Hilfe des Johansen-Trace-Tests und des Saikkonen-Lütkepohl-Tests geprüft. Beide Tests lehnen in allen Fällen die Nullhypothese nichtbestehender Cointegration auf dem 5% Signifikanzniveau ab. Bei Wiederholung der Tests für alle fünf Preisreihen zusammen, unter Beachtung des Bruchs in August 2004 und der Verwendung von zwei Verzögerungstermen, bestätigen beide Tests einen I(3)-Prozess, also eine Cointegration dritten Ranges. Somit liegen drei Gleichgewichtsbeziehungen zwischen den fünf Preisreihen vor.

Anpassung linearer Modelle

Zur Bestimmung der Langfristbeziehungen werden zunächst lineare VFKMs geschätzt. Diese weisen Probleme in der Parameterkonstanz (Chow-Breakpoint-Test) und den Residualeigenschaften (Heteroskedastisität und Normalverteilung) auf. Im linearen Modell zeigt der Sojapreis eine signifikante Anpassung von α = 0,063 (0,020)[9] zum Langfristgleichgewicht mit dem Rapspreis von $p^s = 0{,}687\ (0{,}091)\ p^R +\ 66{,}0\ (23{,}1)$ und somit einen Anstieg der Preisdifferenz

[8] Aufgrund formaler Restriktionen muss hier von der Veröffentlichung einzelner Testergebnisse abgesehen werden, diese werden aber auf Anfrage vom Autor zur Verfügung gestellt.
[9] Standardabweichungen in Klammern.

bei zunehmenden Preisen. Die Langfristbeziehung zwischen Raps und Weizen liegt bei 2,055 (0,061) was auf ein langfristiges Niveau des Rapspreises bei etwa dem doppelten des Weizenpreises hindeutet. Die Anpassung an das Gleichgewicht erfolgt in dieser Beziehung alleinig durch den Rapspreis, der eine deutlich höhere und signifikante Korrekturgeschwindigkeit (α = 0,035 (0,008)) als der Weizenpreis aufweist (α = 0,007 (0,004)).

In der Schätzung der letzten Langfristbeziehung findet sich ein Gleichgewicht, dass nicht signifikant vom physischen Gewicht der Verarbeitungsprodukte (42% Rapsöl, 58% Rapsschrot) im Ausgangsprodukt Raps abweicht. Eine Marge von 47 €/t Raps tritt dabei als Konstante auf, die sich nach einem Bruch im Juli 2004 signifikant auf 77 €/t erhöht. Die Berücksichtigung dieses Bruches begründet sich aus dem Ertragssprung von 2004 (vgl. Abb. 2) und dem daraus resultierenden Anstieg der heimischen Produktion, der einen Einbruch der Rapspreise um 30% innerhalb eines Monats nach sich zog (Der Bruch ist in den vorausgegangenen Modellen nicht signifikant, spielt also in der Beziehung zum Weizen- und Sojapreis keine Rolle.). Das Modell weist signifikante Korrekturen sowohl der Rapspreise (α = 0,095 (0,030)) als auch der Rapsschrotpreise (α = 0,037 (0,018)) auf.

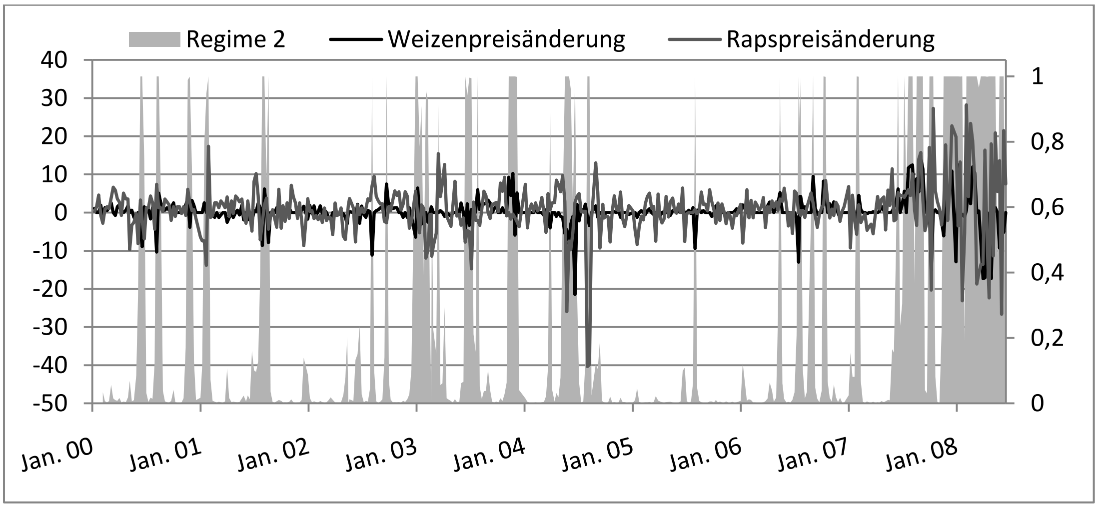
Anpassung nichtlinearer Modelle

Da die linearen Modelle Probleme in der Parameterkonstanz aufwiesen, werden die einzelnen Preispaare erneut, jedoch mit dem regimeabhängigen MS-VFKM, geschätzt. Die Anzahl der Regime und die Regimespezifizierung werden dabei mit Hilfe des Schwarz Kriteriums bestimmt. Es ergibt sich für alle vier Modelle das MSAH(2)-VFKM als günstigstes Modell, welches Markovsprünge in der Ladungsmatrix, den Autoregressiven Parametern (A) und den Standardfehlern (Heteroskedastizität, H) zwischen zwei (2) Regimen zulässt. Die Langfristgleichgewichte werden dabei aus den linearen Modellen übernommen, wie auch die Anzahl der integrierten Vorperioden.

In der Beziehung der Raps- und Weizenpreise tauchen zwei Regime auf, die sich in ihrer Anpassung an die Langfristbeziehung unterscheiden. Das erste Regime ist durch eine signifikante Fehlerkorrektur des Weizenpreises (α = 0,004 (0,002)) gekennzeichnet, während das zweite Regime (Abb. 3) diese im Rapspreis aufweist (α = 0,071 (0,020)). Während die Weizenpreise im ersten Regime fast dreieinhalb

Jahre bräuchten, um die Hälfte einer Abweichung vom Gleichgewicht abzubauen (Halbwertzeit), brauchen die Rapspreise im zweiten Regime dafür nur neuneinhalb Wochen. Weiterhin weist das erste Regime mit zehn Wochen eine wesentlich höhere Persistenz als das zweite Regime (3 Wochen) auf, das als sehr kurzlebig erscheint.

Abb. 3: Auftreten der signifikanten Anpassung des Rapspreises an das Gleichgewicht mit dem Weizenpreis

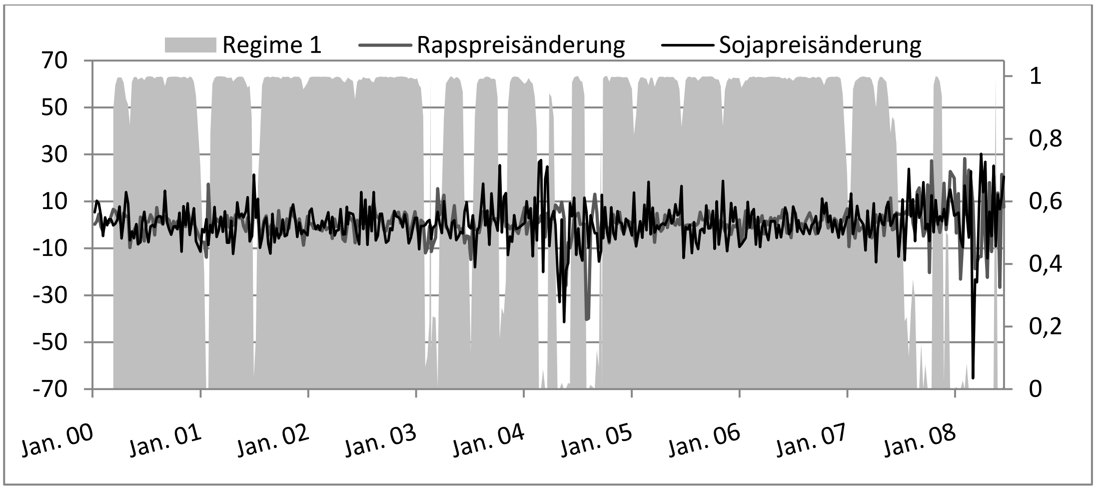


Quelle: Eigene Darstellung.

In der Beziehung zwischen den Raps- und Sojapreisen lassen sich die Regime ebenfalls durch das Anpassungsverhalten abgrenzen. Eine signifikante Fehlerkorrektur findet dabei nur im ersten Regime (Abb. 4) und ausschließlich durch den Sojapreis (α = 0,036 (0,017)), mit einer Halbwertzeit von über vier Monaten, statt. Das erste Regime weist eine hohe Persistenz von über fünf Monaten auf, während das zweite durchschnittlich weniger als sechs Wochen vorherrscht.

Eine weitere Abgrenzung findet sich im Kurzfristverhalten, in dem das erste Regime keine Anpassung der Rapspreise an Änderungen der Sojapreise in den Vorwochen aufweist, während das zweite Regime signifikante Einflüsse der Sojapreisänderungen aus der vorausgegangenen vierten bis siebten Woche in Höhe von 0,28 (0,12) bis 0,39 (0,12) auf die Rapspreisänderungen aufweist. Somit würde eine Anstieg der Sojapreise um 10 €/t einen Anstieg der Rapspreise um 13 €/t in der folgenden vierten bis siebten Woche nach sich ziehen, während im ersten Regime lediglich eine Fehlerkorrektur auftreten würde, bei der innerhalb von sieben Wochen 22,8 % des Gleichgewichtfehlers durch Sojapreisanpassungen abgebaut werden.

Abb. 4: Auftreten der signifikanten Anpassung des Sojapreises an das Gleichgewicht mit dem Rapspreis



Quelle: Eigene Darstellung.

Bei der Schätzung des Einflusses der Rapsöl- und Rapsschrotpreise auf den Rapspreis wird der Rapsölpreis als exogene genutzt, da weder im linearen, noch in einem Regime des regimeabhängigen Modells eine signifikante Fehlerkorrektur auftritt. Die beiden Regime lassen sich durch ihr Fehlerkorrekturverhalten voneinander abgrenzen. Das erste Regime weist eine signifikante Anpassung der Rapsschrotpreise auf (α = 0,036 (0,015)), die einer Halbwertzeit von 19 Wochen entspricht, bei einer durchschnittlichen Regimedauer von knapp 14 Wochen. Das zweite Regime (Abb. 5) weist eine Kurzlebigkeit von weniger als vier Wochen auf, in der es aber zu bemerkenswerten Anpassungen kommt. Mit einem α von 0,540 (0,102) beträgt die Halbwertzeit der Fehlerkorrektur durch den Rapspreis weniger als eine Woche. Eine signifikante Anpassung durch den Rapsschrotpreis findet nicht statt.

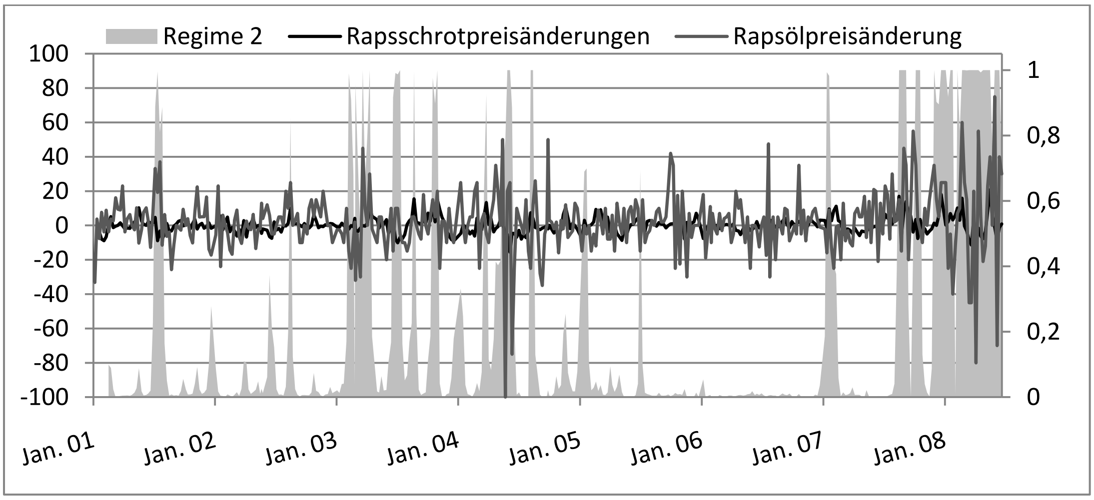
Damit können in allen drei Modellen Regime identifiziert werden, in denen es zu einer signifikanten Anpassung der Rapspreise kommt, und andere, in denen diese nicht zur Korrektur der Abweichungen von den Langfristgleichgewichten beitragen. Die signifikante Anpassung der Rapspreise fällt dabei vornehmlich mit Phasen erhöhter Volatilität zusammen. Die Probleme der Nicht-Normalverteilung konnten gelöst werden, das Problem der Heteroskedastisität zumindest im Verhältnis der Rapspreise zu Soja-, Rapsschrot- und Rapsölpreisen.

4.5 Diskussion

Determinanten der Rapspreisentwicklung bis 2007

Nachdem das unterschiedliche Verhalten der Rapspreise in Verbindung mit Soja-, Weizen- sowie mit Rapsöl- und Rapsschrotpreisen bestimmt wurde, soll dieses im Folgenden in Beziehung zu wichtigen Impulse für die Preisentwicklungen gesetzt werden. Signifikante Korrekturen des Rapspreises zum langfristigen Gleichgewicht treten in der Beziehung zum Rapsöl- und -schrotpreis sowie in Verbindung zum Weizenpreis jeweils im zweiten Regime auf. Eine Reaktion des Rapspreises auf Änderungen im Sojapreis tritt bei einer Verzögerung von vier bis sieben Wochen ebenfalls im zweiten Regime auf, das klassische Fehlerkorrekturverhalten wird jedoch ausschließlich im ersten Regime ausgeübt, wobei dieses ökonomisch nur als mittelfristig relevant bezeichnet werden kann.

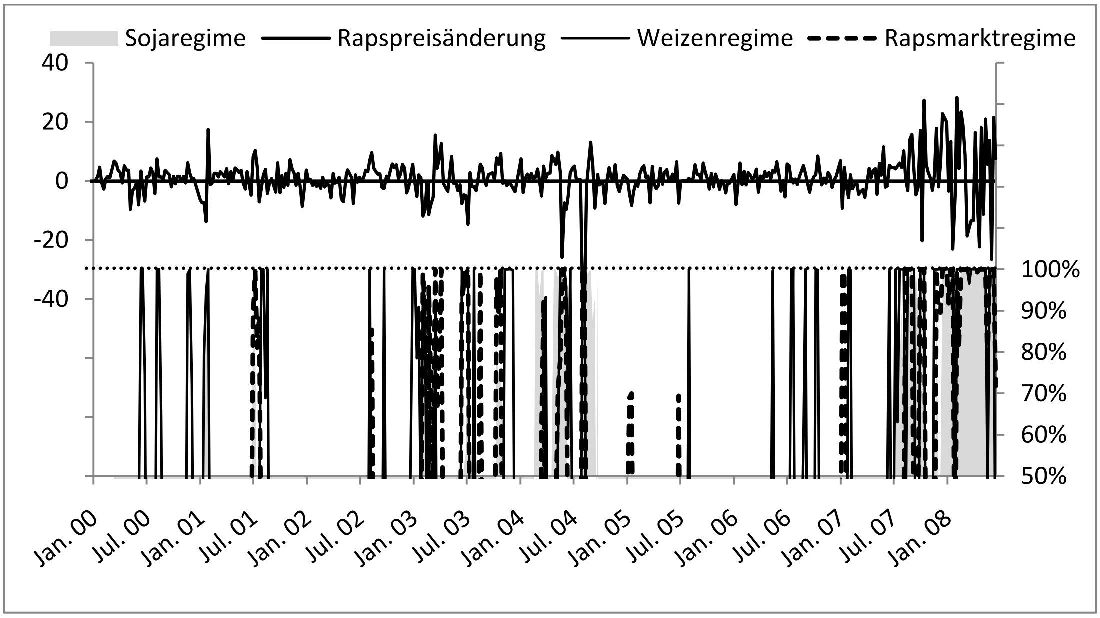
Abb. 5: Auftreten der signifikanten Anpassung des Rapspreises an das Gleichgewicht mit Rapsöl- und Rapsschrotpreisen



Quelle: Eigene Darstellung.

Das zweite Regime tritt in allen drei Gleichgewichtsbeziehungen in Phasen erhöhter Volatilität auf, also vornehmlich zwischen Januar 2003 und Sommer 2004 sowie ab Sommer 2007 (Vgl. Abb. 6). Die Phasen geringer Volatilität zeigen schwache Fehlerkorrekturtendenzen, die in keiner der drei Beziehungen signifikant durch den Rapspreis ausgeübt werden. Die Phase 2003/04 weist mit einem Abfall der Rapsölpreise um 120 €/t bis März 2003, dem Erreichen eines Rekordhochs (680 €/t) im Mai 2004 und dem anschließenden Abfall um 100 €/t in Wochenfrist (Juni 2004) ausgeprägte Volatilitäten auf. Gleichzeitig stieg der Rapsschrotpreis im Herbst 2003 um 70% auf 190 €/t mit Preissprüngen von bis zu über 15 €/t. Ursache war die angespannte Versorgungslage nach zwei unterdurchschnittlichen deutschen Rapsernten in 2002 und 2003, bei zunehmender Nachfrage durch die wachsende Biodieselindustrie. Dieses endete mit der Rekordernte in 2004, deren Niveau erst 2009 wieder erreicht wurde.

Abb. 6: Wöchentliche Rapspreisänderungen (linke Skala) und Auftreten der Regime mit signifikanter Anpassung der Rapspreise (rechte Skala Regime-wahrscheinlichkeit)



Quelle: Eigene Darstellung.

Hohe Volatilitäten wies auch der Sojapreis auf, der zwischen August 2003 und März 2004, infolge rückgängiger Weltproduktion, um 73% auf 360 €/t stieg und dabei in einzelnen Wochen um über 25 €/t zulegte, bevor im April ein dramatischer Preiseinbruch einsetzte (bis -40 €/t pro Woche). Die Schwankungen beim Raps waren lange Zeit eher moderat und überstiegen nur in Einzelfällen die 10 € Marke bevor es in Folge des Sojapreiseinbruchs im Mai zu Preiseinbrüchen um bis zu 25 €/t in Wochenfrist kam. Der Weizenpreis wies sehr geringe Volatilitäten auf und im Zuge des Preisanstiegs in der zweiten Jahreshälfte 2003 (von 107 auf 154 €/t) kam es nur zweimal zu Preisanstiegen, die 6 €/t in der Woche überstiegen.

Determinanten der Rapspreisentwicklung 2007/2008

Die Preisvolatilität 2007/08 ist bei Soja, Rapsöl und Rapsschrot mit der von 2003/04 vergleichbar, allerdings tritt sie nun über einen wesentlich längeren Zeitraum auf. Bei

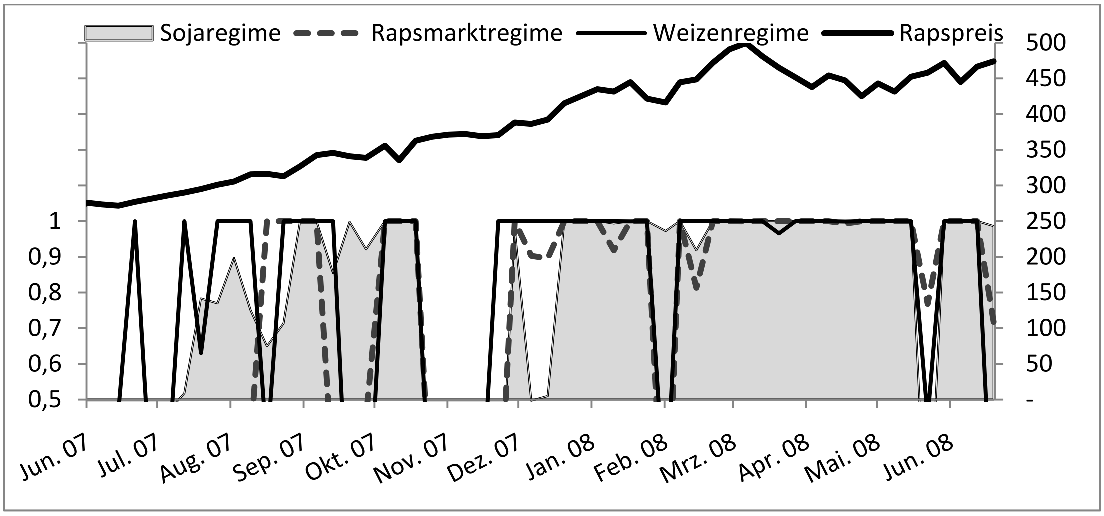
Raps (Abb. 6) und Weizen liegt die Volatilität hingegen deutlich über der von 2003/04, wobei vermehrt Sprünge von über 20 € bei Raps und 10 € bei Weizen auftraten. Alle hier beobachteten Preise erreichten im Februar/März 2008 einen, in dieser Beobachtungsperiode einmaligen, Höchststand (vgl. Abb. 1). Während die Regime mit signifikanter Anpassung der Rapspreise an das langfristige Gleichgewicht zum Weizenpreis und zum Gleichgewicht mit dem Rapsschrot- und Rapsölpreis bzw. der verzögerten Reaktion auf Sojapreisänderungen in der Phase 2003/04 jeweils nur sehr kurzweilig und zum Teil zeitlich versetzt auftraten, erfolgte dieses seit Sommer 2007 wesentlich persistenter und größtenteils parallel.

Aus Abb. 7 wird deutlich, dass im Sommer 2007 zunächst die signifikante Anpassung des Rapspreises an das langfristige Gleichgewicht mit dem Weizenpreis erfolgte, welcher bereits im Juni zu steigen begann. Schon Ende Juli fiel der Rapspreis stark unter den Gleichgewichtspreis, konnte also der Weizenpreisentwicklung trotz erhöhter Anpassungstendenzen nicht folgen. Das Regime zeigt ein häufiges Auftreten bis Ende Oktober, wobei der Rapspreis 90 €/t und der Weizenpreis 80 €/t gewann.

Die signifikante Anpassung des Rapspreises an das Gleichgewicht mit seinen beiden Derivaten erfolgte zwischen Mitte August und Anfang September, sowie in der ersten Oktoberhälfte. Hier gab insbesondere der Anstieg der Rapsölpreise um 80 €/t in der zweiten Augusthälfte dem Rapspreis weiteren Auftrieb, aber auch der Rapsschrotpreis stieg, nach zunächst verhaltener Tendenz, um 13% an. Ein durchgehend negativer Fehlerkorrekturterm weist hier darauf hin, dass der Rapspreis Mitte September 30 €/t unter den Gleichgewichtspreis fiel und bis zum Jahreswechsel unterbewertet blieb. Im November waren die ersten Regime präsent, die durch langsame Fehlerkorrektur durch Rapsschrot- bzw. Weizenpreis gekennzeichnet sind.

Ebenfalls im Juli erfolgte der Regimesprung in der Verbindung zum Sojamarkt, wobei hier erst Ende August mit hoher Wahrscheinlichkeit die Regimezuordnung erfolgen kann. Das Regime, das insbesondere durch die Eigenschaft gekennzeichnet ist, dass Änderungen im Sojapreis erst in der folgenden vierten bis siebten Woche komplett durch Anpassungen im Rapspreis ausgeglichen werden, kann als Indiz gewertet werden, dass der Abfall des Sojapreises im Juli für den sich abschwächenden Preisanstieg von Raps im September verantwortlich war. Diese hohe Anpassungsverzögerung zeigt deutlich, dass sich der Markt 2007/08 in einer ungewöhnlichen Situation befand.

Abb. 7: Rapspreise in €/t (rechte Skala) und Auftreten der Regime mit signifikanter Anpassung der Rapspreise (linke Skala Regimewahrscheinlichkeit)



Quelle: Eigene Darstellung aus Modellergebnissen.

Der Sojapreis wird generell als Schrittmacher für den Rapspreis angesehen, wobei die Verarbeitung von Sojabohnen nur stattfindet, wenn sich diese gegenüber der Rapsverarbeitung lohnt. Der frühe Anstieg der Rapspreise im Juni führte zu einem Anstieg der Differenz zum Sojapreis auf 57 €/t und erhöhte somit kurzfristig die Attraktivität der Sojaverarbeitung in der deutschen Verarbeitungsindustrie, die sich auf die Rapsnachfrage ausgewirkt haben dürfte. Die Phase ging Mitte Oktober in das Regime der schwachen Anpassung durch den Sojapreis über, wobei sich die beiden Preise im Gleichgewicht befanden und bis Mitte November sowohl der Sojapreis als auch der Rapspreis leicht stiegen. Wenn man in der Phase steigender Preise generell von einer erhöhten Tendenz zur vertraglichen Preisabsicherung ausgeht, würden sich, zumindest ansatzweise, Erklärungen für die starke zeitliche Verzögerung finden.

Der erneute Impuls zum Anstieg der Rapspreise erfolgte mit dem Regimewechsel im Weizenmarkt, welcher bis Januar 2008 anhielt. Der Weizenpreis verzeichnete einen Anstieg von 20 €/t während der Rapspreis um 74 €/t anstieg, das Gleichgewicht wurde jedoch nicht vor April erreicht. Der Regimewechsel im Rapsöl- und Rapsschrotmark erfolgte Anfang Dezember. Der Rapsölpreis stieg bis Ende Dezember auf 1 000 €/t und lag damit 300 € über dem Augustwert. In diesem

Regime, das einen außergewöhnlich hohen Korrekturkoeffizienten aufweist, wies der Rapspreis bis in den Januar hinein starke Bestrebungen auf, das Gleichgewicht durch Preissteigerungen wieder zu erreichen. In Verbindung zum Sojapreis war das Regime der zeitlich verzögerten Anpassung ab Dezember bis Mitte Mai präsent, und der Sojapreis zeigte bis Ende Februar positive Tendenzen, die den Rapspreis hier nachhaltig beeinflusst haben. Das zwischen November und März erreichte stabile Gleichgewicht zwischen den Preisen ging in ein deutliches Ungleichgewicht zu Gunsten des Rapspreises über, der sich nur Ende April noch einmal kurzzeitig dem Gleichgewicht nährte.

Das leichte Nachgeben der Rapspreise Ende Januar kann auf einen Rückgang der Rapsölpreise im Januarverlauf zurückzuführen sein, die mit der weiteren Steuererhöhung für Biodiesel unter Druck gerieten und im Januar um 80 €/t fielen. Unter dem positiven Einfluss der steigenden Sojapreise und mit dem Erreichen des Gleichgewichts im Rapsöl- und -schrotmarkt erreichte der Rapspreis Ende Februar seinen Höchststand von 500 €/t. Trotz hoher Schwankungen des Fehlerkorrekturterms um das Gleichgewicht hielt dieses bis zum Sommer an. Dieses war der erste längere Zeitraum seit Beginn der Phasen der stetigen Unter- (ab Sommer 2005) und Überbewertung (ab Sommer 2006). Die Entwicklung des Rapspreises bis zur Ernte wurden durch sich, nach zwischenzeitlichen Schwächen, erholende Rapsöl-, Rapsschrot- und Sojapreise bestimmt, die zu stabilen Rapspreisen um die 450 €/t führte. Im Zuge des Rückgangs der Weizenpreise stellte sich auch hier wieder das Gleichgewicht ein.

Die Gründe der Rapspreisentwicklung 2007/08 sind somit vielseitig, jedoch lassen sich klare Tendenzen erkennen. Als Impulsgeber für den Anstieg der Rapspreise im Spätsommer und Herbst 2007 lässt sich die Anpassung an den Weizenpreis bestimmen, die allerdings in späteren Phasen von anderen Anpassungsprozessen überlagert wurde. Die Anpassung an den Sojapreis setzte später ein und fand zeitlich verzögert statt, jedoch zeigt sich hier eine deutliche Einflussnahme. Angesichts der Tatsache, dass Soja über die Hälfte der Weltölsaatenproduktion ausmacht und 2007/08 maßgeblich zum ersten Produktionsrückgang im neuen Jahrtausend beitrug, ist dieses nicht überraschend. Ungewöhnlich sind allerdings die zeitliche Verzögerung und die fehlende Fehlerkorrektur, die auf ein Abweichen von gewöhnlichen Preisanpassungsprozessen hindeutet. Die Anpassung könnte durch verstärkte vertragliche Bindung verzögert worden sein, es scheint aber wahrscheinlicher, dass diese insbesondere über den Pflanzenölmarkt bestimmt wurde und somit nur indirekt auftrat.

Diese Hypothese wird zudem durch das Auftreten der Phasen mit starker Anpassung an das Gleichgewicht mit Rapsöl- und Rapsschrotpreisen durch den Rapspreis gestützt. Diese setzte ab Ende August 2007 ein und hatte den größten Einfluss auf die Rapspreisentwicklung. Die Anpassung an das Gleichgewicht zwischen dem Rohstoff und seinen beiden Derivaten trug entscheidend, sowohl zu dem letztendlichen Ausmaß des Anstiegs der Rapspreise, als auch zu dem langen Anhalten dieses Preishochs bei.

4.6 Schlussbemerkungen

Ziel der Analyse war die Bestimmung der Determinanten der Preisentwicklung im deutschen Rapsmarkt in der Phase zwischen Juni 2007 und Juni 2008, in der zunächst historische Höchststände erreicht wurden, bevor sich der Markt wieder beruhigte. Wöchentliche Beobachtungen von Raps-, Rapsschrot-, Rapsöl-, Soja- und Weizenpreisen werden verwendet, um Wechselbeziehungen zwischen den Preisen zu bestimmen. Da die Parameterkonstanz in den Preisanpassungsprozessen abgelehnt werden musste, wurde ein regimeabhängiges Markovsprung-Vektor-Fehlerkorrektur-Modell verwendet. Dieses identifizierte in den einzelnen Beziehungen zwischen den betrachteten Agrarprodukten je zwei Regime mit unterschiedlichem Anpassungsverhalten an das langfristige Gleichgewicht. Als bedeutsam erwies sich dabei der Unterschied zwischen Phasen mit hoher und geringer Volatilität der Rapspreise. In der Preisentwicklung 2007/08 lassen sich Parallelen zu der Entwicklung 2003/04 aufzeigen, die ebenfalls durch unterdurchschnittliche Ernten ausgelöst wurde. Allerdings unterscheidet sich die aktuelle Phase von der vorausgegangenen sowohl durch eine wesentlich höhere und länger anhaltende Volatilität als auch durch das Niveau der Rapspreise.

Der Rapspreis weist im Verhältnis zum Weizenpreis in diesen Phasen eine signifikante Anpassung an das gemeinsame Gleichgewicht auf, wobei sich der Weizenpreis als Impulsgeber für die Preissprünge herausstellt. Zudem weist der

Rapspreis zeitlich stark verzögerte Anpassungen an Sojapreisänderungen auf. Als treibende Kraft, die maßgeblich das Ausmaß der Preissteigerung und die Persistenz dieser beeinflusste, sind hier der Rapsölpreis und, auf Grund seiner geringen wertmäßigen Bedeutung nur in zweiter Linie, der Rapsschrotpreis zu nennen. Die überaus hohe Fehlerkorrekturgeschwindigkeit fand sich insbesondere in 2008 wieder und trug sowohl zum absoluten Preisniveau, als auch zur Beständigkeit desselben bei. Dabei wurde das langfristige Preisgleichgewicht zwischen den drei Gütern wieder erreicht.

Somit bleibt festzuhalten, dass in den Phasen erhöhter Preisvolatilität eine Reihe von Ereignissen in den verschiedenen Märkten auftrat, die in unterschiedlichem Ausmaß Einfluss auf die Rapspreisentwicklung genommen haben. Im Gegensatz zu 2003/04 ist die Phase 2007/08 durch ein langes Anhalten von Regime gekennzeichnet, die von den normalen Anpassungsprozessen abweichen. Dabei kamen frühe Impulse vom Weizenmarkt, was zum Teil auf psychologische Effekte, und damit möglicherweise auf Spekulationsverhalten, zurückgeführt werden kann. Das letztendliche Ausmaß des Rapspreisanstieges wurde hingegen durch den Markt, und dabei insbesondere durch die Rapsölnachfrage, bestimmt, die heute im Wesentlichen aus dem Biodieselsektor kommt.

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5 Investigating Rapeseed Price Volatilities in the course of the Food Crisis

Abstract

This article investigates the development of volatilities in agricultural commodity prices during and after the food crisis with a focus on rapeseed future prices at the MATIF. We apply a dynamic conditional correlation model belonging to the class of multivariate GARCH models on price returns for rapeseed, crude oil and related agricultural commodity prices. Volatility developments on a daily basis between 1999 and 2009 are investigated with a focus on the period of the 2007/08 food crisis. An increasing correlation between the returns in rapeseed and crude oil prices is found. Additionally, this correlation did not only increase during the food crisis but further rose afterwards. This implies that rapeseed prices react in an increasing manner to the same information as crude oil prices. Furthermore, rapeseed prices show high sensitivity to shocks and low persistency in volatilities and, thus, bear the risk of overreactions in volatile phases. The increased correlation introduces the potential of even more pronounced volatilities in agricultural commodity prices during the next price boom since crude oil prices exhibited a higher volatility level versus agricultural commodity prices in the past. Furthermore, due to the difficulty in distinguishing commodity price trends, caused by changes in supply and demand, from volatilities, stemming from expectations and speculations, optimal production schemes are difficult to set up. Therefore they bear the risk of more pronounced price level changes in the long-run.

Key words: Multivariate GARCH, MATIF, rapeseed, crude oil, volatilities, food crisis

JEL classification: C32, E44, G1, Q11, Q13, Q49

5.1 Introduction

In course of, as well as after, the price boom in 2007/08 the level of agricultural product prices and their increasing volatility raised concerns of many policy makers and interest groups. The WORLD BANK (2009) declared that "High volatility in food prices, combined with the impact of the financial crisis, threatens to further increase food insecurity […]". Increased volatilities imply higher uncertainty and therefore influence production and consumption decisions. Price changes should usually reflect supply or demand shifts to which markets adjust. In phases of high and persistent volatility, it is, however, difficult to distinguish between market instability and higher price levels (FAO, 2009).

The discussion about the integration of agricultural markets with energy markets already took place before the price boom and could be shown for several commodities using different econometric techniques (c.p. BALCOMBE AND RAPSOMANIKIS (2008), SERRA ET AL. (2008), DE GORTER (2008)). The topic of volatilities in agricultural markets is, on the contrary, rather new. A number of recent applications exist which study price volatilities in agricultural and energy markets. MEYERS AND MEYER (2008) investigated the causes and implications of price increases between 2005 and 2008. The impact of biofuels was particularly discussed. While it could be easily concluded about its impact on the agricultural price levels, no clear conclusions could be drawn about the effects on price volatility. However, DU ET AL (2009) were able to show volatility spillovers from crude oil to corn prices in the US using a stochastic volatility model. Multivariate GARCH models were used by BEKKERMAN AND PELLETIER (2009) who study the effect of ethanol demand on corn and soybean in the US using a dynamic conditional correlation model (DCC). TEJEDA AND GOODWIN (2009) used similar data applying a regime switching dynamic correlation model. They found positive dynamic correlation between corn and soybeans, and discussed the impact of ethanol demand. KANAMURA (2008) used a DCC model and found changing correlation between petroleum and agricultural commodity prices.

The methods commonly used to analyze volatilities in time series are General Autoregressive Conditional Heteroskedasticity Models (GARCH- Models). These allow for rich insights into the volatility structure of time series. The multivariate versions additionally provide information about conditional correlation between the volatilities of different price series (for a survey on this model class see BAUWENS ET AL, 2006). The strongest drawback of multivariate GARCH models (MGARCH) is their data requirement since they demand a number of observations which is usually hard to obtain for agricultural commodities.

We contribute to this literature with an analysis of the volatility developments in the European market. Rapeseed prices quoted at the Marché A Terme International de France (MATIF) in Paris are used and their volatility structure is compared to commodity spot market prices of vegetable oil at trading place in Rotterdam and Brent crude oil prices. The MATIF is nowadays the most important trading place for rapeseed but the volatility behavior of these prices during and after the food crisis has up to now not been analyzed in detail. We aim to fill this gap and provide some insights into the volatility behavior. This should help to understand price developments, and especially volatility developments, during the past years. Furthermore, correlation in the price volatility of the different commodities as well as their development over time is investigated. This allows for conclusions about how closely different price pairs follow the same market information and, hence, how closely volatilities in different markets are related. The DCC model is chosen since it yields the dynamic correlation in volatilities between different series and, hence, allows for conclusions about changes of these.

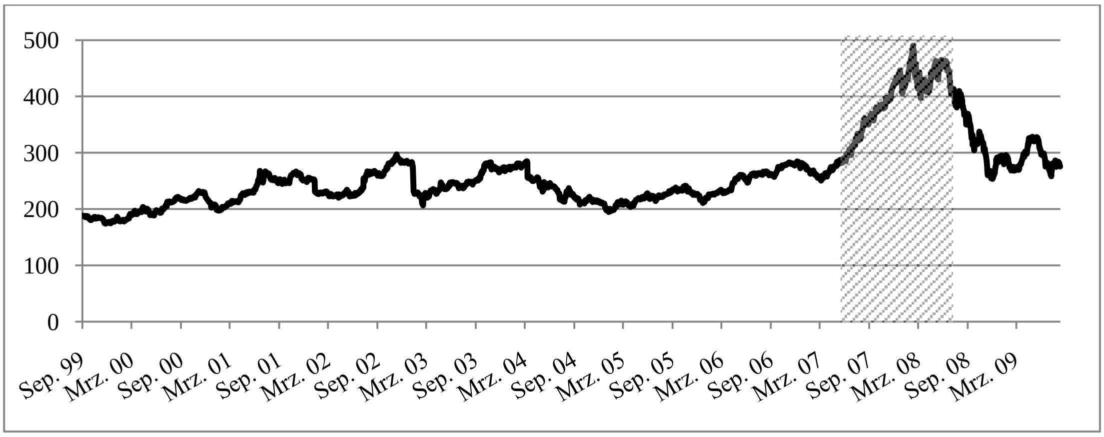
The following chapter describes the market development during the last years and outlines the role of the MATIF. The third chapter gives the model theory and the following chapter, the empirical results. These will be discussed in detail in the fifth chapter before conclusions close the paper.

5.2 Market overview

Although, the cultivation of rapeseed has a long tradition in Europe, the crop especially gained importance with the rise of the biofuel industry in the first decade of the new millennium. Biodiesel developed during this time and was transformed from being a niche product into an important player in the rapeseed oil market. The rapeseed area as well as production within the European Union (EU) increased strongly from 4.4 million ha (1998) to 8.1 (2007), raising production from 12.0 to 20.4 Mt. On the global scale, the rapeseed production area increased from 25.8 million ha to 30.8 million ha, production rose during this period from 35.7 to 50.6 Mt. While rapeseed is the most important oilseed in the EU, it plays a much smaller role on the world market. Globally, soybean (90 million ha / 221 Mt) is the most important oilseed but was outperformed by palm oil in terms of vegetable oil quantity produced some years ago (FAOSTAT, 2009).

Figure 1 shows the rapeseed price development over the past decade. In the food crisis of 2007/08, rapeseed prices, as most other agricultural commodity prices, increased strongly reaching a peak in early 2008. The price level was the highest within this decade and the peak price of 500 €/t reflects a doubling of prices within a year's time. The data shown here was obtained from the MATIF which is the most important stock exchange for rapeseed worldwide (for details see www.euronext.com). Figure 2 shows the increase in volume traded at the MATIF during the past ten years. The MATIF offers different contracts with the expiration dates of February, May, August and November for six consecutive contract months. The most important, and, hence, those with the highest volume are the nearest (first) and the second nearest front month which are plotted in Figure 2. The series are constructed in such a way that with the expiration of one contract, the system is shifted towards the next date. The same principle will be used later on for constructing the price series.

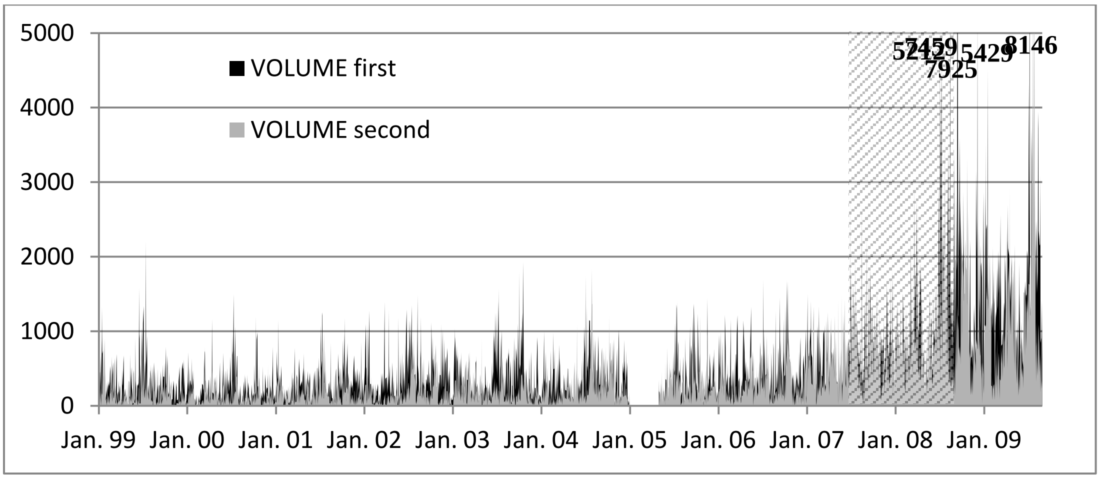
Fig. 1: Rapeseed price notation at the MATIF in €/t, food crisis period (shaded area)



Source: Own elaboration based on MATIF (2009).

The MATIF's increasing importance is illustrated by the increasing volume reaching a level of up to 8,000 contracts per day. The average daily volume of the nearest contract was 1,562 contracts in 2008/09 compared to 945 during the food crisis in 2007/08 and 536 in the pre-crisis period (2006/07). The average daily volume in 2008/09 is almost six times higher than in 1999/2000. The maximum observed volume on the first contract represents about 0.73 %, all six contracts combined almost 1 % of annual world rapeseed production traded on a single day. This rise in volume is not solely a phenomenon for rapeseed at the MATIF but was observed also for other agricultural commodities at stock exchanges around the world (ROBLES ET AL., 2009). The importance of rapeseed price notation at the MATIF grew not only for global traders but also for wholesalers and framers. These do not necessarily participate at the MATIF but use these price trends for their own production and trading decisions.

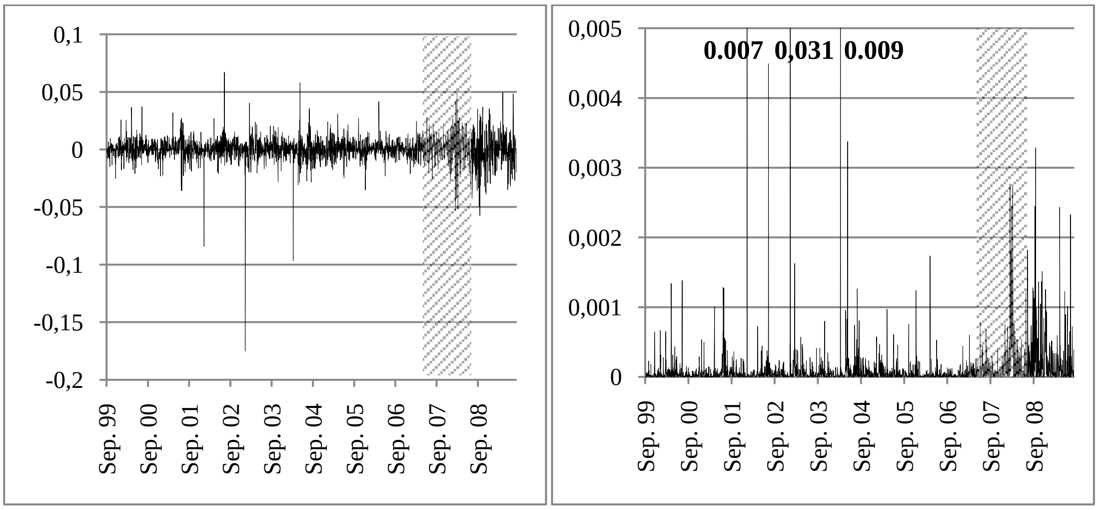
Fig. 2: Volume of contracts traded during one day at the MATIF nearest (first) and second nearest expiration (truncated)



Source: Own elaboration based on MATIF (2009).

The price increase in 2007/08 was, in many markets, accompanied by strong price fluctuations. The daily returns in rapeseed prices are shown in the left part of Figure 3. The right part shows the squared returns in order to give a clearer picture of the development of volatility over time. A change in volatility over time can be observed here. More important than the range of the price changes, is the volatility persistency. The right panel shows clearly a much higher persistency of price fluctuations in 2008, compared to e.g. 2006. It should be noted that the price increase in 2007 was obviously not accompanied by increased volatility but rather took place steadily. The volatility rose as late as in December 2007 and became especially high in summer 2008. The most interesting point to note is that volatility in rapeseed prices did not decrease substantially during the months after the food crisis. A more detailed analysis of this behavior will be provided when discussing the empirical results of the estimated model.

Fig. 3: Returns (left Fig.) and squared returns (right Fig./ truncated) of rapeseed prices



Source: Own elaboration based on MATIF (2009).

5.3 Methods and data

Theoretical framework

The model used to analyze the price behavior belongs to the class of multivariate GARCH models. MGARCH models allow for investigation of volatilities in markets as well as the correlation of volatilities between markets. These can occur as certain news might affect not only the price volatility on a specific market but might affect the volatility of different commodity prices simultaneously. The model used in this analysis is the Dynamic Conditional Correlation model (DCC) in the specification of ENGLE (2002) which BAUWENS ET AL (2006) categorized as a nonlinear combination of univariate GARCH models. It can be seen as a generalization of the Constant Conditional Correlation model (CCC) model proposed by BOLLERSLEV (1990).

The data used is calculated in "returns" and r_t describes the return of one commodity at time index t. The conditional mean (μ_t) and conditional variance (${\sigma^2}_t$) of the series r_t given the information set available at time $t-1$ denoted by F_{t-1} with:

$$\mu_t = E(r_t|F_{t-1}) \qquad (1)$$

$$ {\sigma^2}_t = Var(r_t|F_{t-1}) = E[(r_t - \mu_t)^2|F_{t-1}] \qquad (2)$$

It is assumed that r_t follows an ARMA(*p*,*q*) process so that:

$$r_t = \mu_t + a_t \qquad (3)$$

$$\mu_t = \phi_0 + \sum_{i=1}^{k} \beta_i x_{it} + \sum_{i=1}^{p} \phi_i r_{t-i} - \sum_{i=1}^{q} \theta_i a_{t-1} \quad (4)$$

k, p and q are non-negative integers and x_{it} are explanatory variables. a_t is the innovation of the commodities return at time *t*. In the context of GARCH models, this equation is often referred to as the *mean equation* for r_t. Combining (2) and (3) gives,

$$ {\sigma^2}_t = Var(r_t|F_{t-1}) = Var(a_t|F_{t-1}) \qquad (5)$$

The analysis focuses on the evolution of ${\sigma^2}_t$ in the so called *volatility equation* for r_t.

A GARCH(1,1) process can be described as

$$a_t = \sigma_t \epsilon_t \qquad (6)$$

$$ {\sigma^2}_t = a_0 + a_1 {a^2}_{t-1} + \beta_1 {\sigma^2}_{t-1} \qquad (7)$$

with

$$0 \leq \alpha_1, \beta_1 \leq 1, (\alpha_1 + \beta_1) < 1 \qquad (8)$$ (TSAY, 2005).

We are using the ENGLE (2002) specification, where the single univariate processes are estimated in the first step and the multivariate part in the second step. ENGLE (2002) uses h_t to denote the conditional variance. $h_{i,t}$ is therefore described as:

$$h_{iit} = \omega_i + \alpha_i {\varepsilon^2}_{i,t-1} + \beta_i h_{ii,t-1} \quad i = 1, \dots, N \quad (9)$$

The α-coefficient represents here the influence of the lagged error, and hence, the role of shocks to the market. The β-coefficient indicates the impact of lagged volatility and therefore the persistency of volatility in the market. ${\varepsilon^2}_{i,t-1}$ are the residuals of the ARMA(*p*,*q*) process which are assumed to be *iid*.

ENGLE (2002) defines the covariance matrix of the DCC model as:

$$H_t = D_t R_t D_t \text{ ,} \qquad (10)$$

$$\text{where } D_t = diag\{\sqrt{h_{i,t}}\}, \qquad (11)$$

R_t is the correlation matrix containing the conditional correlations. The correlation estimators $\rho_{i,j,t}$ in this matrix are allowed to be time varying. R_t can be described by

$$R_t = diag\ \{Q_t\}^{-1} Q_t \{Q_t\}^{-1} \qquad (12)$$

where

$$Q_t = S\ (1-\alpha-\beta) + \alpha(u_{t-1}{u'}_{t-1}) + \beta Q_{t-1} \qquad (13)$$

S is the unconditional correlation matrix of u which is defined as

$$u_t = D_t^{-1} r_t \qquad (14)$$

α and β have to be non-negative and satisfy the condition $\alpha + \beta < 1$ (ENGLE, 2002). If this latter condition is violated, the correlation is not mean-reverting. Of particular interest are the conditional correlation estimates ($\rho_{i,j,t}$) which can take values between plus and minus one.

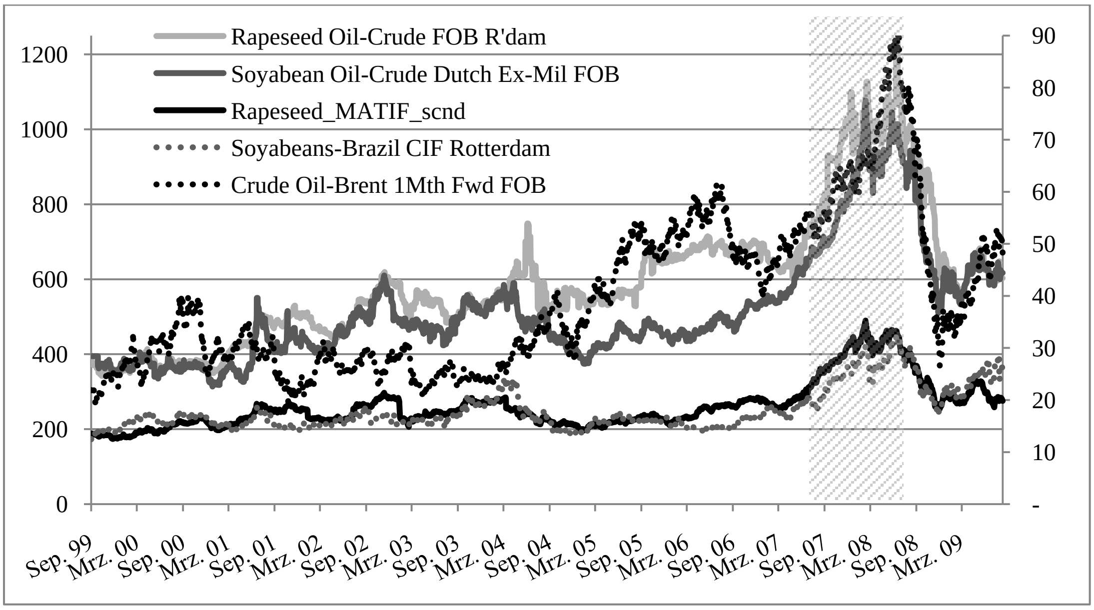
Data

The data used in this analysis are daily observations (5 obs./week) of commodity prices over the period 1999 to 2009 (2,537 obs.). Rapeseed prices were obtained from the MATIF in Paris, nowadays the most important stock exchange for rapeseed worldwide. Prices of the second nearest contract are used since prices of the nearest contract tend to fluctuate heavily when the contract expires. Later contracts show a substantially lower level of activity. The other commodity prices were obtained from THE PUBLIC LEDGER (2010). Soybean oil and rapeseed oil prices are collected in

Rotterdam (Netherlands) as FOB (Free on board) prices for crude vegetable oil. The soybean prices are import prices CIF (cost, insurance and freight) Rotterdam for beans imported from Brazil[10]. All agricultural prices presented in Figure 4 are in Euros per ton without VAT. The crude oil prices are Brent prices one month forward for crude oil FOB (presented in Euros per barrel).

The dataset has been chosen in order to obtain comparability. Rotterdam is currently the most important trading place for agricultural commodities in Europe. Vegetable oil prices from Rotterdam are assumed to represent EU prices. Import prices for soybeans are chosen since almost no soybeans are grown within the EU. Rapeseeds as well as soybeans are crushed within the EU and very little extra-European trade of soybean oil and rapeseed oil takes place. Palm oil and sunflower oil prices are not used for the analysis since the latter has a small market share and serves a specific segment of the food oil market. Palm oil is usually crushed in the exporter countries and imported as oil. While a competition to rapeseed oil appears on the food oil market, the competition on fuel oil markets is much lower and no competition to rapeseed appears in the processing industry. In favor of a more parsimonious model setup, the focus is laid on the most important commodities in relation to rapeseed.

Fig. 4: Price development 1999- 2009 in €/t (crude oil €/ barrel)



Source: Own elaboration.

[10] The usage of CIF and FOB prices in one model has the disadvantage that developments of e.g. transportation costs are not taken into account. However, we argue that these prices best reflect the market prices and determine the crushers and buyers choice in the EU market.

5.4 Empirical results

For the empirical analysis, the prices are used as daily returns to ensure stationarity. The ADF test reveals non-stationarity in levels where the null hypothesis of the existence of a unit root cannot be rejected for any series (Table 1). However, the returns series show stationarity. From Table 2 it can be seen that all series show excess kurtosis in levels as well as returns. The standard deviation of crude oil prices in levels is much higher than that of the agriculture commodities, where it is approximately one quarter of the average value.

Tab. 1: ADF test for unit roots in levels and returns

	levels		returns	
	Test statistic	lags	Test statistic	lags
Rapeseed	-1.62	1	-47.55***	0
Soybeans	-1.98	1	-52.60***	0
Rapeseed oil	-1.64	5	-42.17***	1
Soybean oil	-1.54	8	-42.17***	1
Crude oil	-1.63	0	-21.13***	5

Note: (*) indicates 10 % significance level, (**) 5 % and (***) 1 %; lags according to AIC
Source: Own elaboration.

Tab. 2: Distribution characteristics

	levels	returns	levels	returns	levels	returns
	Mean (Standard deviation)		Skewness		Kurtosis	
Rapeseed	261.58 (62.57)	0.00015 (0.0107)	1.51	-2.19	5.02	37.66
Soybeans	250.39 (56.21)	0.00029 (0.0188)	1.42	-0.29	4.20	14.06
Rapeseed oil	595.19 (176.20)	0.00017 (0.0159)	1.04	0.51	3.92	30.52
Soybean oil	517.49 (150.98)	0.00018 (0.0177)	1.52	0.44	5.03	15.88
Crude oil	39.41 (15.14)	0.00031 (0.0226)	0.98	-0.12	3.45	5.31

Source: Own elaboration.

Next, the DCC model (ENGLE, 2002) is estimates in two steps. The univariate part is defined as a ARMA(1,1)-GARCH(1,1) process including a constant in the mean and variance equations. The underlying ARMA(1,1) process captures serial correlation in the residuals, while the GARCH(1,1) process accounts for serial correlation in squared residuals. The second step consists of a maximum likelihood estimate based on the assumption of a t-distribution. The model specification is chosen according to the Akaike information criteria and to the residual behavior, i.e. correlation in residuals and squared residuals. The results of the univariate models are displayed in

Table 3. The rapeseed as well as crude oil model seems over specified since none of these shows significant autoregressive or moving average behavior in the returns series. However, both show a significant positive drift indicated by the constant in the mean equation. Since the other three models show significant autoregressive and moving average behavior, the ARMA specification is maintained for all models in order to keep the residuals free from serial correlation.

The GARCH estimates α and β appear to be significant at the 1 % level in nearly all equations. The conditions on α and β holds for all processes, hence, all GARCH processes show mean reverting tendencies. The sum of α and β is close to unity, a phenomenon commonly observed when using high frequency data. This implies a high volatility persistency after shocks to the prices since the sum of α and β defines the decay factor of the exponentially declining auto correlation function. High β's furthermore indicate a strong impact of own variance on the volatility development. This can be interpreted as the general volatility development in the market. Rapeseed prices show a comparatively low volatility persistency (β) and a high sensitivity to external shocks (α). A large α combined with a low β as observed here for rapeseed prices, indicates the tendency to overreact in volatile phases.

Tab. 3: Estimation results for the univariate part of the MGARCH model

	Rapeseed	Soybeans	Rapeseed oil	Soybean oil	Crude oil
Cst (M)	0.0007 (0.0002)***	0.0003 (0.0002)	0.0003 (0.0003)	0.0005 (0.0002)**	0.0007 (0.0004)*
AR (1)	0.161 (0.316)	0.773 (0.102)***	-0.846 (0.044)***	0.371 (0.078)***	0.110 (0.178)
MA (1)	-0.014 (0.324)	-0.838 (0.089)***	0.828 (0.039)***	-0.495 (0.073)***	-0.149 (0.143)
Cst (V)	0.000019 (0.000007)***	0.000001 (0.000004)	0.000002 (0.000001)*	0.000001 (0.000002)	0.000007 (0.000003)**
ARCH (α)	0.368 (0.147)***	0.018 (0.024)	0.022 (0.009)***	0.028 (0.011)***	0.041 (0.011)***
GARCH (β)	0.551 (0.082)***	0.978 (0.036)***	0.972 (0.010)***	0.968 (0.016)***	0.944 (0.016)***
$\alpha + \beta$	0.918	0.996	0.994	0.997	0.986
Log like	8142.82	6580.63	7135.74	6842.12	6144.09

Note: (*) indicates a 10 % significance level, (**) a 5 % level and (***) a 1 % level.
Source: Own elaboration.

Table 4 displays the estimated conditional correlations of the DCC model. Furthermore, an α of 0.0025 (0.0004) and a β of 0.9973 (0.0005) are estimated. The high β coefficient indicates that the conditional correlation between the residuals is highly persistent. Although the conditional correlation is time-varying, the coefficients presented in Table 4 are often interpreted as their average. At first glance, soybeans show a comparatively high correlation with rapeseed, rapeseed oil and soybean oil while all commodities show a low correlation with crude oil. Our focus will lie on rapeseed price volatilities and these show, as expected, highest correlation with soybeans and rapeseed oil. The correlation between rapeseed and crude oil is not significant. This is due to the dynamics in correlation, which will later be discussed when analyzing the development over time.

Tab. 4: Estimated conditional correlations

	Rapeseed	Soybeans	Rapeseed oil	Soybean oil
Soybeans	0.386 (0.098)***			
Rapeseed oil	0.255 (0.087)***	0.400 (0.092)***		
Soybean oil	0.141 (0.070)***	0.371 (0.085)***	0.107 (0.068)***	
Crude oil	0.095 (0.065)	0.152 (0.069)***	0.097 (0.049)***	0.005 (0.080)

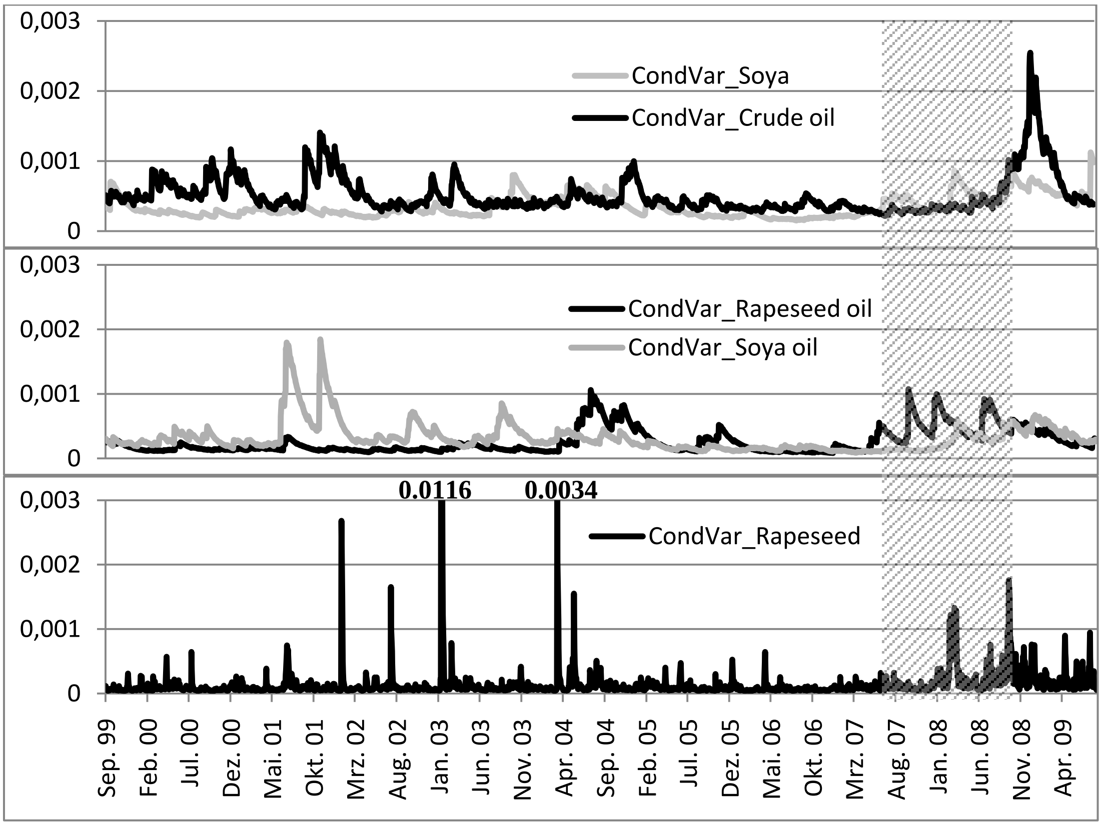
Note: (*) indicates 10 % significance level, (**) 5 % and (***) 1 %
Source: Own elaboration.

5.5 Discussion

The empirical results will now be discussed in detail with a focus on rapeseed price volatilities. Figure 5 shows the development of the conditional variances over time. The figure had to be truncated since the variance of rapeseed price returns peaked at 0.012 in January 2003. Rapeseed prices exhibited a lower conditional variance during most of the period studied in comparison to the other series; and all series besides rapeseed show a relatively high persistency in the conditional variance.

The variance in soya oil was higher than that of other agricultural commodities during most of the first half of the sample period but was in line with the others thereafter. All series show a comparatively low conditional variance between summer 2005 and summer 2007 but the appearance of volatility also clusters. The agricultural raw materials show similar patterns except for the soybean price, where the variance is on a higher level. This might be due to the fact that soybeans are imported from more unregulated countries. The vegetable oil prices show comparable variances in levels, however frequently increased variances appear to be more pronounced for soya oil in the first half of the sample period. Until 2008, rapeseed prices show a very low level of variance. The variance of the crude oil price also increased the most in 2008. Both prices were at their lower levels throughout the year 2007 while soybean and rapeseed oil prices had already started displaying increased variance. During this period agricultural prices started increasing sharply.

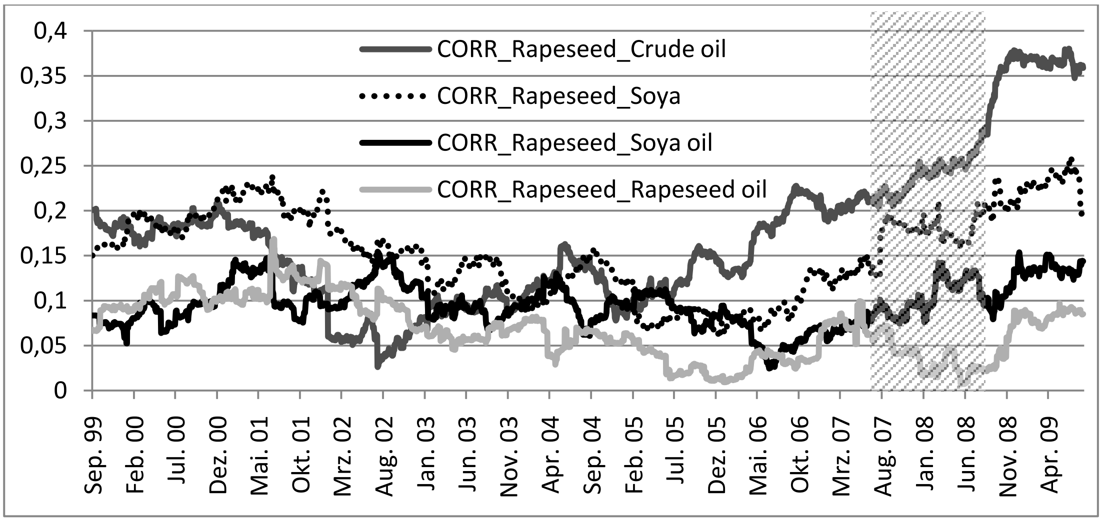
Fig. 5: Conditional variance of different commodity price returns



Source: Own elaboration.

The conditional covariances should show a similar pattern if constant ratios to the variances are assumed. Instead of discussing the issue of covariances, we proceed directly to discuss the topic of conditional correlation estimates. These display the ratio between the covariances and the variances of price pairs. Most of the conditional correlations presented in Figure 6 show a significant time varying behavior. While the correlation of rapeseed with rapeseed oil was decreasing, the correlation with crude oil reached a level that had not been observed before during the sample period. This indicates strong structural changes in the pricing behavior as both prices do increasingly react to the same market signals and their volatility develops concurrently. The model neither allows for conclusions about causal mechanisms of volatility spillovers nor measures the effect of influence of one market on the other. Correlations in volatility can occur from similar impacts of market signals but also from direct transmission. Since the role of crude oil in the world economy is disproportionally higher than that of any agricultural commodity and gained importance for many agricultural commodities, it can be assumed that a part of this correlation is due to reactions in rapeseed prices to volatilities in crude oil prices.

Fig. 6: Dynamic conditional correlation of rapeseed price returns and other commodities

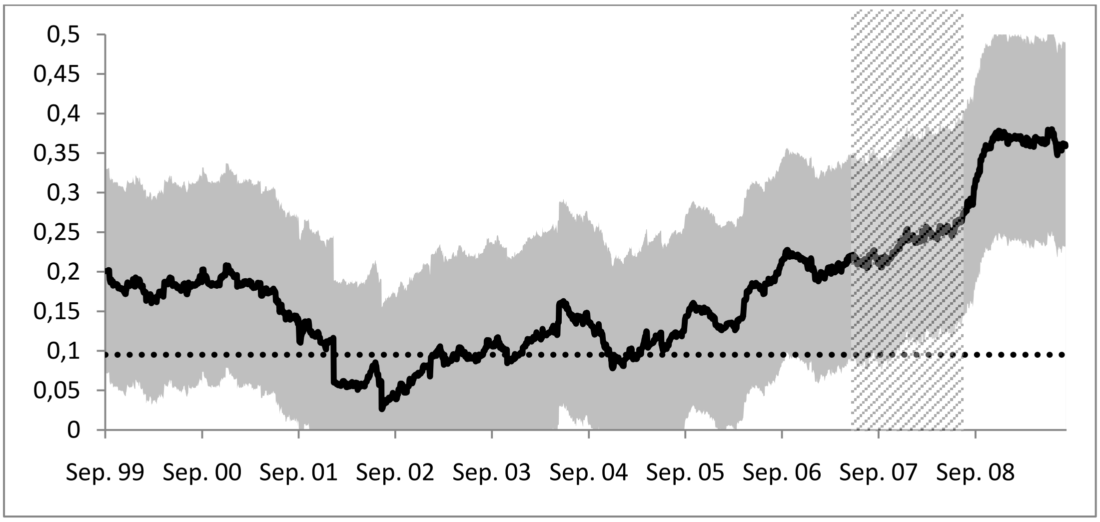


Source: Own elaboration.

Crude oil prices showed higher volatility during most of the sample period compared to rapeseed. Furthermore, rapeseed prices at the MATIF are shown to be very sensitive to external shocks and tend to overreact if shocks occur in volatile phases. The conditional correlation is higher with crude oil prices than with the corresponding spot market prices. This shows that rapeseed price volatilities do not follow the same market signals as those of the commodities on the spot markets, but rather follow the same market signals as crude oil.

Figure 7 shows this development over time separately and also highlights the dynamics of the conditional correlation. The dotted line represents the average correlation where the shaded area indicates the 95 % confidence interval. The conditional correlation estimate was not significantly different from zero under most of the period between 2001 and 2005. Furthermore, it moved around the average until the end of 2007. In 2006 and 2007 the correlation reached the level of the pre 2001 period. Most notably is, however, the strong increase after the food crisis in summer 2008. A conditional correlation between 0.35 and 0.40 is observed in 2008/09 which is considerably higher than during the crisis and significantly different from the estimated average correlation. The high persistency which was estimated for the conditional correlations can be seen here. This further indicates that this correlation will not reduce quickly in the future.

Fig. 7: Conditional correlation rapeseed and crude oil, straight line indicates constant correlation, shaded area +/- 2 standard deviations



Source: Own elaboration

Price fluctuations alone are not problematic since they display market adjustments to changes in supply and demand. However, overreactions and high volatilities in the short-run might not only represent market adjustments but also speculation. If market signals are blurred by those effects, it becomes difficult to distinguish the effects from another. It is therefore difficult to adjust production and processing processes in an appropriate way. Furthermore, market actors have to adjust their behavior in order to cope with the increased price risk. The observation that rapeseed prices react increasingly to the same signals as crude oil prices, and little to the same developments as commodities on spot markets, might be indicative of spillovers from investors behavior on oil markets.

This behavior might be mainly influenced by the expectations about biodiesel production and policy. Crude oil prices determine the profitability of biofuels and any increase (or decrease) in crude oil prices improves (worsens) the competitiveness of biofuels which leads to increasing (decreasing) demand for rapeseed as the main biofuel feedstock. Hence, volatility in crude oil prices might increasingly lead to volatility in rapeseed prices since prices are adjusted towards changing expectations caused by crude oil price changes. The reactions, hence, do not reflect actual changes in the markets but rather expectations towards changes in the medium-term. Whether, and to what extent, volatilities originate from changes in crude oil prices or from other market signals is difficult to distinguish from each other. Vegetable oil prices on the spot market seem thereby to be less affected by these market signals.

The MATIF has gained importance during the past years not only for traders but also as a price and trend indicator for farmers and wholesalers. Ambiguous price signals due to volatility makes it more difficult not only for traders to define their business strategies but also for farmers to make their production decisions. Our empirical findings raise suspicion on how strongly returns of rapeseed prices at the MATIF reflect changes on agricultural markets. The sensitivity of the rapeseed prices to shocks and the increased volatility correlation with crude oil prices points into another direction. However, it should be noted that we do not argue about whether the levels of the rapeseed prices are determined by crude oil prices. The market interdependencies seem to be restricted to volatility spillovers.

The variance of rapeseed price returns as well as that of crude oil price returns has increased substantially in 2008 and 2009 compared to previous years (+59 % for crude oil, +179 % for rapeseed). Furthermore, the variance in crude oil price returns was higher than that of the agricultural commodities, and in the case of rapeseed more than five times higher. Based on the increased and persistent conditional correlation with crude oil price returns, a higher volatility for rapeseed prices can be expected to also continue in the future. Since the analysis is conducted on price returns, and price levels are currently considerably lower than in 2008, the effects will become more apparent if prices start to increase again. The discussion about volatility in agricultural commodity prices and the influence of crude oil prices widened during the food crisis. It however calmed down in 2008 when agricultural prices returned to the levels which were observed before, even though the relative volatility did not decline. It becomes, hence, obvious that up to now, long-term price fluctuations were much more of concern than short-term changes, so long as these occur on a low price level. However, an inefficient utilization of production capacities and risk-averse behavior of market actors, which are caused by high (short-run) volatilities, might well contribute to more pronounced fluctuations of price levels in the long-run.

5.6 Conclusions

In this study we investigated the volatility behavior of rapeseed prices noted at the MATIF. We found an increasing correlation between the volatilities in rapeseed and crude oil prices. Furthermore, it could be shown that the rapeseed prices at the MATIF are sensitive to shocks and show tendencies to overreact in volatile phases. The correlation in returns of MATIF rapeseed prices with vegetable oil and soybean price on the spot market is much lower than that with crude oil and did only increase moderately. This indicates that rapeseed price volatilities react increasingly to the same market signals as crude oil prices, if not even directly to these. Since the MATIF gained importance for the rapeseed market during the past years, our findings concern not only participants at the stock exchange but also traders and farmers who follow these price signals. Since volatilities, if they do not reflect market adjustments, blur the signals of supply and demand changes, the optimization of production schemes at each stage of the processing chain becomes more difficult.

We argue that the increased rapeseed price volatilities are influenced by speculation. Additionally, the increased correlation with crude oil indicates that these are not based on market adjustments. The potential for a further increase in volatilities in the future is therefore high. The concerns about agricultural price levels and the influence of crude oil prices on these were much larger than those concerning short-term fluctuations. The impact of the latter on the former should, however, not be underestimated. Our findings further imply that in the discussion on how to deal with increased volatilities, the role of the stock exchange should not be neglected. The volume increase at the MATIF shows how its importance for the global agricultural markets rose during the past years.

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6 Die Biokraftstoff-Nachhaltigkeitsverordnung: Ein erster Schritt in eine nachhaltige Bioenergiepolitik oder ein weiteres Stück Bürokratie?

M.SC.AGR STEFAN BUSSE

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Zusammenfassung

Zum 1. Januar 2010 wird die Biokraftstoff-Nachhaltigkeitsverordnung, mit der in Deutschland auf die Anforderungen aus der EU-Richtlinie 2009/28/EG reagiert wird, in Kraft treten. Hiermit werden zum ersten Mal die Anforderungen an die Nachhaltigkeit der zur Energiegewinnung genutzten Biomasse gesetzlich definiert. Hauptkriterien der Nachhaltigkeit sind die Mindesteinsparung von Treibhausgasen durch Bioenergie sowie die Vermeidung negativer Umwelteffekte. Die in diesem Beitrag vorgenommene Analyse der Verordnung und der Richtlinie lassen Zweifel daran aufkommen, dass die gesetzliche Regelung überhaupt einen substantiellen Beitrag zur Zielerreichung leistet: Statt einer nachhaltigeren Bewirtschaftung lässt sich vermuten, dass lediglich eine stärkere Marktsegmentierung auftritt. Eine umfassende Regulierung scheitert dabei sowohl an der Umsetzbarkeit (z.B. Bewertung indirekter Effekte) als auch an der rechtlichen Zulässigkeit im Rahmen der WTO (begrenzter Rahmen für handelsbeeinflussende Maßnahmen). Positive Ansätze wie eine Vereinheitlichung der Bewertungsverfahren können dabei kaum als Rechtfertigung für einen hohen bürokratischen Aufwand ausreichen. Der Versuch, sowohl allgemeine Umweltschutzaspekte als auch spezielle biokraftstoffbezogenen Nachhaltigkeitsaspekte in eine einzige Richtlinie zu pressen, muss folglich als wenig erfolgsversprechend eingestuft werden.

Schlüsselwörter: Biotreibstoffe, Nachhaltigkeit, Treibhausgaseinsparung, Handelswirkung, Politikanalyse

The Biofuel Sustainability Regulation: A first step towards a sustainable bioenergy policy, or rather, another piece of red tape?

<u>Abstract</u>

At 1 January 2010, the German Biofuel Sustainability Regulation which implements the requirements set out by EU directive 2009/28/EC comes into force. For the first time, these regulations define legal sustainability standards for biomass used for energy production. The main criteria proposed are a minimum level of greenhouse gas savings and the avoidance of negative environmental impacts. However, the analysis of these regulations done in this article casts doubt on the achievability of its targets: Rather than the desired improvement in the sustainability of biomass production, increased market segmentation is the likely outcome. A broader regulation is constrained both by its practicability (e.g. in the case of quantification of indirect effects) and by the legal framework of the WTO (use of trade distorting measures). The minor merits of this legislation, e.g. standardization of evaluation methods, do not justify the high bureaucratic burden. Hence, the attempt to cover general environmental aspects and particular biofuel related sustainability aspects within one single regulatory framework seems an unpromising avenue towards improved sustainability of biomass production.

<u>Keywords:</u> Biofuels, sustainability, Greenhouse gas savings, trade effects, policy analysis

6.1 Einleitung

Biokraftstoffe wurden in Deutschland lange Zeit relativ unkritisch gefördert, nicht zuletzt da auf der EU-Ebene die zusätzliche Marktentlastung eine Rolle spielte. Der Absatz von Biokraftstoffen wurde, nicht nur in Deutschland, insbesondere durch Steuererleichterungen vorangetrieben. Spätestens seit den Preisentwicklungen der Jahre 2007/08 deuten sich grundlegende Änderungen auf den Agrar- und Energiemärkten an, welche für landwirtschaftliche Rohstoffe die Nutzungskonkurrenz zwischen Tank und Teller stärker in die öffentliche Wahrnehmung gerückt haben. Die Biokraftstoffe stehen vermehrt in der Kritik, nicht pauschal ökologisch nachhaltig zu sein. Kritisiert werden vor allem die Bedingungen der Produktion der Rohstoffe zur Biokraftstofferzeugung und die damit einhergehenden Auswirkungen auf die Ökosysteme, sowohl im In- als auch im Ausland. Als politische Reaktion auf diese Diskussion hinsichtlich der Sinnhaftigkeit der bislang genutzten Förderinstrumente erstellte die EU-Kommission eine Richtlinie, welche zumindest die nachhaltige Erzeugung der Rohstoffe für Biokraftstoffe sicherstellen soll (KOM, 2009).

Im Januar 2008 erschien der Entwurf einer Richtlinie des Europäischen Parlaments und des Rates zur Förderung der Nutzung von Energie aus erneuerbaren Quellen aus der am 17.12.2008 die Richtlinie 2009/28/EG zur Förderung der Nutzung von Energie aus erneuerbaren Quellen […] hervorging (KOM, 2009). Auf die daraus resultierenden Anforderungen an die Mitgliedsstaaten reagierte Deutschland im September 2009 mit der Verordnung über Anforderungen an eine nachhaltige Herstellung von Biokraftstoffen (Biokraft-NachV). Diese setzt die Erfüllung definierter Nachhaltigkeitskriterien sowohl für die Gewährung von Steuererleichterungen, als auch für die Anrechnung auf die Erfüllung der nationalen Pflicht zur Nutzung von Biokraftstoffen voraus (§1, BNV, 2009).

Die Kernfrage ist dabei, ob und in welcher Form diese Regelungen zu einer nachhaltigeren Entwicklung des Biokraftstoffsektors beitragen. Hierzu sollen zunächst die Markt- und Politikentwicklung dargestellt werden. Anschließend werden die Grenzen dieser Gesetzestexte ermittelt und ihr Wirkungsbereich kritisch hinterfragt. Die Studie schließt in einer Bewertung, aus der Empfehlungen abgeleitet werden.

6.2 Markt- und Politikentwicklung

Politische Entwicklung

In Deutschland war die Nutzung von nicht fossilen Kraftstoffen seit 2004 auf Grundlage des Mineralölsteuergesetzes von der Mineralölsteuer befreit. Im August 2006 wurde eine Steuer von 9 ct/l Biodiesel-Reinkraftstoff (B100) eingeführt, die Nutzung von reinem Pflanzenöl als Kraftstoff blieb zunächst steuerfrei. Seit 2009 beträgt die Steuer für beide Kraftstoffe 18 ct/l. Ethanolkraftstoffe mit einem Ethanolanteil von 70 bis 90% (E85) sind steuerbegünstigt, BtL und Ethanol aus Zellulose bis 2015 steuerbefreit (ENERGIESTG). Eine Mindestbeimischungspflicht von Biokraftstoffen besteht seit 2007 (BIOKRAFTQUG) nach der alle Dieselkraftstoffe einen Mindestanteil von 4,4% Biodiesel auf Energiebasis beinhalten müssen. Für Benzin wurde die Quote zunächst auf 1,2% festgelegt. Als Gesamtquote soll nach aktuellen Plänen für 2009 5,25% und für den Zeitraum von 2010 bis 2014 6,25% gelten. Biokraftstoffe innerhalb dieser Beimischungsquote unterliegen der vollen Besteuerung (Benzin 65,45 ct/l, Diesel 47,04 ct/l) (BMU, 2006A).

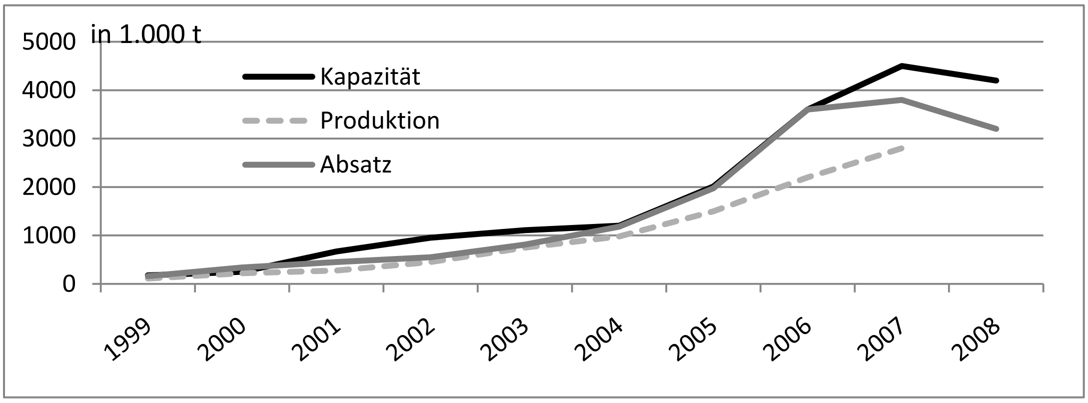
Sowohl auf Bundesebene als auch auf EU-Ebene wurde in den vergangenen Jahren intensiv daran gearbeitet, Regeln aufzustellen, welche die ökologische Nachhaltigkeit geförderter Biokraftstoffe sicher stellen sollen. Im April 2009 wurde die EU-Richtlinie zur Förderung der Nutzung von Energie aus erneuerbaren Quellen (KOM 2009) veröffentlicht, die in Deutschland mit der Verabschiedung der Biokraft-NachV umgesetzt wurde (BNV, 2009). Hauptkriterium der ökologischen Nachhaltigkeit von Biokraftstoffen ist die durch die Verwendung erzielte Einsparung an Treibhausgasemissionen (THG), gemessen in CO2-Äquivalenten (CO2äq). Die Einsparung muss zunächst mindestens 35% betragen, ab 2017 dann 50%. Bei Anlagen, die ihre Produktion ab dem 1. Januar 2017 aufnehmen, muss ab 2018 eine Mindesteinsparung von 60% nachgewiesen werden. Anlagen, die am 23. Januar 2008 bereits in Betrieb waren, genießen einen Bestandsschutz bis zum 1. April 2013 (§8; BNV, 2009).

Als weiteres Nachhaltigkeitskriterium dient der Ausschluss bestimmter sensibler Anbaugebiete, in denen mit wesentlichen negativen Konsequenzen für die Ökosysteme zu rechnen ist. Biokraftstoffe dürfen somit nicht aus Rohstoffen hergestellt werden, die auf Flächen mit anerkanntem hohem Wert hinsichtlich der biologischen Vielfalt erzeugt wurden. Darunter können Flächen fallen, die im oder nach Januar 2008 für Naturschutz genutzt wurden, oder auch Grünland mit besonders großer biologischer Vielfalt. Zudem dürfen Flächen mit hohem Kohlenstoffbestand (z.B. Feuchtgebiete, bewaldete Flächen) nicht genutzt werden, wenn sich ihr Status durch die Nutzung ändert (§3; BNV, 2009).

Marktentwicklung

In Deutschland lag der Kraftstoffabsatz 2008 bei 21,0 Mio. t Benzin und 30,1 Mio. t Diesel, darunter 1,5 Mio. t beigemischter Biodiesel (MWV, 2009). Der Anteil erneuerbarer Energien im Kraftstoffbereich lag 2007 insgesamt bei 7,6% (BMU, 2008). Das BMU (2006B) sieht für Biokraftstoffe aus heimischer Produktion ein Potential von langfristig etwa 10% des deutschen Kraftstoffverbrauchs. Bis zur Steuereinführung 2006 wurde der Biokraftstoffabsatz in Deutschland von B100 dominiert, seitdem gewinnt die 5%ige Beimischung von Biodiesel zu Diesel (B5) immer stärker an Bedeutung. Der Biodieselmarkt wuchs insbesondere zwischen 2004 und 2006, als sich Absatz und Kapazität jährlich verdoppelten (vgl. Abb. 1).

Abb. 1: Produktion, Kapazität und Absatz von Biodiesel (inkl. Pflanzenölkraftstoff) in Deutschland



Quelle: Eigene Darstellung, basierend auf UFOP (2007), VDO (2008), BIOKRAFTSTOFFBERICHT (2008).

In Deutschland hat dabei insbesondere Raps als Biodieselrohstoff an Bedeutung gewonnen. Trotz eines starken Anstiegs der Rapsanbauflächen (1,5 Mio. ha) und einer Ertragssteigerung, welche die Produktion auf über 5 Mio. t wachsen ließ, stieg Deutschlands Importbedarf auf 1,5 Mio. t Raps (2006/2007). Bei Rapsöl entwickelte sich Deutschland in den vergangenen fünf Jahren vom Nettoexporteur (0,6 Mio. t) zum Nettoimporteur (0,9 Mio. t). Das BMVEL (2005) schätzt, dass auf Grund der natürlichen Gegebenheiten (insb. Fruchtfolgerestriktionen) und unter Berücksichtigung des Bedarfs an Rapsöl für Nahrungsmittel, die Grenze für den Rapsanbau für Biodiesel bei etwa 1,5 Mio. ha erreicht sein wird.

Bioethanol wird in Deutschland als Reinkraftstoff nicht angeboten, ist aber im Ottokraftstoff als Direktbeimischung bis zu fünf Prozent (E5), als Ether (ETBE, 50% aus Ethanol), oder als E85 enthalten. Nach Angaben der FNR (2008) belief sich die Anlagenkapazität bei Bioethanol 2008 auf 0,55 Mio. t. Weitere 1,2 Mio. t befinden sich in der Bau- oder Planungsphase. Getreide war mit 44% der Hauptrohstoff in 2008, allerdings lag der Anteil in 2007 noch bei 78%, der Anteil an Zuckerrüben stieg von 2% auf 32% (F.O.LICHTS, 23/2008).

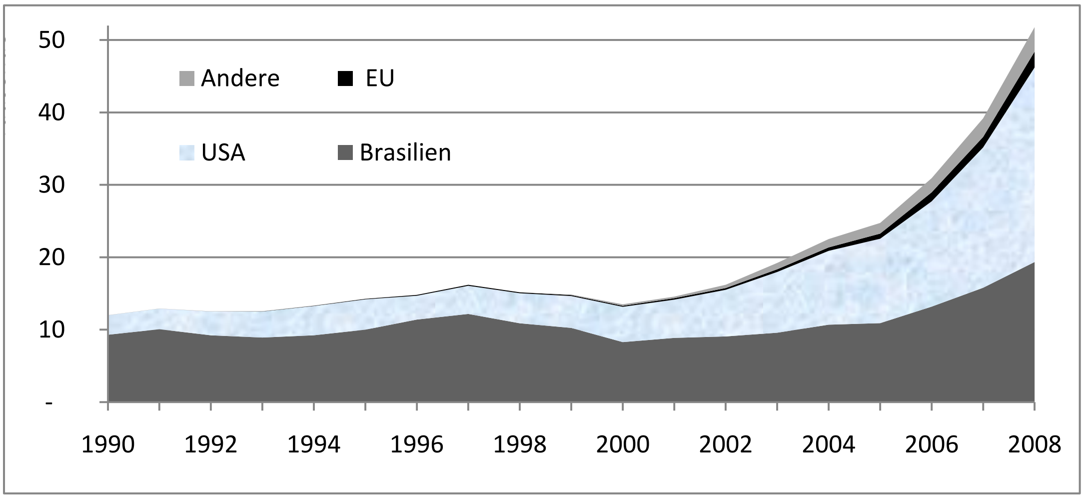
Nach Schätzungen des EBB (2008) lag die Biodieselproduktion 2007 in der EU bei 5,7 Mio. t, die Kapazität soll 2008 bei 16 Mio. t liegen. 2007/08 flossen 5,0 Mio. t Rapsöl, 1,3 Mio. t Sojaöl und 0,2 Mio. t Sonnenblumenöl in die Produktion von Biodiesel (F.O.LICHTS, 22/2008). Trotz starker Produktionsausweitung reicht auch europaweit die Produktion von Raps und Rapsöl nicht mehr aus, um den durch die Biodieselproduktion stark erhöhten Gesamtbedarf zu decken (STRATÉGIE GRAINS, 2008). Die Bioethanolproduktion in der EU lag 2007 bei 1,4 Mio. t, Hauptrohstoffe waren 2006 Weizen (36%), Rohalkohol (22%) und Zuckerrüben (16%) (EBIO, 2008). Trotz vergleichsweise hoher Importzölle für Bioethanol von 19,2 ct/l[11] ist brasilianischer Ethanol im EU-Markt konkurrenzfähig, so dass die Importe in den vergangenen Jahren kontinuierlich angestiegen sind (AGRA-EUROPE, 22/2008).

Weltweit betrug die Biodieselproduktion im Kalenderjahr 2007 9 Mio. t (FAPRI, 2008). Auf dem Rapsmarkt dominierte Kanada 2007 die Exportseite mit 5,6 Mio. t (75% Weltmarktanteil) und bei Rapsöl waren sie ebenfalls größter Exporteur (1,1 Mio. t, 80%). Die größten Nettoexporteure von Soja sind gegenwärtig Brasilien (29,6 Mio. t) und die USA (26,9 Mio. t). Im Handel mit Sojaöl hatte Argentinien 2007 mit Nettoexporten in Höhe von 6,4 Mio. t (65%) eine dominante Position. Die größten Produzenten von Palm- und Palmkernöl sind Indonesien (20,3 Mio. t) und Malaysia (18,6 Mio. t). Bei den Palmölnettoexporten liegt Indonesien (13,6 Mio. t) ebenfalls vor Malaysia (12,7 Mio. t) (FAPRI, 2008). Bei Ethanol (vgl. Abb. 2) bestimmen die

[11] Importzoll für unvergällten Ethylalkohol (zulässig für die Nutzung als Biokraftstoff, TARIC 2008).

USA mit 52% der Weltproduktion (insgesamt 51,8 Mio. t, überwiegend auf Maisbasis) und Brasilien mit 37% (auf Zuckerrohrbasis) den Weltmarkt. Nach Prognosen des FAPRI (2008) sollen die Exporte Brasiliens in den nächsten 10 Jahren 10,7 Mio. t erreichen, was auf Energiebasis knapp 9% des aktuellen EU Benzinabsatzes entspricht.

Abb. 2: Weltethanolproduktion in Mio. t



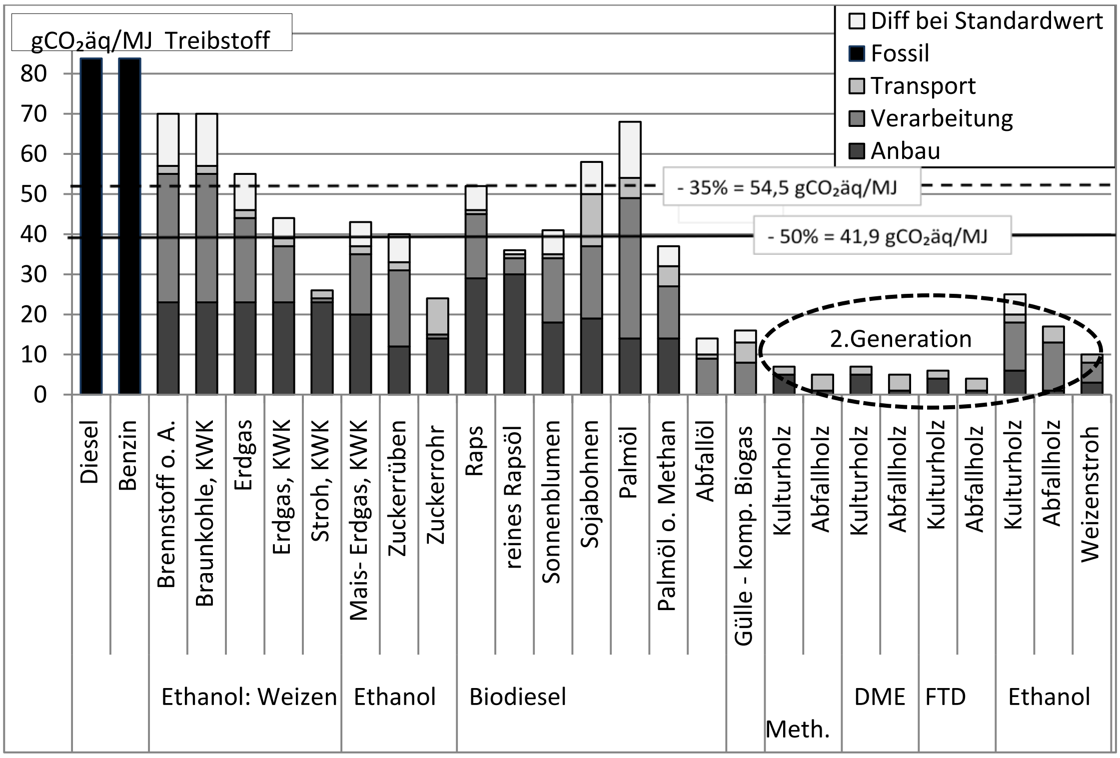
Quelle: F.O. Lichts.

6.3 Die Umsetzung der EU-Richtlinie in der deutschen Biokraft-NachV

Für die Verwendung eines Biokraftstoffs in der EU werden in der Zukunft gem. der Biokraft-NachV vorrangig zwei Kriterien eine entscheidende Rolle spielen: THG Minderungen und die Vermeidung negativer Umwelteffekte. Die in §8 BNV definierten THG Minderungsanforderungen wurden bereits dargestellt und dürften in der Zukunft das Hauptkriterium für die Bestimmung geeigneter Rohstoffe sein, da diese Grenzen als Ausschluss-Kriterien gelten. Bei der Vermeidung von negativen Umwelteffekten wird gem. §4 bis §7 BNV die Verwendung von Flächen mit hohem Naturschutzwert oder hohem Kohlenstoffbestand, und von Torfmooren begrenzt, und der Anspruch an eine nachhaltige landwirtschaftliche Bewirtschaftung definiert. Diese Kriterien lassen Bewertungsspielraum offen und werden im Folgenden vorrangig unter dem Gesichtspunkt der internationalen Durchsetzbarkeit diskutiert.

Zur Berechnung der THG-Einsparungen lässt die Biokraft-NachV verschiedene Vorgehensweisen zu. So können a) festgelegte Standardwerte für Biokraftstoff-Herstellungswege angenommen werden, b) tatsächliche Werte nach einer festen Methodik berechnet werden oder c) eine Kombination beider Vorgehensweisen unter Berücksichtigung vorgegebener, disaggregierter Standardwerte gewählt werden (§8; BNV 2009). Abb. 3 schlüsselt die Zusammensetzung der sogenannten Standard- und typischen Werte für verschiedene Produktionsverfahren in Anbau, Verarbeitung und Transport auf. Während letztere die erwartete THG-Einsparung im Einzelfallnachweis abbilden soll, geben erstgenannte den Wert an, der ohne Einzelnachweis standardmäßig unterstellt wird.

Abb. 3: Standardwerte für THG-Einsparpotential nach Biokraft-NachV und Aufschlüsselung Typischer Wert nach KOM (2009) (in gCO_2äq/MJ Treibstoff)

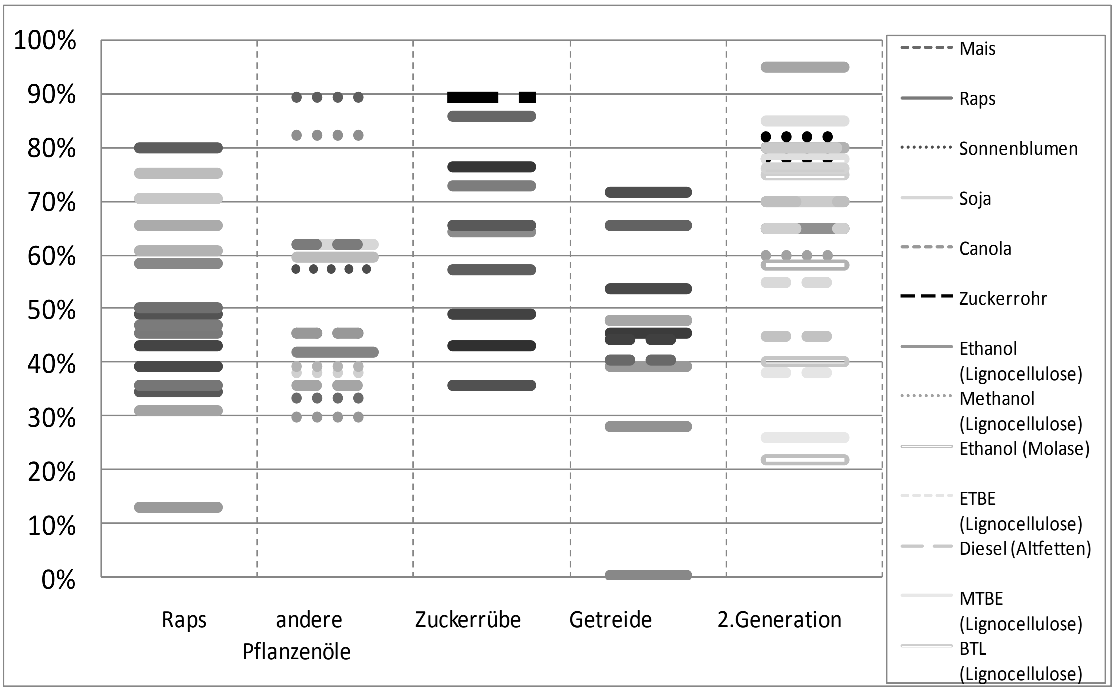


Quelle: Eigene Darstellung, basierend auf BNV (2009), KOM (2009).

Während bei der Ethanolherstellung aus Weizen und Zuckerrüben ein Großteil der Emissionen bei der Verarbeitung entsteht, fallen diese beim Raps vorwiegend im Anbau an. Rapsbasierter Biodiesel erreicht zwar die 35% THG-Einsparung, nicht aber die langfristig notwendige 50%-Grenze. Die Biokraftstoffe der zweiten Generation weisen insgesamt sehr niedrige THG-Emissionen auf. Bisher befinden sich diese Verfahren jedoch im Versuchsstadium. Es gibt weltweit noch keine großtechnische kommerzielle Produktion von Biotreibstoff aus Lignozellulose (EBIO, 2008). Das BMU (2008) schätzt, dass Kraftstoffe der zweiten Generation nicht vor 2020 in relevanten Mengen zur Verfügung stehen werden. Somit gibt es noch erhebliche Unsicherheit über die Kosten und die entstehenden Emissionen bei der Produktion von Biokraftstoffen der zweiten Generation.

In der Literatur tauchen bei der Bewertung der THG-Einsparungen verschiedener Rohstoffe Werte mit einer sehr hohen Bandbreite auf (vgl. Abb. 4). Für Biodiesel aus Raps schwanken die Werte zwischen 13% und 80%, der Standardwert gem. Biokraft-NachV liegt hier bei 38%. Einfluss auf diese Ergebnisse haben Annahmen über Erträge und Produktionsparameter, sowie die Wahl der Berechnungsmethode, bei welcher die Bewertung von Nebenprodukten und Lachgasemissionen, die Wahl von Konversionsverfahren und von Prozessbrennstoffs sowie die Berücksichtigung von Landnutzungsänderungen eine wichtige Rolle spielen.

Abb. 4: Einsparungen von CO_2äq der verschiedenen Biokraftstofflinien in % (jeder Strich stellt das Ergebnis einer Studie dar)



Quelle: eigene Darstellung basierend auf IFEU (2004), Wissenschaftlicher Beirat Agrarpolitik (2007), UFOP (2007), Adem (2002), Elsayed et al. (2003), GM (2002a), GM (2002b), IE (2007), JRC (2007), Richards (2000), Schmitz (2003), Wagner (2003).

Die Aufteilung von THG-Emissionen zwischen Haupt- und Nebenprodukt soll gem. Biokraft-NachV anhand des unteren Heizwerts erfolgen (ANLAGE 1 (ZU §8 ABSATZ

3) NR. 17 BNV, 2009). Alternativansätze wären die Substitutionsmethode, bei der die THG-Emission eines Rohstoffes für die Biokraftstoffgewinnung mit einer Gutschrift für die THG-Emission des durch das Nebenprodukt substituierten Produkts verrechnet wird (WAGNER, 2003). Weitere verwendete Methoden sind die Aufteilung der Emissionen nach Marktpreisen der Endprodukte und die alleinige Zuordnung zum Biokraftstoff. Bei RME könnte allein die Variation der Berechnungsmethode zu Wertspannen zwischen 25% (Zuordnung aller Emissionen zum Biodiesel) und 60% THG-Einsparung (Energiegehaltsmethode) führen.

Große Unbekannte in der Bilanz ist die Höhe der Lachgasemissionen (N_2O). Diese sind von besonderer Bedeutung, da das THG-Potential von N_2O ca. 296 mal höher ist als das von CO_2. I.d.R. wird der IPCC-Richtwert (vgl. IPCC, 2006) zu Grunde gelegt, wonach 1% des ausgebrachten Stickstoffs als N_2O emittiert wird. Im IPCC (2006) Bericht wird jedoch auch auf eine hohe Variation hingewiesen; der Wert könnte auch bis zu 3% betragen. Jede Erhöhung des hier unterstellten Anteils der N_2O-Emissionen am ausgebrachten Stickstoff würde insbesondere den rapsbasierten Biodiesel betreffen, bei dem gemäß Standardwerten die Hälfte der Emissionen im Anbau auftreten, von denen ca. 80 % auf die Stickstoffdüngung entfallen (BNV, 2009).

Landnutzungsänderungen werden in den meisten Studien nicht berücksichtigt und insbesondere die Messung der Auswirkungen indirekter Effekte stellt systembedingt ein methodisches Problem dar. Auch in der Richtlinie werden die indirekten Landnutzungsänderungen bei der Berechnung der Standardwerte ausgeklammert. Allerdings wurde der EU-Kommission seitens des Parlaments aufgegeben, bis 2011 einen Bericht über die Auswirkungen der Herstellung von Biokraftstoffen auf die Flächennutzung, einschließlich der Auswirkungen von Verdrängungseffekten, vorzulegen (ARTIKEL 23, KOM, 2009).

Dieser Überblick zeigt, wie hoch die Unsicherheit über die Höhe der THG-Emissionen von einzelnen Biokraftstoff-Wertschöpfungsketten ist. Die Biokraft-NachV definiert hier ein einheitliches Bewertungsverfahrens und fördert somit die objektive Vergleichbarkeit der Ergebnisse. Die vielfältige Unsicherheit über naturwissenschaftliche Zusammenhänge und ökonomische Interdependenzen macht jedoch deutlich, dass es keine endgültige Festlegung geben kann. Auch aus gesamtwirtschaftlicher Sicht sollte sich nicht langfristig auf eine Wertschöpfungskette festgelegt und – in Anbetracht der zu erwartenden Veränderungen in den Rahmenbedingungen – nicht länger als notwendig an dieser festgehalten werden. Zudem muss die Flexibilität erhalten bleiben, auf neue wissenschaftliche Erkenntnisse reagieren zu können. Da dieses den Wettbewerb um die besten Produktionsverfahren voraussetzt, sollte primär auf den Einsatz marktwirtschaftlicher Koordinierungsinstrumente gesetzt werden, die eine schnellere Anpassung an veränderte Informationen erlauben als dies bei zentral koordinierten, hierarchischen Instrumenten der Fall ist.

Rechtliche Grenzen und Wirksamkeit

Eine Grenze beim Ausgestaltungsspielraum der Nachhaltigkeitskriterien stellte insbesondere die Konformität mit dem WTO-Recht dar. Die Einordnung der Richtlinie in die Terminologie des internationalen Handelsrechts gestaltet sich schwierig, da sie in den Bereich der "nicht-produktbezogene Verarbeitungs- und Produktionsverfahren" (non-product related process and production methods, NPR-PPM) fällt. Sie könnte entweder im Bereich der unmittelbaren Anwendung des Vertrags oder in der Anwendung des Abkommens für technische Handelsbarrieren (Agreement on Technical Barriers to Trade, TBT) liegen.

Das Meistbegünstigtenprinzip (ARTIKEL 1, GATT) fordert die Gleichbehandlung aller Länder und schließt eine Unterscheidung von Produkten und Produktionsverfahren allein aufgrund der geografischen Herkunft aus. Der inzwischen gescheiterte Versuch einer deutschen Übergangsregelung für die Zeit bis zur Etablierung funktionierender Zertifizierungssysteme wäre kaum mit dem Grundsatz der Meistbegünstigung vereinbar gewesen, da diese vorsah, bestimmte Anbaustandorte allein aufgrund der geografischen Lage zu diskriminieren. Aus ART. 1 ergibt sich auch die Regel, dass die konkreten Anforderungen an die Nachhaltigkeit für alle WTO-Mitgliedsländer gleich sein müssen, was hier gewährleistet wurde.

Ein Verstoß gegen die Gleichbehandlung (ARTIKEL 3, GATT) würde vorliegen, wenn heimische und importierte nicht-zertifizierte Produkte ungleich behandelt werden würden, was ebenfalls nicht der Fall ist. Eine Diskriminierung könnte aber auftreten, wenn es ausländischen Produzenten nicht möglich ist, schnell und günstig zertifiziert zu werden (UNCTAD, 2008), was bei Forderung von Einzelflächennachweis mit entsprechenden Bilanzen und Untersuchungen vorliegen könnte. In die gleiche Richtung würden die Allgemeinen Vorgaben ('Chapeau') des ARTIKEL 20 GATT gehen, nach dem keine beliebige oder ungerechtfertigte Diskriminierung zwischen Ländern mit vergleichbaren Bedingungen vorliegen darf. Problematisch wären beispielsweise die systematische Unterscheidung zwischen den Standard- und typischen Werten für THG-Einsparungen zwischen EU- und nicht EU- Produkten.

Die Anwendbarkeit von ART. 20 B) GATT, der auf Maßnahmen zum Schutz von menschlichen, tierischen oder pflanzlichen Leben und Gesundheit abzielt, wäre ähnlich problematisch wie beim oben diskutierten ART. 1, wenn die Richtlinie die pauschale Anerkennung und Ablehnung von ganzen Regionen auf Grund ihrer Anbauverfahren vorsähe. Aus ART. 20 G) GATT hingegen, der die Maßnahmen zum Schutz erschöpflicher Ressourcen zum Inhalt hat, wäre eine Begründung für Anforderungen an den Erhalt der Biodiversität, insbesondere aber an den Ausschluss von Naturschutzflächen, Grünland, Feuchtgebieten vom Anbau von Rohstoffen für die Biokraftstoffgewinnung möglich. Solange heimische und importierte Güter der gleichen Kategorie gleich behandelt werden, sollten hier keine Probleme auftauchen.

Bei einer Begründung von Anforderungen aus ARTIKEL 20 (B) und (G) gilt die strikte Vorgabe, dass es um den Schutz von Natur oder Gesundheit gehen muss. Anforderungen an Arbeits- und Sozialstandards in exportierenden Ländern, eine Verbesserung der Nahrungsmittelqualität oder die Verbesserung der Einkommensmöglichkeiten für Produzenten, wie sie vom Europäischen Parlament in die Debatte gebracht wurden, fallen nicht in den Bereich des ARTIKELS 20, auch wenn eine breite Definition von Nachhaltigkeit mehr als nur die Umweltaspekte umfasst. Wenn also im Kern auf die Umwelteffekte abgestellt werden soll, dürfen Sozial- und Arbeitsstandards nicht zur Unterscheidung der Produkte herangezogen werden. Probleme der Vereinbarkeit mit dem WTO-Recht treten auch bei jeglichen Maßnahmen auf, die auf die Nutzungskonkurrenz zwischen Biokraftstoffen und Nahrungsmitteln abstellen, oder wenn es um indirekte Landnutzungseffekte, lokale Wirtschaftseffekte oder soziale Effekte geht.

Eine Legitimation von Anforderungen hinsichtlich der ökologischen Nachhaltigkeit von Rohstoffen zur Erzeugung von Biokraftstoffen anhand des eigentlichen

GATT/WTO-Vertrags ist somit grundsätzlich möglich. Die Entscheidung eines möglichen WTO-Panels bei Streitigkeiten wäre aber unabhängig davon, ob die Prüfung unmittelbar aus dem GATT- Vertrag oder aus dem TBT-Abkommen erfolgt: Entscheidend wird es sein, ob die Anforderungen als notwendig zur Erreichung der umweltbezogenen Ziele angesehen werden. Diese werden aber auch von anderen Organisationen adressiert, wie etwa dem seit Jahren implementierten Roundtable on Sustainable Palm Oil (RSPO) und dem im Aufbau befindlichen Round Table on Responsible Soy Association (RTRS).

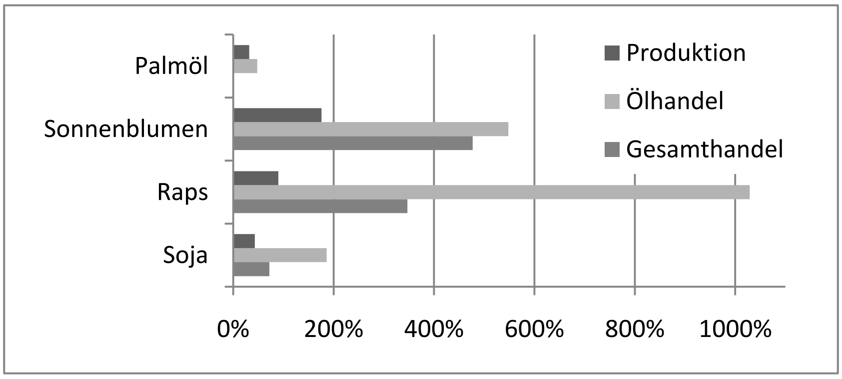
Im Bereich der Zertifizierung der Nachhaltigkeit soll hier noch die deutsche Initiative des ISCC (International Sustainability and Carbon Certification System) erwähnt werden, die von der Consultingagentur meó geleitet und vom BMELV gefördert wird. Diese sieht zunächst eine Zertifizierung von Biokraftstoffen vor, langfristig soll diese aber auf die gesamte landwirtschaftliche Produktion für Nahrungs- und Futtermittel, andere energetische Verwendungen sowie für die stoffliche Nutzungen ausgeweitet werden. Die dabei vorgesehene Zertifizierung und Registrierung aller beteiligten Betriebe und verwendeten Flächen (ISCC, 2008) birgt die Gefahr der Diskriminierung insbesondere kleiner und armer Betriebe, die dieses nicht leisten können.

Als Nachweissystem für die Erfüllung der Nachhaltigkeitskriterien wird in Deutschland das Massenbilanzsystem verwendet (§16; BNV, 2009). Dieses erlaubt die Mischung von Lieferungen von Rohstoffen oder Biokraftstoffen, sowie die spätere Entnahme der einzelnen Partien mit den jeweils zugeordneten Eigenschaften. Ein getrennter Transport oder Lagerung von nachhaltig und nicht nachhaltig erzeugter Ware ist somit nicht notwendig, allerdings muss ein physischer Übergang vorliegen. Langfristig soll auch die Möglichkeiten geprüft werden, dass „Angaben über Nachhaltigkeitseigenschaften nicht physisch bei speziellen Lieferungen oder Gemischen verbleiben müssen“ (ARTIKEL 18, KOM, 2009). Dieses unter dem Namen „book and claim“ bekannte System würde im Idealfall lediglich den Erwerb und Nachweis entsprechender Nachhaltigkeitszertifikate erfordern, nicht aber den physischen Übergang zum Verwendungsort. Die Ware wird vielmehr, wie beispielsweise im RSPO-System vorgesehen, in die vorhandenen Lieferketten eingespeist und wieder aus dieser entnommen. Da es zu keiner Änderung der physischen Warenströme kommt, muss dieses System unter ökonomischen Gesichtspunkten als langfristig erstrebenswert eingestuft werden.

6.4 Wirkung der Richtlinie

Um die Effekte der Richtlinie bestimmen zu können, soll zunächst ihr Wirkungsbereich abgegrenzt werden. Da eine Übertragung der Nachhaltigkeitskriterien auf den gesamten Nahrungsmittelbereich gegenwärtig bestenfalls als ungewiss einzuschätzen ist und die Übernahme der Kriterien durch nicht-EU Länder zweifelhaft erscheint, soll hier der Geltungsbereich der EU beleuchtet werden. Eine ausschließliche Analyse der Effekte im deutschen Markt wäre aufgrund des gemeinsamen EU-Binnenmarktes unangebracht.

Abb. 5: EU-Bedarf für 10% Biodiesel bei ausschließlicher Verwendung eines Rohstoffs



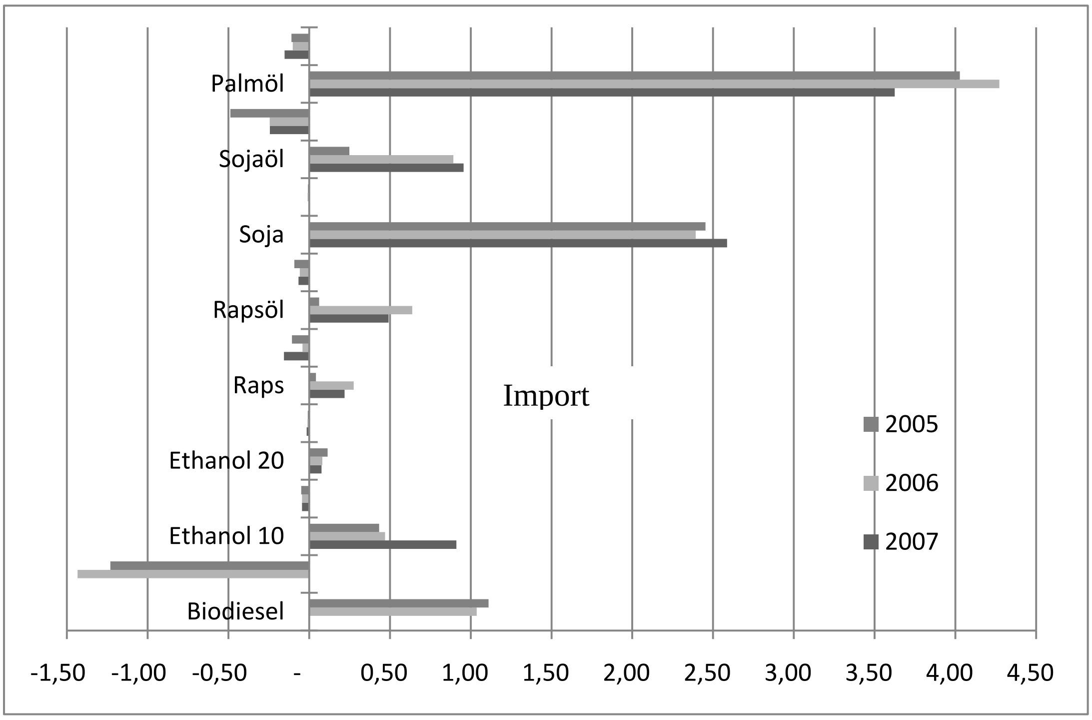
Quelle: Eigene Darstellung.

Die Erfüllung des 10% Biokraftstoffziels bei Biodiesel, würde 2020 bei unveränderter Fokussierung auf Rapsöl die Nutzung von etwa 90% der Weltrapsproduktion erfordern. Auch bei breiterer Rohstoffbasis würden voraussichtlich große Anteil des Welt Raps- und Rapsölhandels in den europäischen Biodiesel fließen und damit unter die Nachhaltigkeitsanforderungen fallen. Bei Soja- und Palmöl wären die Anteile der europäischen Biodieselnutzung an der Produktion jedoch moderat (z.B. 32% der Weltpalmölproduktion bei ausschließlicher Verwendung von Palmöl, vgl. Abb. 5).

In Hinblick auf die Erfüllung einer 10% Ethanolquote (energetisch) zeigt sich ein anderes Bild. Bei ausschließlicher Verwendung von Zucker würden lediglich 13%

der Weltproduktion für EU-Ethanol genutzt werden, bei Mais und Weizen jeweils um die 5%. Somit wäre hier der Anteil an der Weltproduktion derart gering, dass keine nachhaltigen Effekte auf die weltweite Produktion zu erwarten sind.

Abb. 6: EU-Außenhandel von Biotreibstoffen und Pflanzenölen in Mt Öl-Äquivalent, bei Ölsaaten Menge an enthaltenem Öl (Anteil in Raps 42%, Soja 17%)



Quelle: Eigene Darstellung, basierend auf WITS (2008).

In Hinblick auf den Außenhandel der EU mit Pflanzenölen und Ölsaaten spielt in der Gesamtmenge Soja die größte Rolle. Aufgrund des geringen Ölgehalts (17% bei Soja) liegt die importierte Menge an Sojaöl und in Sojabohnen enthaltenem Öl unter der von Palmöl (Abb. 6). Im Falle einer Marktöffnung durch den Wegfall des Außenschutzes bei Bioethanol und einer Erweiterung des durch die Normen bestimmten Rohstoffspektrums sind die potentiellen Lieferländer schnell ausgemacht. Die Importstrukturen der EU im Bereich Palm- und Sojaöl stützen sich gegenwärtig auf je zwei Herkunftsländern, bei Ethanol spielt als Exporteur im Weltmarkt gegenwärtig nur Brasilien eine Rolle.

Die weitere Steigerung der EU-Nachfrage nach Biokraftstoffen dürfte global gesehen keine großen Effekte nach sich ziehen, solange sie mit einer Öffnung der Märkte einhergeht. Bislang beobachtete Effekte wie beispielsweise die starke Verschiebung hin zur Rapsproduktion und der Auftrieb der Rapsölpreise in Deutschland begründen sich in der Regel aus politisch induzierten Fehlallokationen. Die notwendige Produktionssteigerung auf globaler Ebene bewegt sich hingegen bei den meisten Rohstoffen nur im einstelligen Prozentbereich. Diese überschaubaren Änderungen in der Gesamtproduktion sagen allerdings nur wenig über die zu erwartenden Preiseffekte aus; hierzu ist ein Blick auf die zu erwartenden Änderungen im Welthandel aufschlussreich.

Im Gegensatz zur Produktion würde der Handel in den meisten Fällen wesentlich stärker ansteigen, was zu nachhaltigen Preiseffekten führen könnte. Wie bereits diskutiert hängen hier die Effekte insbesondere vom zugelassenen Rohstoffmix ab. Eine Fokussierung auf einzelne Rohstoffe zur Biokraftstoffherstellung würde beispielsweise bei Rapsöl, Sojaöl oder Sonnenblumenöl zu einer teilweise mehr als Verdoppelung des aktuellen Welthandels führen. Die internationalen Handelsströme sind insbesondere wichtig, um auf Fluktuationen in nationalen Angeboten und Nachfragen zu reagieren und somit die Preise zu stabilisieren.

Je weiter hier das Spektrum der potentiellen Rohstoffe gefasst wird, desto geringer werden die Preiswirkungen sein. Bei starker Einschränkung der Rohstoffbasis oder Fokussierung auf heimische Rohstoffe kann es hingegen zu deutlichen Diskrepanzen beispielsweise zwischen den Preisen vergleichbarer Pflanzenöle kommen. Autarkiebestrebungen im Kraftstoffbereich mit dem Ziel, den gesamten Bedarf aus heimischen Biokraftstoffen zu decken, sind kaum realistisch und allenfalls unter sehr hohen gesamtwirtschaftlichen Kosten zu erreichen. Entscheidungskriterium sollte daher auch im Biokraftstoffbereich sein, Produktion dort zu fördern, wo diese gesamtwirtschaftlich durch Nutzung komparativer Vorteiler am sinnvollsten erscheint.

Bei aller Diskussion um den Biokraftstoffmarkt darf aber die alternative Verwendung der Rohstoffe nicht außer Acht gelassen werden, bei der derzeit Nachhaltigkeitskriterien keine Rolle spielen. Insbesondere der Nahrungs- und Futtermittelbereich spielt bei den meisten Rohstoffen weiterhin die wichtigere Rolle. So liefen in der EU im Bereich der Öle und Fette in 2007 nur 8 Mio. t der insgesamt 27,7 Mio. t in den Biodieselbereich, der Hauptanteil floss weiterhin in den Nahrungsmittelbereich. Allerdings stellt der Biodieselbereich für Rapsöl mit zwei Dritteln des Absatzes mittlerweile den bedeutendsten Absatzmarkt dar. Grade hier dürften also gesteigerte Anforderungen an Eigenschaften der Rohstoffe große Bedeutung haben, was zweifelsohne vornehmlich heimische Produzenten betreffen wird.

6.5 Diskussion und Empfehlungen

Bei der Analyse der Wirkung der deutschen Biokraft-NachV und der ihr zugrundelegenden EU-Richtlinie muss somit festgestellt werden, dass selbst das Primärziel, nämlich eine Verminderung der THG-Emissionen, nur bedingt erreicht wird. Der Grund hierfür liegt in der Tatsache, dass diese nur Rohstoffe betreffen, die zur Bioenergienutzung in der EU genutzt werden. Darüber hinaus wird die gesamtwirtschaftliche Dimension der Bioenergienutzung außer Acht gelassen, so findet weder eine Kosten-Nutzen-Analyse einzelner Biokraftstoffketten untereinander statt, noch eine Abwägung von Biokraftstoffen gegenüber anderen Bioenergienutzungen oder THG-vermeidenden Technologien. Insbesondere die Festschreibung nationaler Biokraftstoffziele für 2020 unterbindet dabei eine ökonomisch optimierte Ausrichtung der Bestrebungen von THG-Reduktionen.

Auch das Nebenziel der Vermeidung negativer Umwelteffekte durch die Biokraftstoffnutzung wird durch die neuen Regularien kaum erreicht werden. Dieses liegt an der starken Nutzungskonkurrenz der Rohstoffe für die Produktion von Biokraftstoffen der ersten Generation zu ihrer Verwertung als Futter- und Nahrungsmittel. Da der europäische Biokraftstoffsektor selbst bei Erreichen des 10% Zieles in 2020 für die globalen Agrarmärkte von geringer Bedeutung bleibt, ist hier lediglich mit einer verstärkten Marktsegmentierung zu rechnen. Rohstoffe, die nicht den Nachhaltigkeitsanforderungen entsprechen, fänden dabei weiterhin Absatz sowohl im außereuropäischen Biokraftstoffmarkt als auch im außer- und innereuropäischen Futter- und Nahrungsmittelbereich.

Wahrscheinlichster Effekt dieser Segmentierung ist die Schaffung zusätzlicher Renten für nachhaltig erzeugte Rohstoffe. Dieser Effekt wurde bereits bei Soja beobachtet, bei dem sich garantiert „gentechnikfreie“ Ware preislich deutlich von unspezifizierter Ware absetzte (BACKUS ET AL., 2008). Die negativen Umwelteffekte, insbesondere solche, die durch Landnutzungsänderungen hervorgerufen werden, lassen sich dabei aber kaum vermeiden, da für die Produktionsentscheidung die Grenzverwertung entscheidend ist. Solange diese Grenzverwertung aber durch Märkte bestimmt wird, auf denen wohl auch mittelfristig keine strengen Nachhaltigkeitsregularien zur Anwendung kommen, ist die Steuerungswirkung von Nachhaltigkeitsforderungen im Biokraftstoffbereich für die Erzeugung von Biomasse schlicht nicht vorhanden. Im Bereich Bioethanol spielt als Handelspartner gegenwärtig nur Brasilien eine Rolle. Der hier aus Zucker erzeugte Kraftstoff erfüllt, wie gezeigt, problemlos die Anforderungen an THG-Einsparungen. Ob die weiteren Nachhaltigkeitsanforderungen dort signifikante Effekte haben, ist auf Grund der geringen Bedeutung des EU-Bioethanolmarktes bestenfalls ungewiss.

Wesentliche Mengen der Weltproduktion fallen unter den Geltungsbereich der Nachhaltigkeitsanforderungen lediglich im Bereich der Rapsproduktion, die heute die Stütze der europäischen Biodieselproduktion bildet und bei der ein Großteil der Produktion in der EU stattfindet. Bei einer weiteren primären Nutzung von Raps als Rohstoff für die Biodieselproduktion dürften die Effekte auf den internationalen Rapshandel erheblich sein. Bei dem vielkritisierten Palmöl und dem global gesehen ebenso bedeutendem Sojaöl sind hingegen kaum Effekte zu erwarten.

Eine strenge Ausgestaltung der Anforderungen, wie etwa die Einbeziehung sozialer Kriterien, würde insbesondere an der Vereinbarkeit mit den WTO-Regeln scheitern. Die Vereinheitlichung der Regeln auf EU-Ebene ist gegenüber einem deutschen Alleingang von Vorteil, da der Wirkungsbereich nationaler Regelungen noch geringer wäre. Allerdings erfordert eine nachhaltige Wirkung, insbesondere bei den verfolgten Umweltzielen, eine globale Regelung, und diese nicht nur im Biokraftstoffsegment, was, zumindest gegenwärtig, nicht als realistisch erscheint.

Im Hinblick auf die Reduzierung der entstehenden administrativen Kosten ist mit der Massenbilanz die second-best Lösung gewählt worden. Diese erfordert im Gegensatz zum book-and-claim System die Bindung der Zertifikate an physische Warenströme. Zudem werden auf einzelnen Produktionsstufen Einzelnachweise notwendig, wenn von den Standardwerten abweichende Werte genutzt werden müssen oder Anbaugebiete nicht unter den Bereich der Standardwerte fallen. Liegen keine unilateralen oder multilateralen Übereinkünfte vor bzw. erfüllen Rohstoffe durch die geltenden Standardwerte nicht die im Zeitablauf steigenden Grenzwerte, kann es hier zu erheblichem Nachweisbedarf kommen.

Empfehlungen für die zukünftige Politik im Bereich der erneuerbaren Energien und insbesondere auch für die Nachhaltigkeitsbestrebungen im Biokraftstoffbereich ließen sich anhand der von Tinbergen aufgestellten Grundsätze einer rationalen Wirtschaftspolitik, dass die Zahl der Instrumente wenigstens der Zahl der Ziele entsprechen sollte, der Einsatz der Instrumente systematisch koordiniert werden muss und veränderte Daten eine Anpassung des Instrumenteneinsatzes erfordern, strukturieren. Bereits der Verstoß gegen den ersten Grundsatz deutet die Schwäche der gewählten Regulierung an. So werden neben dem Ziel der THG-Einsparungen auch Ziele wie die Vermeidung von Landnutzungsänderungen, Umweltschutzziele, die Förderung der Biotreibstoffe der zweiten Generation und die Verbesserung von Arbeits- und Sozialstandards -diese zumindest auf EU-Ebene ausführlich diskutiert- in ein und demselben Regelwerk verfolgt. Ein klares Bekenntnis zur Zielsetzung THG-Einsparung unter Minimierung der THG-Vermeidungskosten wäre hier wünschenswert. Doch auch dieses Primärziel ist weniger konkret, als es die Vorgaben auf den ersten Blick scheinen lassen. So kam es beispielsweise im Laufe der Verhandlungen der EU-Richtlinie zu „Anpassungen" der THG-Werte einzelner Biokraftstoffe, und auch die Ankündigung der regelmäßigen Anpassung der Werte an neueste wissenschaftliche Erkenntnisse lassen viel Raum für Spekulationen. Diese werden durch die aufgezeigte Bandbreite der Berechnungsmethoden und Ergebnissen genährt. Mit der Festlegung einer einheitlichen Berechnungsmethode für THG-Einsparungen wird hier zumindest der Grundstein für eine wissenschaftlich fundierte Diskussionsbasis gelegt.

Zu einer Begünstigung heimischer Rohstoffe, wie es vom Parlament gefordert wurde, ist es in den Gesetzestexten nicht gekommen. Diese wäre auch weder unter ökonomischen, noch unter ökologischen Gesichtspunkten erstrebenswert. Bei der Einschätzung der Biokraftstoffe der zweiten Generation tritt hingegen eine begünstigende Bewertung auf. Diese werden gemäß ihrer THG-Einsparungen als sehr positiv ausgewiesen, ohne dass hier Erfahrungen im kommerziellen Bereich vorliegen. Die Unsicherheit der Auswirkungen einer großflächigen Nutzung von Kulturholz oder großindustriellen Nutzung von Stroh ist gegenwärtig hoch und weist großen Forschungsbedarf auf. Die pauschale Befürwortung dieser Technologien erinnert stark an die politische Wahrnehmung der Biokraftstoffe erster Generation vor einigen Jahren, bei der die Erwartungshaltung in Bezug auf die Umweltwirkung ebenfalls sehr hoch war.

Auch der Grundsatz der systematischen Koordinierung der Instrumente wird bei der Nachhaltigkeitsregulierung für Biokraftstoffe vernachlässigt. So steht beispielsweise ein tarifärer Außenschutz für Ethanol klar dem Ziel der Reduktion von THG-Emissionen entgegen. Zudem wurde bereits dargestellt, wie gering die Auswirkungen einer ausschließlichen Regulierung des europäischen Biokraftstoffsektors im globalen Kontext sind. Erstrebenswert wäre daher die Umsetzung der Umweltstandards auf globaler Ebene und eine internationale Koordinierung der Politikinstrumente. Da dieses kaum im Rahmen der WTO, die eine reine Welthandelsorganisation ist, umgesetzt werden kann, empfiehlt sich hier beispielsweise die Einbeziehung der landwirtschaftliche THG-Emissionen und Biokraftstoffpolitiken in die internationalen Klimagespräche.

Die Notwendigkeit der Anpassung an veränderte Daten scheint durch die Nachhaltigkeitsverordnungen gewährleistet, sie wird in den Gesetzestexten sogar explizit genannt. Allerdings bedeutet dieses auch, dass es keine vollkommene langfristige Planungssicherheit geben kann und Absatzgarantien, insbesondere durch langfristige Beimischungsquoten, vermieden werden sollten. Kritischer ist noch eine durch Partikularinteressen motivierte Anpassung von Umweltanforderungen oder Richtwerten. Die finanzielle Förderung von Pilot- und Versuchsanlagen widerspricht nicht diesem Grundsatz, allerdings kann eine langfristige Subventionierung eines bestimmten Biokraftstoffbereiches um seiner selbst willen weder ökologisch noch ökonomisch sinnvoll sein. Hier sollten Kosten-Nutzen-Erwägungen verstärkt in den Vordergrund rücken.

Die den Gesetzestexten verankerten Nachhaltigkeitskriterien müssen vor diesem Hintergrund durchaus kritisch hinterfragt werden. Die Gefahr besteht hier, dass es primär zu einer verstärkten Segmentierung der Rohstoffmärkte kommt, ohne dass ein wirklicher Beitrag zu einer möglichst kostengünstigen Reduktion von THG-Emissionen geleistet wird. Die administrativen Kosten sollten dabei nicht unterschätzt werden, insbesondere unter dem Gesichtspunkt, dass diese im Zeitablauf noch ansteigen dürften. Die Nutzung von Bioenergien birgt aus unserer Sicht

Zukunftspotential auch für die deutsche Landwirtschaft. Dieses hängt aber gegenwärtig noch primär von der Steuerung durch die Agar- und Energiepolitik ab. Nach heutigem Stand der Wissenschaft liegt dieses Potential aber nicht bei den Biokraftstoffen der ersten Generation, über die Biokraftstoffe der zweiten Generation sollten aufgrund der fehlenden wissenschaftlichen Kenntnisse über ihr globalen Auswirkungen kein vorschnelles Urteil gefällt werden. Diese grundlegende Erkenntnis bleibt durch die Forderung und Umsetzung von Nachhaltigkeitsvorgaben, wie sie in der Biokraft-NachV und der ihr zugrundeliegenden EU-Richtlinie formuliert sind, unberührt.

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7 Discussion of results and open questions

7.1 Summary of research results

This chapter summarizes the main findings and discusses some of their limitations. The analyses focus on the EU biofuel sector with an emphasis on the German biodiesel market. Biofuels represent only a part of the biomass used for energy generation. This sector mainly developed during the past decade and is continuously growing in many segments. According to the ambitious targets and regulations put in force during the past years, the importance of energy production from biomass is expected to increase further. In many segments where energy is generated from biomass, a wide range of commodities can be used as feedstock, including woody biomass and organic waste as well as field and forest residuals. However, the range is currently limited for biofuels. In Europe, rapeseed oil is primarily used to produce biodiesel. Ethanol is also mainly based on a single commodity in most countries, e.g. corn in the US and sugar in Brazil. The narrow feedstock basis is not exclusively due to comparative advantages, but is in many cases further restricted by norms or tariffs.

Even though the research on second generation biofuels, i.e. those forms that do not compete directly with the food sector for agricultural commodities, is promoted, they are still not available on a commercial scale. Up to now only a number of pilot and demonstration plants have been announced or set up (IEA, 2010). Furthermore, most experts do not expect them to reach a large market share by 2020[12]. Therefore, it is assumed that no fundamental changes in the structure of the biofuel production will be observed in the near future. Hence, our analysis of the past developments is of high relevance for the further development of biofuel promotion policies.

In the chapter entitled “Price Formation in the German Biodiesel Supply Chain: A Markov-switching Vector Error Correction Modelling Approach”, we found evidence for an integration of the German biodiesel market with both the diesel market and the vegetable oil markets. Furthermore, stable long-run price equilibriums between the market pairs were found, which is in line with expectations

[12] The European Commission assumes in its impact assessment on the 10 % biofuel target that second generation biofuels will form 30 % of the biofuel share by 2020. It however argues that the assumption is linked to a number of uncertainties (COM, 2007a). Furthermore, they estimate, based on ETP calculations, that second generation biofuels might be available on a commercial scale by 2020, but with only a small contribution (COM, 2007b). The IEA (2010) estimates that 60 % of biofuels could come from second generation technologies by 2030.

under these market conditions. The price adjustment behaviour was, however, not found to be stable but regime dependent. Furthermore, it differed from the expectation that, with an increasing use of rapeseed oil for biodiesel, the speed of adjustment in rapeseed oil prices towards changes in biodiesel prices increases. The reverse effect was found with weaker error correction taking place in 2006 and 2007 in comparison to earlier years where biodiesel played a much smaller role.

These results cannot be explained by market behaviour alone. Weak price adjustment is in the literature often linked to market power where one stage in the processing chain uses its strategic position to increase its margins. Weak price adjustments are also linked to market imperfections, in which governmental interventions influence trade flows. Despite an increasing concentration along the processing chain for biodiesel, market power is assumed to not play an important role. The biodiesel sector is one of the segments where vegetable oil can be used and the markets for oilseeds show strong integration to international markets. Furthermore, the structure of the biodiesel industry and in particular the occurring overcapacity does not allow for strategic behaviour. On the contrary, governmental interventions have played an important role during the past years and reasons could be found here.

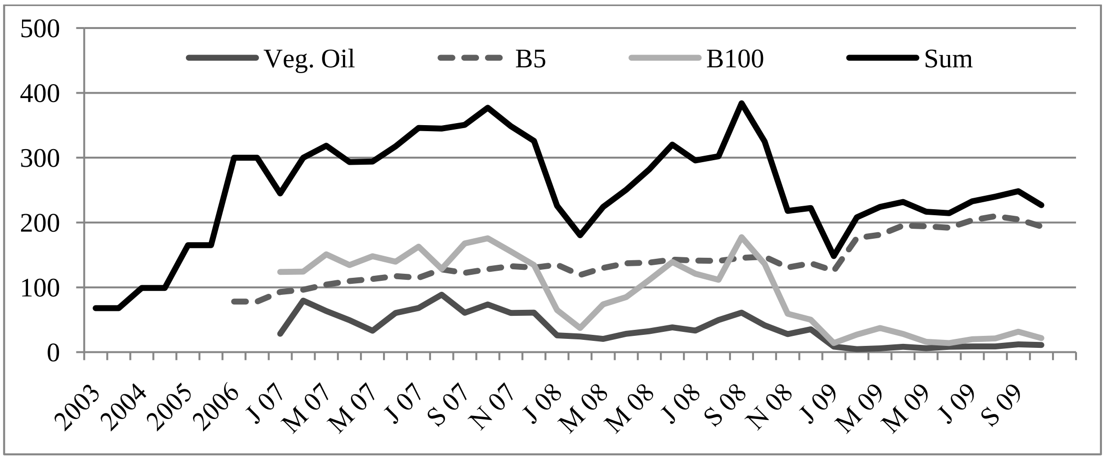
Although the biodiesel industry was a fast growing sector in the beginning of the first decade of this millennium, it is essentially dependent on political support. The legal framework concerning biodiesel support changed in the course of the years with a fundamental change in 2006 with the introduction of the blending mandate and the reduction in tax credit. Consequently, strong overcapacity occurred. These changes took place in a comparatively sudden manner in a sector characterized by the need for long-run investments. These changes required adaption processes within the industry and left the market in uncertainty about the future. These two factors were determined as the main reasons for the detected price behaviour. However, these factors cannot be verified to be causal by using time series techniques. The paper finds its limitation here and different data and models would be needed to analyse the underlying causal mechanisms. Reliable high frequency data on production quantities as well as trade flows would allow for better insights into the development of the market but are difficult to obtain. Furthermore, the literature on industrial organization could provide more explanations about how market actors behave under such changing market conditions.

The fourth chapter (“Bestimmungen der Determinanten der Rapspreisentwicklung in der Hochpreisphase auf Basis von Markovzeitreihenmodellen“) addressed selected open questions concerning the rapeseed price increase in the German market in 2007/08 from the perspective of price interactions. Long-run equilibriums were found between the price of rapeseed and prices for wheat, soybeans, rapeseed meal and rapeseed oil. A distinct, and from the previous years differing, price adjustment behaviour occurred in this phase. It must be noted, however, that several events of this nature also occurred earlier in 2003/04. An early but weak influence of wheat prices on the rapeseed price development was found, but the main driving force was the oilseed market itself. Strong equilibrium adjustment towards rapeseed oil and meal prices as well as a lagged adjustment to soybean prices indicates working market mechanisms and a strong influence of vegetable oil prices.

The influence of biodiesel on the rapeseed price development in 2007/08 was not explicitly discussed in chapter 4. Different aspects of the demand for biodiesel have to be considered when determining its influence on price developments in agricultural commodities. Even though the demand for B100 is encouraged by tax credits, the quantity sold in this market segment is determined by market forces. B100 needs to be competitive to (taxed) diesel in the market. Due to the lower energy content of biodiesel, a certain price spread between both products has to exist in order to provide buying incentives. In 2007/08, rapeseed oil prices exceeded 1,000 €/t and made B100 uncompetitive despite the strong increase in crude oil prices. The consequence of this was a collapse in B100 sales (Figure 1). It therefore seems implausible to assume that this market segment crucially contributed to the rise in rapeseed oil prices.

However, the opposite holds for the B5 market. The blending of 5 % biodiesel to diesel was enforced for the first time in 2007 and represents the lower blending limit ensured by high penalties. On the other side, this share is also the upper limit determined by German fuel norms. Thus, an almost inelastic demand for biodiesel arises from the petrol industry and a low fluctuation in B5 sales results (Figure 1). The effect on rapeseed oil prices depends strongly on the feedstock mix in biodiesel, i.e. the share of rapeseed oil. The share was usually above 80 % in B100 and B5. This is due to the requirements defined by the German fuel norms which treat both market segments equally. The consequence of this constellation is an almost inelastic demand for rapeseed oil as a base product for biodiesel. Since any demand from the biodiesel sector reduces the amount of rapeseed oil available in the market, increasing price levels can be expected. However, the biodiesel demand was increasingly fed by B99 imported from the US in 2007/08. Hence, the inelastic biodiesel demand did not translate into a constant demand for rapeseed.

Figure 1: Monthly sales of vegetable oil as fuel, B5 and B100 in 1,000 tons January 2007 to October 2009; monthly average of annual sales 2003- 2006



Source: Own elaboration based on UFOP (2010).

The question of the behaviour of price volatilities in this phase was addressed in chapter 5 ("Investigating Rapeseed Price Volatilities in the course of the Food Crisis"). Due to the high data requirements of the model, daily observations from the MATIF and the spot market in Rotterdam were used. This allowed us to complete the analysis of the previous chapter with respect to volatility developments. Rapeseed prices have shown much higher volatility since 2007 than in the period before, as most of the other prices. Furthermore, we found rapeseed prices to be more sensitive to shocks in comparison to the other prices investigated. Finally, an increased correlation between the volatilities of rapeseed prices and crude oil prices could be shown. These results are not contradictory to the findings in chapter 4 since the price volatilities and not price levels were analysed in chapter 5.

Under perfect market conditions, price changes should reflect adjustments to changes in supply and demand. However, volatility, due to speculative behaviour, blurs market signals and makes it difficult to distinguish markets trends and reactions to changes in supply and demand from fluctuations. Our empirical results indicate that the fluctuations were not solely due to market changes. Rapeseed price volatilities show stronger correlation with crude oil than with other agricultural commodities on the spot market. It is not possible to distinguish here how strongly the markets influence each other. Hence, it has to be assumed that the correlation indicates a reaction to the same market signals.

However, nowadays, everybody seems aware of the role of the biodiesel market for the rapeseed oil market. Any price signals from crude oil markets indicate the rising (falling) competitiveness of biodiesel which is expected to increase (decrease) rapeseed demand in the medium-run. Furthermore, the co-movement of crude oil with many agricultural commodity prices became the popular belief during the past years. Hence, it is possible that parts of the rapeseed price volatility are due to expectations of market actors raised by changes in crude oil prices. In the past, crude oil prices have regularly been more volatile than most agricultural commodity prices. Since this correlation has a high persistency, it is possible that rapeseed prices follow this path. This phenomenon can be expected to continue at least until a fundamental change in biofuel regulations and usage takes place.

The analyses in chapter 4 and 5 answer specific questions regarding the price mechanisms in the EU rapeseed market. Only direct factors influencing these prices were analysed. How the price developments of other commodities were influenced and which role the measures taken by important exporting countries during the food crisis played, was not addressed. Hence, this partial view does not yield information about the source of the overall price developments. With respect to this question we would like to refer to the literature cited above, which explicitly addressed it. Furthermore, the empirical results are only valid for the EU rapeseed market. Other commodity prices and prices in other countries might have behaved quite differently. Finally, the analyses carried out in chapter 3, 4 and 5 were based on secondary data. Even though the data were mainly provided by official agencies, common limitations regarding their reliability and validity apply here. This seems especially critical in the case of biodiesel prices which were collected by a German lobby organization.

The support for biofuels seems to continue but tax credits for biofuels and their accountability for the fulfilment of blending requirements will crucially depend on sustainability criteria. The chapter “Die Biokraftstoff-Nachhaltigkeitsverordnung: Ein erster Schritt in eine nachhaltige Bioenergiepolitik oder ein weiteres Stück

Bürokratie?” discussed the criteria which define sustainability and identified some of the weaknesses of the new directive. The effects of this directive are rather limited since it covers too small a fraction of world production. Even more critical is the direction the EU seems to take with this directive. It appears that the promotion of biofuels will be continued while the share of biofuels is to be increased. Furthermore, the percentage GHG savings appear to be the most important indicator. The different objectives associated with biofuel promotion will be discussed in the following chapters. Our analysis was limited to a number of selected topics and a wide range of further research would be needed to take all aspects into account. However, the economic problems and questions regarding current biofuel policies will not fundamentally change with the implementation of this directive. Unintended effects as those on agricultural markets and the promotion of large scale cost-inefficient biofuel production are likely to continue in the medium-term.

7.2 A note on bioenergy promotion measures

It has been noted several times in this thesis that the biofuels market in Germany and the EU grew primarily based on political support. We now want to briefly discuss the measures taken with regard to economic theory. Political interventions in markets generally have to be in accordance with the economic system of the country. Therefore, any intervention needs a justification and has to be efficient as well as effective to reach its objective. The stronger the intervention intensity, the lower its market conformity usually will be. In the following, the most important measures used for biofuel promotion will be reviewed with respect to their economic justification and their welfare impacts. Furthermore, reasons for changes in market interventions will be discussed since several changes occurred during the past decade.

Interventions in a market can be classified according to Henrichsmeyer and Witzke (1994) as following:

- *Information and advisory services* are used to increase market transparency and efficiency

- *Recommendations* can be used to influence the decision making processes and increase the awareness for e.g. environmental issues
- *Financial aids or charges* serve to influence production and consumption
- *Direct interventions* are used to determine prices and quantities
- *The state as a market actor* when buying out quantities or providing credits

The intensity of the interventions obviously increases along this list and they become, hence, more difficult to justify. While the tax credit for biodiesel and the investment aids for production plants can be classified in the third category, the blending mandate falls into the fourth category.

Henrichsmeyer and Witzke (1994) argue that the allocation reached by price mechanisms reflects some kind of welfare maximum. However, this is not always the case. Market failure can occur, if market mechanisms do not work properly. Different reasons for this exist but we see three of them to be able to justify interventions in the case of the promotion of biofuels:

- *Externalities*
- *Private risk aversion*
- *Private time preferences*

Private risk aversion plays a role when justifying the assistance in the research and development of renewable energies. New developments are in general very costly while the outcome is uncertain. Furthermore, the construction of large scale demonstration plants is necessary in the area of biofuels to assess economic and environmental impacts. Even though the necessity of interventions in research and development might be arguable, we will leave this discussion and proceed instead to the other two points mentioned above.

Externalities and private time preferences might be reasons why market failures occur in the market for biofuels. Assuming that biofuels reduce GHG emissions and, hence, have a social benefit, it is likely that the market does not reward this. Market actors do not account for this since they do not value the long-term impacts nor see their direct benefits (often problematic with environmental effects). Consequently, a divergence between social and private marginal costs is present in the market (Koester, 2005). Therefore, the state might feel obliged to correct this market failure and take measures to increase the market quantity to a socially optimal level. The necessary condition for an intervention in the biofuel market seems fulfilled.

Changes in interventions over time might become necessary if either the objectives or their valuation change (Koester, 2005). In the case of biofuels, the objective of GHG savings gained importance during the past years (for the detailed discussion about biofuel promotion objectives see chapter 7.3). Hence, it seemed to be necessary to adapt the measures to this objective. Furthermore, the biodiesel sector developed strongly over time. Measures which were initially used such as tax exemptions for biodiesel appeared to be costly at annual sales of three million tones. The reduction in tax credits could also be consistent if production technology has changed or average production costs have decreased. However, this was not observed in the German market over the past years. Measures which are not used to internalize external costs should, in general, only be used temporarily. If this is not ensured they might conserve production schemes rather than foster market adjustments. Problematic are especially any measures that are difficult to withdraw for political reasons and require further governmental interventions (Koester, 2005).

Regulative judgment

In the previous section we concluded that there is evidence for the presence of a market failure in the biodiesel market and that interventions can be necessary to correct it. Koester (2005) argues that the measure that is closest to the divergence should be applied. The potential interventions therefore have to be rated according to their contribution to reduce market failure, their possible side effects on other markets and the costs of the measures. Henrichsmeyer and Witzke (1994) argue that the measure with the lowest intervention intensity has to be used. Most important is that the intervention helps to cure the market failure. Furthermore, it is important that it costs less than the failure itself. This is especially relevant, if the intervention is not able to fully correct the market failure. In any case, the market failure after the intervention should be lower than before.

We mentioned that biofuels, as long as they emit less GHG than their fossil counterparts, create social benefits. The intervention should, hence, serve to reach the socially optimal production level. Tax credits could be a suitable measure to correct the market failure, if they are set up correctly. However, when regarding the current worth of GHG savings and the different amounts of savings achieved by different biofuels, the tax credits overcompensate the positive social benefits. In 2006, the tax credits for biodiesel were reduced and the blending mandate implemented. This was mainly done due to budgetary consideration. The blending mandate enforces the use of biodiesel under full taxation. This would correct the market failure if it, by chance, would represent the socially optimal amount of biodiesel used in the market.

Problematic are particularly the side effects of the mandate. A fixed demand for biodiesel is generated from the petrol industry. This is mainly met by using rapeseed oil for biodiesel production. Consequently, there is no variation in demand from this side and, hence, a smaller scope for shifting quantities between biodiesel demand as whole and rapeseed oil demand from the food sector. Furthermore, the strict biodiesel norms in combination with the fixed demand reduce an efficient factor use since a certain amount of rapeseed has to be produced on high quality land to meet these obligations. The functioning of market mechanisms is reduced. Finally, with the blending obligation, a permanent measure is implemented which has the potential to conserve production rather than increase competition and, hence, development.

Import tariffs on biofuels have been in place for a long time and have not been reduced up to now. These can be supported by the infant industry argument since the sector was small and sensitive to international competition. However, this does not seem valid any more, at least not for the biodiesel sector. Furthermore, import tariffs increase the domestic price and lead to an increase in domestic production while domestic demand decreases. The consequence is an inefficient factor allocation which leads to a decrease in welfare. Misdirected investment due to protection from import competition and higher market prices can be seen all over the EU. The return from these investments is higher than it would be under undisturbed market conditions. The consequence of these interventions and changes in interventions are challenges that especially the German biodiesel industry currently has to face. Since large investments were made, market interventions are difficult to withdraw and further political involvement will be necessary, at least in the medium-term. Consequently, the interventions cannot be justified as being an attempt to correct market failures arising from the missing reward for the social benefits of GHG savings.

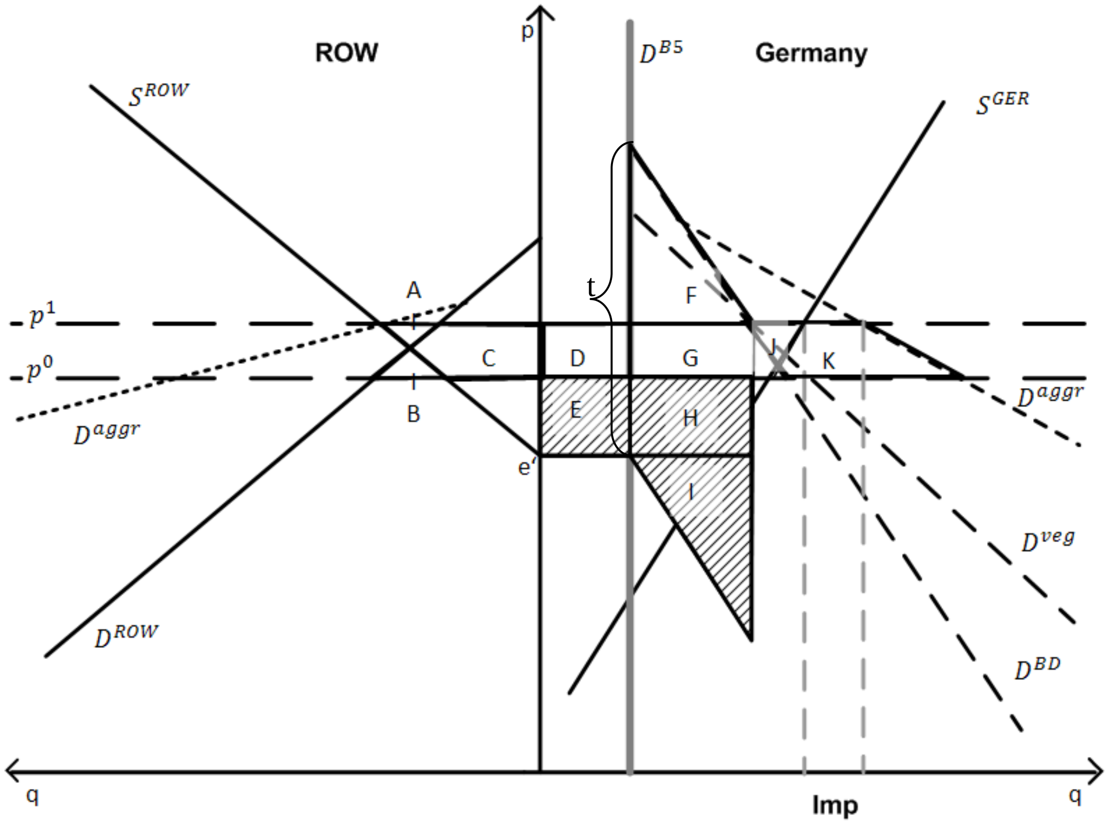
Welfare analysis

We argued above that the intervention has to be efficient in correcting market failure and that it needs to cost less than the market failure itself. To examine this, a welfare analyses is conducted. If interventions improve the efficient functioning of markets, the overall welfare is assumed to increase. In the case of the promotion of biodiesel in Germany, several agricultural markets in Germany as well as other countries are involved. The most important markets have been analysed in detail in this thesis. Since it is complex to cover all the side effects of the biodiesel promotion, we restrict our investigation now to a partial analysis on the rapeseed oil market. The analysis is based on the concept developed in Chapter 3.2 (for details see there).

In the base scenario, no measures are used to promote biodiesel consumption and, hence, no rapeseed oil is used for biodiesel production since it is not competitive. An equilibrium price at p^0 is observed at which Germany is a net-exporter of rapeseed oil (cp Chapter 3.2). Given this base scenario the blending mandate and tax credit for B100 are introduced in Germany (Figure 2). The blending obligation sets an inelastic demand for rapeseed oil (D^{B5}) and shifts the demand for rapeseed oil from the food sector (D^{veg}) to the right. An inelastic demand is assumed since the blend of biodiesel to diesel is enforced and biodiesel is mainly based on rapeseed oil. The tax credit (*t*) for B100 shifts the demand for rapeseed oil from the biodiesel industry (D^{BD}) upwards by the amount of tax credit. Consequently, B100 becomes competitive to fossil fuel and a demand from the biodiesel industry appears. The aggregated demand (D^{aggr}) from all three segments exceeds the domestic supply (S^{GER}). Germany switches from a net-exporter to a net-importer of rapeseed oil (right panel of Figure 2).

In the left panel of Figure 2, the effects in the rest of the world (ROW) are shown. Besides the foreign supply (S^{ROW}) and demand (D^{ROW}), an import demand from Germany occurs. The intersection of the aggregate of import demand and ROW demand (D^{aggr}) with the foreign supply determines the new equilibrium price level (p^1). At this price level, a certain amount of rapeseed oil imports (Imp) results. Furthermore, it can be seen that the price of rapeseed oil is identical for all uses. The price of the rapeseed oil used for biodiesel, produced to meet the blending obligations (B5) is determined by the price of B100 and thereby indirectly by the size of the tax credit on B100. (e') indicates the price level of rapeseed oil at which rapeseed-based biodiesel would become competitive to fossil fuel on the energy basis without any interventions. This price (e') is well below the observed equilibrium price (p^1) with the different measures in place.

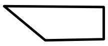
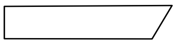
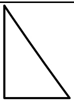
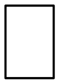
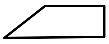
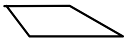
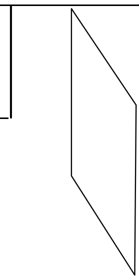
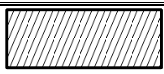
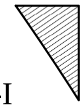
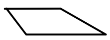
Figure 2: Supply and demand for rapeseed oil with the blending obligation for biodiesel and tax credits for B100 in place.



Source: Own elaboration.

The welfare effects are summarized in Table 1. Rapeseed oil producers in Germany (+D +G +J) as well as the rest of the world (+A +C) profit from the increased demand for rapeseed oil and its higher price. At the same time consumers of rapeseed oil for nutrition purposes lose (ROW: -B -C; Germany: -K), since a smaller quantity is consumed at a higher price level. Welfare losses occur for fuel consumers (-D -E) since they have to pay the additional cost arising from the obligation to blend more expensive biodiesel to fossil fuel. Biodiesel producers gain (+F) since the most efficient of them make profits under these conditions. Budgetary costs arise due to the amount of biodiesel sold as B100 under the tax credit (*t*) granted (-F -G -H -I). Only a small part of this money appears as income transfer to biodiesel producers (F) and rapeseed oil producers (G). Furthermore, (D) is a direct transfer from fuel consumers to rapeseed oil producers since arising costs are assumed being passed through by the petrol industry to consumers.

Table 1: Welfare effects in Figure 2

	ROW	Germany
Δ Rapeseed oil producer rent	+A +C 	+D +G +J 
Δ Biodiesel producer rent		+F 
Δ Fuel consumer rent		-D -E 
Δ Veg. oil consumer rent	-B -C 	-K  
Δ Budget		-F -G -H -I
Δ Welfare	+A  -B 	+J  -E -H  -I  -K 

Source: Own elaboration.

While some money appears as income transfer, large welfare losses occur. Parts of the welfare losses (+A -B +J -K) stem from the increase in rapeseed oil production since less competitive producers with higher production costs join the market. Furthermore, consumers who formerly purchased rapeseed oil for food purposes leave the market. However, additional welfare losses (-E -H -I) occur due to “water” in the system. Private as well as public money is used to bridge the gap between the value of rapeseed oil for biodiesel production (e’) and the market price of rapeseed oil (p^1). Consequently, the welfare losses are substantially higher than one would expect a priori.

While the political intervention in the biofuel market seems to be justifiable by market failures in principal, the chosen measures fail their validation. The missing reward for social benefits from GHG savings was discussed. The measures chosen were not able to correct this market failure and substantial welfare losses occur. Later on, the ratio between tax credits and the value of the GHG savings will be discussed. When arguing about income transfers to farmers through the biofuel policy, the low transfer efficiency should be kept in mind. Other objectives such as e.g. the increasing security of energy supply could also be used to justify the interventions. These have not been discussed here and might even be difficult to quantify.

7.3 A note on bioenergy objectives

In particular when the applied measures for promoting biofuels are not justified by economic theory they should at least serve to reach the official objectives. In the following, we briefly review the most important biofuel objectives. This analysis is not exhaustive, but is rather limited to a critical examination of developments in the German biofuel promotion policies. Some aspects will be discussed in the EU context since these are not restricted to the German market. The most important measures used up to now for promoting biofuels were tax credits, blending mandates, fuel norms and import tariffs. The promotion framework for biofuels in Germany has changed substantially in the course of the first decade of the new millennium. The changes were partly due to fiscal considerations. Other driving forces were environmental issues and, in the course of the food crisis, an increasing awareness of the impact on agricultural commodity prices.

While the import tariffs and fuel norms account in all European countries, the implementation of fiscal measures is rather diverse. Several countries (e.g. Belgium, France, Greece, Ireland, Italy and Portugal) defined a quantity of biofuels which is eligible for tax credits or gave out licences for these. While some countries only grant tax credits on blended fuels (e.g. Austria, Belgium and the Netherlands) other countries grant these only on pure biofuels (e.g. The Czech Republic and Luxembourg). However, most countries grant tax credits for both segments. Denmark exempts biofuels only from CO2 taxes (~3 cent/l) and Lithuania only from environmental pollution taxes (for detailed overviews see e.g. Stratégie grains, 2008).

The objectives of biofuel promotion are diverse. GHG savings can be pointed out as the most recent officially announced main objective. The EU Renewable Energy Directive (COM, 2009) defines as further objectives:

- *Security of energy supply*[13]
- *Promotion of technological development and innovation*
- *Provision of opportunities for employment and regional development in rural areas*

Certainly none of the measures used to promote biofuels is able to satisfy all objectives. However, the degree to which they contribute to the various objectives differs substantially. In the following, the most important objectives will be discussed in general and with regard to the measures used to achieve them.

Reduction of GHG emissions

For some years, the environmental impacts of biofuels, and in particular the unintended consequences of increasing biofuel usage, have led the discussion around the promotion of biofuels. None of the measures implemented during the first decade of the new millennium was really set up with respect to GHG reductions. The Renewable Energy Directive (COM, 2009), which has to be implemented by Member States in 2010, is the first regulation that explicitly tackles this topic. Furthermore, German biofuel targets are on their way to being transformed. While they are currently based on biofuel usage obligations in quantitative terms, fixed amounts of GHG savings have to be achieved from 2015 onwards (BioKraftQuG, 2010). Both of these changes bring GHG savings more into the focus of the biofuel policy.

GHG emissions in general are a global problem and their reduction has to take place globally. Its content in the atmosphere cannot be restricted to specific regions. Savings or emissions in any place in the world have the same effects. Therefore, they should be rewarded or taxed equally. Any discrimination between different reduction approaches violates the objective of reducing GHG emissions. Moreover, a reduction in one region on the cost of rising emissions in other regions is inefficient. If the highest savings are to be achieved, the most cost-effective reduction approach needs

[13] The problem of the dependence on imported oil is seen to be most acute in the transport sector.

to be chosen. With regard to biofuels, import tariffs clearly countervail this attempt. With regard to GHG savings in general, biofuels are certainly not the cheapest approach. Fixed consumption targets and targets for GHG savings in one sector inhibit the shift to the most cost-effective reduction technology. The money tied in the biofuel sector would be better invested in other areas as the improvement of the efficiency of energy usage and the promotion of energy savings.

Security of energy supply

In light of the objective of an increasing independence from crude oil imports and the security of energy supply, the promotion of biofuels does not seem to be the most promising attempt. Domestically produced biofuels, in their current form, cannot fully replace fossil fuels. Furthermore, the expansion of agricultural production is, particularly in the EU, limited. Hence, the achievement of large market shares will inevitably come at the cost that agricultural commodity imports have to increase (SRU, 2007). Even on the global scale, biofuels currently contribute to only 1.5 % of the demand for transport fuel (IEA, 2010). Europe's increasing independence from crude oil imports increases its dependence on imports of agricultural products for biofuels as well as for food purposes. This trade-off occurs as long as biofuels compete directly with food for agricultural resources. Furthermore, the tariffs in place clearly countervail the objective of an increasing security of energy supply.

The measures taken so far were tailored towards the increase of biofuel quantities. The net-energy supply through biofuels was not taken into account. However, the production of energy from biomass requires energy as a production factor and in the processing process. Hence, a certain share of biofuels does by no means indicate that the identical amount of energy from crude oil has been replaced by biofuels. Consequently, the increasing use of biofuels does not necessarily reduce the dependence on energy imports. To reach this objective, the net-energy generation per hectare has to be taken into account. How to use the limited natural resources most efficiently does not only have to be discussed in the context of biofuels but also in general. In the case of the factor soil, the installation of solar power might for example represent an alternative choice. As it becomes competitive to other renewable energy sources, it has the potential to yield more net-energy per hectare than any biomass production.

At least the increasing diversification of energy sources might have enhanced the security of the energy supply to some degree. The origin of the imports plays, thereby, an important role. While a large share of fossil energies has to be imported from politically instable regions, agricultural commodities are often imported from democratic countries. This might not only be important with respect to the security of energy supply but also with respect to the question about which kind of countries and governments profit from European expenditures on imports.

Promotion of technological development and innovation

The objective of finding alternatives to the limited fossil energy resources and promoting technological development and innovation was tackled by investments in research on renewable energy sources. Biomass represents only part of a wide range of possible energy sources but was considered as the best alternative to replace fossil fuels in the transport sector. Especially in the field of rapeseed-based biodiesel, the scope for improvement seems limited since the processing costs account for less than 20%[14] of the product price. Furthermore, the IEA (2010) argues that "it is increasingly understood that most first-generation biofuels, with the exception of sugar cane ethanol, will likely have a limited role in the future transport mix." Hence, if technological development and innovation is to be promoted, investments in the area of first generation biofuels appear not to be the most promising attempt in the long-run.

The direction of future developments depends crucially on the main objective chosen. A decision needs to be taken between e.g. the increase in energy security and the reduction of GHG emissions. Biofuels can contribute to both targets to a certain extent. The state has to set up an appropriate legal framework which enables private investments in research in this area. However, this does not always suffice since research in new areas is costly and especially the construction of large-scale pilot plants for biofuels might need governmental investment assistance. The state should not guide the development but rather assist the market in finding the best solution. Technological developments and improvement in the area of biofuel production require financial resources which could otherwise be used in other areas of renewable energies or outside this sector.

[14] Estimate of the Wissenschaftlicher Beirat (2007) for an average German plant under prevailing prices.

In general, the amount of money invested in research in each field should be proportional to their expected returns in the long-run. To determine the most promising path in the long-run requires a comprehensive assessment of all alternatives but also comprises several uncertainties. This also requires that approaches need to be given up if they turn out to be unsuitable to achieve the objectives. Finally, investments in research will, in the long-run, pay off better than investments in production capacities in sectors which provide only temporary solutions, such as rapeseed-based biodiesel.

Provision of opportunities for employment and regional development in rural areas

The number of jobs which were created through the growth of the biofuel industry, and which are now dependent on this sector, is often used as an argument for further support. The measurement of the impact on employment and regional development in rural areas would require a comprehensive study on its own. We are therefore going to focus on the influence of different measures on the rapeseed market. With respect to the biodiesel industry it should be noted that this did not grow primarily in remote areas but in urban areas instead. This is mainly due to the need for infrastructure. In particular harbours play an important role for the choice of the site. The growing strength of the biofuel processing and refining industry was in Germany mainly encouraged by tax exemptions. The employment within the industry is today strongly dependent on this support. With rising overcapacity in 2007 many plants had to reduce production or close-down. Private investments and investment subsidies granted by the state got lost or yielded low returns.

In the EU, a variety of measures contributed to the increase in rapeseed production for biodiesel. The energy crops premium of 45 €/ha, which existed between 2003 and 2009, made rapeseed production for biofuels more profitable. The premium was initially only used on 0.3 million ha (2004) but the support limit of 2 million ha was already exceeded in 2007 (2.8 million ha). The possibility to grow biomass on set-aside land was equally important, since it enlarged the potential production area for rapeseed. The compulsory set-aside was introduced in the MacSharry reform in the 1990's and enforced until 2008. Only non-food production was allowed on set-aside land. This option became relevant with growing biofuel production[15]. With these measures and the growing demand for biodiesel, rapeseed production became more profitable and gained in competitiveness to other crops on the farm level.

Despite a substantial increase in rapeseed production in Germany, it became a net-importer of rapeseed and rapeseed oil. Since trade within the EU does not face any tariffs, market actors in other EU countries profit from the growing demand in Germany. Price effects in rapeseed and rapeseed oil can be expected to occur not only in Germany but EU-wide. Since the EU is one of the largest markets for rapeseed in the world, effects on the world market should be observable. Hence, foreign rapeseed producers, rapeseed crushers and refiners, and biodiesel producers profit from price effects caused by consumption incentives set in Germany. We discussed this above with respect to the rapeseed oil market.

The fact that the measures were effective in stimulating production is obvious. On the farm level, the price stabilisation for rapeseed and its increase in competitiveness to cereals can be expected to have positive income effects for crop farmers. A substitution of cereal by rapeseed in the crop rotation does, however, not necessarily create job opportunities. Furthermore, the growth of the processing and refining industry did primarily take place in urban areas. In the case of biodiesel, the effects in rural areas seem therefore rather small and any achievements there came at high costs. Consequently, the biofuel policy as a measure for creating job opportunities and regional development in rural areas seems inefficient. These objectives have to be carefully evaluated with respect to the transfer efficiency of public money spent.

Overall achievements

The above discussed aspects lead to the conclusion that there is little accordance between the official objectives of bioenergy promotion and the measures implemented to increase biofuel production. While most measures only serve one specific objective, some of them (in particular import tariffs) inevitably countervail other objectives. Furthermore, several objectives can only be reached to a limited extent by biofuels; and in many cases biofuels appear not to be the most efficient economic choice. Moreover, substantial welfare losses occur due to misled

[15] Already in 2000, 0.38 million ha of the 1.18 million ha set-aside land was used for non-food crop production for the industrial sector (BMELV, 2009).

investments. The problems discussed show that there is a high potential for the improvement of the biofuel promotion scheme. The bundles of measures which have been used in the past or are currently implemented reflect the heterogeneity of the objectives of biofuel promotion.

It seems therefore essential to define a clear hierarchy of objectives that will be applicable on an EU-wide basis. Furthermore, the legal framework in the EU and the Member States has to be adjusted in accordance to these objectives. A clear focus on GHG savings with the constraint of cost effectiveness could be an improvement. An alternative could be the focus on the search for alternative energy sources with the constraint of the avoidance of negative environmental impacts. However, growth of the biofuel market alone cannot be an objective on its own; it can only serve as a means to reach a specified objective. The definition of the most important objective and the weighting of secondary objectives remains a political decision. It should, however, be based on scientific evidence concerning their technological achievability as well as their environmental and economic impacts.

7.4 Policy implications

The analysis carried out in this thesis so far allowed for insights into the market's developments from different perspectives and the results led to similar policy implications. However, the results and policy implications are derived for large scale commercial biofuel production. These should not be generalized for all forms of bioenergy usage since some of them show very different characteristics.

We found evidence that the growing demand for biodiesel has influenced the rapeseed oil price development. From the theoretical point of view it becomes evident that biodiesel demand contributes to an increased rapeseed price level in the long-run. A possible causality of biodiesel demand for the increase in rapeseed prices in 2007/08 was not analysed econometrically. These connections and the potential for cross market effects have to be considered when discussing biofuel policies. Before and after the food crisis, this discussion mainly took place with respect to environmental impacts and to a minor degree with respect to the economic impacts on agricultural markets. Furthermore, rapeseed and crude oil price volatilities follow increasingly the same market signals. The persistency of this correlation as well as the repeated occurrence of the price level adjustment behaviour raises suspicion that the events of 2007/08 may reoccur. This implies a high risk for biofuel producers since it increases the uncertainty about future developments.

The competitiveness of many types of biofuels depends crucially on political support. However, biofuel policies are sensitive to the public opinion. How fast this can change could be observed in the course of the food crisis. Publications such as that from Mitchell (2008), who accused biofuels of being the main cause for high food prices, found broad media attention. The consequences of sudden changes in the legal framework for biofuel promotion and the missing ability of the biofuel industry to quickly adapt its production have been discussed above.

A range of studies on the impacts of various biofuel policies have been published. Questions regarding how to obtain sustainable development and how to avoid unintended side effects still remain. Some of these points have been addressed with respect to environmental issues. However, questions regarding economic issues have not been tackled. De Gorter and Just (2010) argue that mandates are clearly superior to all other policies. However, they reach this conclusion based on static analyses only. Blending mandates became more popular due to the argument of reduced tax losses. We argued that these contribute to a greater extent to price peaks on agricultural markets in comparison to for e.g. tax credits since they set an inelastic demand and, hence, reduce the quantity available on the spot market. Consequently, tax credits appear superior in this regard. This small dispute shows how difficult it is to evaluate measures if the conclusions are drawn with respect to different objectives.

The cost effectiveness of different biofuel strategies has been ignored for a long time in the discussion on the promotion of biofuels. The market for pure biodiesel absorbs the production that exceeds the blending quota requirements. As long as it exists, it also determines the marginal revenues of the additionally produced biodiesel and therefore the purchasing price for biodiesel used in blends. Any discussion about tax credits and blending mandates is, in principal, only a discussion about shifting the costs from the national budget to the fuel consumers' purse at the petrol station. The transition to flexible blend ratios or the possibility of suspending the blending obligations could reduce the risk of transmitting price peaks from the energy market to the agricultural commodity markets. However, this approach further increases the risk for the biofuel industry and, hence, the risk premium they have to take. The only plausible resort from the policy interventions in place would be a biofuel competitive to fossil fuel.

Competitiveness of rapeseed-based biodiesel

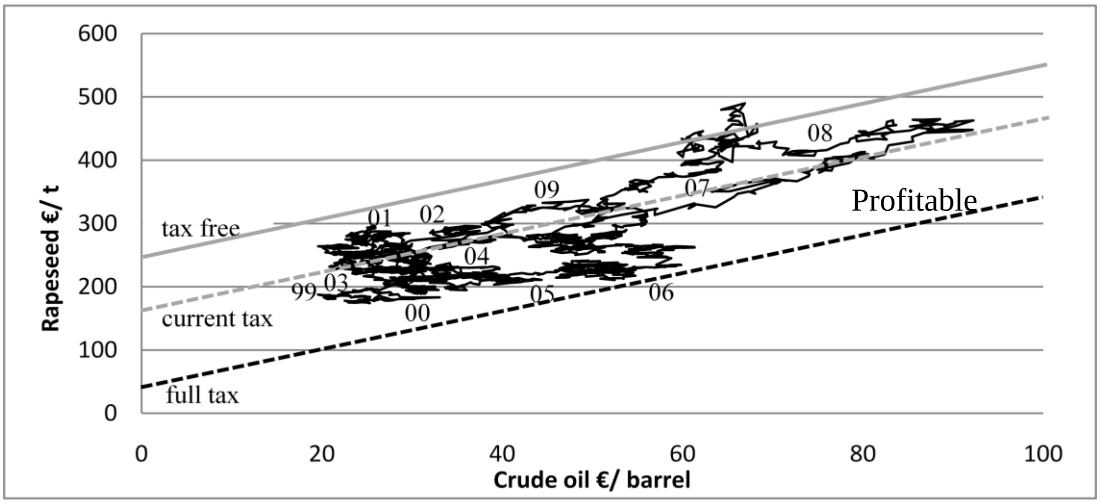
It is often argued in the literature that the break-even point of rapeseed-based biodiesel without any tax credits and remuneration for GHG savings would lie at a crude oil price level of around 90 US$/barrel (~65 €/barrel). However, we argue that these estimates depend crucially on the assumptions made on production costs and cross markets effects. Figure 3 shows an estimate for the break-even line of rapeseed for biodiesel production at different levels of crude oil prices. The estimation is based on the assumption of a 58 % rapeseed meal content with a (comparatively high) price of 180 €/t. Production costs are set to 200 €/t biodiesel[16] and are assumed to be constant as are also the by-product prices[17]. The development of the crude oil and rapeseed price pair over time is represented by the thin black line. An observation below one of the straight lines indicates the profitability of rapeseed-based biodiesel production under the associated assumptions mentioned in the graph. The black solid line indicates full competitiveness. The grey lines show competitiveness at different tax levels placed on biodiesel. The solid line indicates the tax exemption which was in place in Germany until 2006, and the dashed line, the 2010 tax level (18 ct/l biodiesel instead of 47 ct/l).

When the price developments of crude oil and rapeseed displayed in Figure 3 are considered, the shortcoming of a static estimate of a break-even point becomes obvious. Rapeseed-based biodiesel was close to being competitive in 2005 and 2006 at crude oil prices below 60 €/barrel. On the other hand, despite high crude oil prices in 2008, the competitiveness of B100 was, even with tax credits, not reached. Above, we discussed the role of cross market effects and the on-farm competition of rapeseed production. Due to these factors, it is likely that higher crude oil prices

[16] The estimate is based on a plant which produces 100,000 t biodiesel per year under the 2007 market conditions (Wissenschaftlicher Beirat, 2007). However, due to low utilisation rates and changed conditions, the production costs might meanwhile deviate from this calculated value.
[17] An increase in rapeseed meal prices proportional to rapeseed prices would turn the break-even line; furthermore, changes in other assumptions could even change its shape.

alone do not suffice to ensure the competitiveness of rapeseed-based biodiesel in the long-run. Furthermore, whether, and when, a permanent increase of crude oil prices above 90 US$/barrel occurs is uncertain. Sims et al. (2008) argue based on IEA estimates, that alternative energy sources such as heavy oil, tar sands, gas-to-liquids and coal-to-liquids become competitive at crude oil prices of approximately 65 US$/barrel.

Figure 3: Break-even of rapeseed for biodiesel production and price developments



Source: Own elaboration

Changes in the promotion framework

The developments on the German biodiesel market have shown how problematic a support scheme can turn out when it has not been set up in an appropriate way. After the boom and growth of the sector until 2006, the plant's utilisation for biodiesel production fell, on average, below 50 %. Some plants stopped production or even declared bankruptcy. This was, at least initially, not due to a decrease in sales but to a further increase in the production capacity and the increasing import competition from the US. In 2008 and 2009, the breakdown of the B100 market led to a sharp decrease in biodiesel sales. The orientation of the biofuel policy is still under discussion and changes are subject to interest groups as well as different political objectives. Consequently, the development of the promotion framework has not been predictable in the past nor is it currently. Since investments undertaken in this sector are, as in most industry sectors, of long duration, uncertainty increases the investment risk. Furthermore, the immense investment in production capacity, which was made in the past in trust of continuing biofuel support, seems to constrain fundamental political changes.

For an economically sustainable long-run development of the sector, the cost effectiveness of biofuels and the monitoring of market effects have to play a more important role. This discussion is not new and several studies have evaluated the direct costs associated with import tariffs, tax credits and blending mandates (e.g. De Gorter and Just, 2009). While the discussion about the environmental impacts of biofuels reached policy makers, a discussion about the economic impacts seems to have taken place to a much lower extent up to now. The effects of biofuel usage on agricultural prices depends crucially on the range of commodities that can be used for biofuel production and the legal framework for biofuel support, e.g. blending mandates or tax credits. The feedstock basis is currently limited due to norms, trade distortions, the preference for specific (domestic) sectors or the (missing) competitiveness of some feedstock and processing lines[18]. As long as these are not commercially available, any further regulation that is set up as the defined sustainability criteria bears the risk of further reducing the feedstock range. A narrow feedstock range and, in most cases, an artificially created low substitutability of different commodities in biofuel production implies an increased risk of price and volatility spill-over from fossil fuels to their non-fossil counterparts. This risk is highest when the demand for biofuels is enforced by an inelastic demand from the petrol industry which has to meet the blending mandate.

We found evidence for the integration of rapeseed oil prices with biodiesel prices. The integration of other agricultural commodities that are used on a large scale for biofuels with fossil fuel prices was also proven in the literature. Furthermore, we found evidence for an increasing correlation of rapeseed and crude oil price volatilities. The implications of these findings have already been discussed in the previous chapters. However, their negative effects could be mitigated by adjustments in biofuel regulations. Most prominent distortions are strict biodiesel norms and import tariffs on ethanol. A more market oriented biofuel production, rather than the focus on domestic crops, would allow for a wider range of raw products. This is

[18] The last issue concerns in particular second generation biofuels, which are still in the early development stage.

expected to reduce the dependence on selected crops and the impact of crude oil prices on these markets. Additionally, it would foster a more cost effective biofuel production.

Problems of norms and tariffs

The argument for the support of the domestic sector is often brought up in political discussions. However, we discussed in chapter 7.3 that this is neither from an economic nor from an ecological point of view convincing. Measures such as import tariffs for biofuels in addition to other regulations have to be challenged. We argued in chapter 3 that the strict norms for biodiesel, which essentially require the predominant use of rapeseed oil, contributed to the situation that the German biodiesel sector is currently facing. These norms might be justified with respect to engine requirements. However, they apply to biodiesel used in its pure form as well as in blends. To justify this proceeding, it is often argued that it facilitates trade and the handling of biofuels. Since the B100 market seems to be disappearing in Germany, these norms should be scrutinised. Furthermore, countries such as France or Spain allow for a much wider range of vegetable oils used in biodiesel. In some cases biodiesel is produced without any rapeseed oil. The focus on one feedstock brings unintended side effects such as artificial mark-ups for the raw product and an increasing dependence on the yield of one crop. It should therefore be avoided as much as possible.

Import tariffs are used to protect the domestic biofuel industry from non-EU import competition. It seems difficult to justify these economically. The infant industry argument could be used. This, however, should no longer be valid for the biodiesel market. In the more recently developed EU bioethanol market the competition from the US or Brazil might be problematic since the domestic sector lacks competitiveness. However, without fundamental changes in sugar markets or substantial developments in the field of second generation biofuels, the EU bioethanol industry will most likely not become competitive in the short- or medium-term. It is therefore uncertain as to how long such an import tariff has to be maintained until competitiveness is reached and how long in can be maintained in ongoing WTO negotiations. Furthermore, the question remains concerning what consequences a lifting of the tariff will have at the time it has to be abolished.

Finally, import tariffs do not contribute to the achievement of any objective besides domestic value adding (cp chapter 7.3).

Role of research and development

The legal framework for biofuel promotion has a strong influence on the amount of research undertaken in the different areas of renewable energy research since it can stimulate but also depress private and business investment incentives. The ambitious target of the EU in the area of biofuels creates a strong incentive for further research since an increasing use of biofuels seems guaranteed. However, it is uncertain how these targets will be achieved. The quick and sharp changes in biofuel promotion observed during the past years have increased the degree of uncertainty in the market. This might prevent market actors from investments in research. Furthermore, strong overcapacity for rapeseed-based biodiesel production hampers new technologies from entering the market. The concerns about impacts on the environment and on food prices triggered by first generation biofuels promote research in other fuel alternatives. However, it also makes aware the risks a large scale implementation of a new technology bears.

For the future development, apart from research on technical aspects of renewable energies[19], economic research plays an important role. Impact assessments on market interventions are as important as the evaluation of past developments. Promotion strategies in accordance with scientific results have to replace those based on political desires and stakeholder interests. Adjustment of biodiesel prices towards diesel price developments and responses of rapeseed oil prices in a market in which a large share of rapeseed oil is used for biofuels occurred, as expected. Increasing rapeseed production can only be stimulated by increasing its competitiveness on the farm level. Hence, rapeseed production is also determined by competing crops. The competitiveness of rapeseed-based biodiesel to diesel without promotion can only be reached by considerably higher crude oil prices, significantly lower agricultural commodity prices or strong increases in rapeseed yields. Due to the discussed interdependence of the first two effects and the low probability of the latter, the

[19]Sims et al. (2008) argue in the 2008 IEA report that: "Considerably more investment in research, development, demonstration and deployment is needed to ensure that future production of various biomass feedstock can be undertaken sustainably and that the preferred conversion technologies, including those more advanced but only at the R&D stage, are identified and proven to be viable."; see also for a comprehensive summary on the fields where research is needed.

achievement of competitiveness is not foreseeable, at least not in the medium-term. For the achievement of a healthy growth of the industry, more cost effective raw materials have to be used and the focus on domestic raw materials has to be abandoned.

Increasing role of GHG emissions

The explicit consideration of environmental objectives in biofuel promotion raises new economic questions. Some feedstock will be excluded, some conversion lines have to be modified or given up in the future, and some become very advantageous with respect to their environmental impacts. In the short-run, the range of suitable feedstock will be reduced while it is uncertain about when new sources become available on a commercial scale. The advantage of strict thresholds for GHG savings over e.g. the reward per percentage point savings or compensation per kg GHG saving is not evident. Biofuel lines which produce more GHG emissions than their fossil counterparts certainly have no justification. An equal remuneration of savings on a quantitative basis would promote the most cost effective savings and reduce conflict with the objective of a cost-benefit orientation for the promotion of biofuels. Furthermore, this would represent a political intervention which is directly tailored to market failure and able to correct it.

The extent to which the competitiveness of biofuels rises with a remuneration of GHG savings depends on the monetary value of the emission reduction, e.g. the market price of carbon emission certificates. The trading of these is based on the Kyoto Protocol from 1997 which was implemented in 2005. A zero-emission biodiesel could obtain a reward of around 4 ct/l[20] under current prices. This is considerably less than the currently granted tax reduction of 29 ct/l for B100. A remuneration of GHG savings achieved by biofuels will, hence, not enhance the competitiveness of biodiesel to a large extent, at least not at the current prices for carbon certificates. The complete phasing-out of the support for rapeseed-based biofuel production, which would most likely lead to the end of this biofuel line, has not been discussed yet. At least in the short-run, this seems politically unfeasible since support schemes were set up without exit strategies. Furthermore, high and binding biofuel targets, as set up by the EU (COM, 2009), and the currently narrow

[20] Emissions of diesel of 83.8g CO2eq/ MJ are assumed according to COM (2009) and a carbon price of 13 €/t (http://www.pointcarbon.com).

feedstock range for biofuel production, would not allow this. However, this option has to be considered when discussing the future of the biofuel promotion and the promotion of renewable energies in general.

7.5 Open questions for further research

The further increase in biofuel usage within the EU seems predetermined since the EU as well as most of the Member States has defined ambitious targets (cp. COM, 2009). However, which feedstock mix will be used for biofuel production remains uncertain. Most experts estimate the share of second generation biofuels, that is, those that do not compete directly with food demand on agricultural commodity markets, even for 2020 at below 30 %. Furthermore, most of the raw materials used for these second generation biofuels will compete with other crops for agricultural resources, in particular soil. Hence, any further growth of biofuel use in the next years has to be mainly based on the same sources as in the past. Their effects on agricultural markets are therefore expected to be similar to those observed in the past. We have already discussed the limited resources within the EU and the need for further food imports with increasing bioenergy usage. Whether the dependence on food imports is preferred over the dependence on fuel imports remains a political decision for which long-run implications should be assessed carefully.

Need for holistic approaches

The public discussion during the food crisis 2007/08 about biofuel usage showed how sensitive public support for biofuels is to market effects such as rising food prices. On the other side, developments in the German market lay bare the problems a politically induced growth of a non-competitive sector can bring. In light of these developments and the potentially increasing competition of the food and fuel industry for agricultural resources, biofuel policies have to be challenged. Each of the objectives discussed in chapter 7.3 can to some degree be achieved with biofuels. However, there exist alternative approaches within and outside the transport sector to achieve these objectives. The contribution of the different measures to the realization of the different objectives should not only be compared between biofuel lines. The achievements through biofuels have to be rather critically compared to those in other sectors which aim at the same targets. Important criteria are the costs associated with these measures, the potential of their contribution to the realization of the objectives as well as their effects on (agricultural) markets.

The segmentation of bioenergy promotion with separate targets and promotion schemes for several bioenergy segments was criticized by the German Advisory Council on the Environment (SRU) already in 2007. An optimisation of biomass use with respect to economic and environmental issues was thereby strived for (SRU, 2007). However, the costs and the effects of different renewable energies vary not only within the biomass sector but also when compared to non-agricultural sectors. Electric engines could merely be one alternative to biofuels when the dependence on crude oil imports should be reduced. The search for renewable energy sources is not restricted to biomass use; wind and solar power in particular currently show high potential. Furthermore, GHG savings cannot only be achieved by renewable energies but also by a reduction in energy consumption and more efficient energy usage. We therefore argue that research in and the promotion of renewable energies should focus more on holistic approaches instead of sectoral interventions.

Learning from past developments

The further increase in biofuel production raises specific questions on the consequences for agricultural market. An achievement of the EU 10 % biofuel target in 2020, primarily based on agricultural commodities, will not only affect the involved markets but will also lead to reactions in other markets. The impacts will not only depend on the feedstock base but also on the integration with world markets. What changes this could cause should be carefully analysed. Not only market actors but governments in other countries will play an important role, especially when a situation like the 2007/08 price increase reoccurs. Many approaches to analyse these effects have been based on partial or general equilibrium models. However, these disregard the price dynamics and the effects of price volatilities in the markets. As price data are increasingly available for several biofuel markets, more detailed analysis can be carried out using e.g. time series methods. These allow for insights into price formation processes and serve as a basis for conclusions about price responses.

Accordance between objectives and measures

It is clear that subsidies for biofuels, at least above the compensation for GHG savings, cannot be carried on in the long-run. Therefore, the costs of biofuels need to converge towards the price for fossil fuels. Whether this is possible with first generation biofuels and what cost potentials second generation biofuels[21] have depends on various factors. Of importance is how strongly the production efficiency can be improved as well as how quickly alternatives can become available. Both factors depend primarily on the progress in research in this area. In the past, a substantial amount of financial resources has been allocated to subsidize the construction of production capacities and to stimulate demand instead of promoting technology research. It should be of certain interest to analyse how efficient this policy was with respect to the generation of domestic value added in rural areas. Furthermore, how much of the money was lost in inefficient production schemes and misguided investment incentives should also be investigated. Applied research in this area should help make policy makers aware of the need to define clear objectives and rethink current promotion schemes.

With respect to the environmental impacts of biofuels, two attempts have to be distinguished from each other, namely the avoidance of negative effects and the saving of GHG. The minimum GHG savings of biofuels will be ensured by the Renewable Energy Directive (COM, 2009), however, the global effect of biofuels on GHG emissions remains unclear. Changes in GHG emissions through agricultural production, which is not used for biofuels, due to the usage of biofuels, need to be taken into account. Indirect land use changes are heavily discussed and the European Commission is currently seeking approaches on how to measure these. When we criticized the risk of market segmentation due to strong environmental regulations for the EU bioenergy sector, we defined the problem at a higher level. The central issue is not how to measure negative environmental effects and how to allocate these to biofuels, but it is rather how to avoid them globally. Including any agricultural (and forestry) activity into the international climate talks, is currently under discussion. The advantages, problems, consequences and risks of this for the environment as well as agricultural production and the bioenergy sector still need to be evaluated.

[21] Sims et al. (2008) estimate that crude oil prices between 100 and 130 US$/barrel are necessary in order for second generation biofuels to become competitive. However, they see potential for improvement so that the costs could be lowered to 70 to 80 US$/barrel until 2030 (in 2008 dollars).

The most important open question concerns the objectives of the policy for the promotion of renewable energies. In the past, measures were implemented and modified in an attempt to promote domestic production, satisfy stakeholder interests and reduce tax losses. Furthermore, targets were announced for single bioenergy market segments which indicated predetermined growth paths but were not oriented to policy objectives. The definition of a clear objective and an appropriate promotion strategy is not easy and might need modification after some time. It is therefore important that any strategy implemented allows for modification. To ensure this, different policy options have to be developed and their potential impacts have to be assessed. Policy makers would, thus, be enabled to choose strategies based on scientific evidence.

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