Institut für Lebensmittel- und Ressourcenökonomik

Imperfect competition in an oligopsonistic setting

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A study on the German raw milk market

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Abstract

Agricultural markets are best characterized as oligopsonistic markets; usually many farmers face only few manufacturers. The raw milk market in Germany exhibits a high concentration of dairy processors opposed to a large number of dairy farmers. In such a market structure, concerns regarding buyer market power are often raised. Therefore, the German federal cartel authority conducted a sector survey on the raw milk market investigating buyer market power of dairy processors. The inquiry concluded that the competition on the raw milk market is imperfect due to high concentration of dairy processors, high market transparency regarding neighboring dairies' prices, limited switching possibilities of farmers to other processors due to long-term contracts and the obligation to supply the entire production quantity. This supply obligation in combination with long-term contracts may lead to market foreclosure as there is no freely available milk on the market (FCO 2012).

The objective of this thesis is to analyze imperfect competition on the raw milk market in Germany focusing on (i) market foreclosing effects of contracts (ii) estimating buyer market power of the dairy industry in the federal states and (iii) analyzing the effects of the spatial nature of the market on dairies' price setting.

The methodologies applied to elaborate on the objective of this thesis comprise game theoretic modelling to analyze the effects of contracts, empirical estimation of market power in the framework of the conjectural variation approach, and a spatial economics approach to investigate dairies' pricing behavior depending on space. For the empirical analyses a data set on processors' and farmers' characteristics for the time span 2001-2012 is used.

The results of the theoretical analysis show that long-term contracts in combination with the supply obligation can foreclose markets under certain assumptions on farmer's risk attitude and probability of rival's entry. The estimation of the market power parameter in the framework of the conjectural variation approach results in evidence for an oligopsonistic market structure in six federal states and also on the national level. The spatial investigation shows that space is especially important for cooperatives and results in different effects in the North and the South of Germany. The findings give insights into the competitiveness and behavior of the German raw milk market which are important regarding the ongoing concentration of the dairy processors and the increasing volatility of raw milk prices.

Keywords: imperfect competition, oligopsonistic markets, buyer market power, exclusive contracts, conjectural variation, spatial regression

Zusammenfassung

Agrarmärkte weisen generell eine oligopsonistische Struktur auf; wenigen Unternehmen der Verarbeitungsindustrie stehen eine Vielzahl von produzierenden Betrieben gegenüber. Bei einer solchen Marktstruktur liegt die Vermutung eines unvollkommenen Wettbewerbs nahe. Die Situation auf dem deutschen Beschaffungsmarkt für Rohmilch wurde vom Bundeskartellamt in einer Sektoruntersuchung betrachtet. Es wird festgestellt, dass der Wettbewerb auf dem Beschaffungsmarkt regional auf Grund von Konzentration der Molkereien, hoher Markttransparenz über die Preise benachbarter Molkereien, begrenzter Wechselmöglichkeiten der Erzeuger zu anderen Molkereien eingeschränkt ist. Es wird vermutet, dass die vollständige Andienungspflicht in Kombination mit langfristigen Verträgen eine marktverschließende Wirkung haben kann, da es keine freie Rohmilch auf dem Markt gibt, um die Wettbewerb bestehen könnte. (FCO 2012)

Das Ziel dieser Dissertation ist es, den Wettbewerb auf dem Rohmilchmarkt in Deutschland zu analysieren. Dazu wird (i) die marktverschließende Wirkung von Verträgen zwischen Molkereien und Milchproduzenten theoretisch untersucht, (ii) Marktmacht der Molkereiindustrie in den Bundesländern empirisch geschätzt und (iii) in einer räumlichen Regression der Einfluss des begrenzten Marktradius auf den Preis untersucht.

Anhand eines spieltheoretischen Modells wird die marktverschließende Wirkung von Verträgen untersucht, während die Marktmacht der Molkereiindustrie mit dem „conjectural variation approach“ empirisch für die Bundesländer geschätzt wird. Ebenfalls empirisch wird der Einfluss des Raumes auf die Preisbildung der Molkereien mit Hilfe einer räumlichen Regression geschätzt. Für die empirischen Analysen wird ein Datensatz mit molkerei- und landwirtschaftsspezifischen Daten für die Jahre 2001-2012 herangezogen.

Die Ergebnisse zeigen, dass langfristige Verträge in Kombination mit der vollständigen Andienungspflicht unter bestimmten Annahmen über die Risikoeinstellung des Milchproduzenten und die Eintrittswahrscheinlichkeiten eines Rivalen wettbewerbshindernd sein können und den Eintritt von neuen Molkereien in den Markt verhindern. Die Marktmachtschätzung der Molkereiindustrie zeigt, dass die Marktstruktur in sechs Bundesländern sowie auf nationaler Ebene oligopsonistisch ist. Die räumliche Untersuchung zeigt, dass der Raum vor allem für Genossenschaften eine Rolle spielt und die Effekte im Norden und Süden Deutschlands unterschiedlich sind. Die Ergebnisse geben Einblicke in die Wettbewerbssituation und das Marktverhalten des deutschen Rohmilchmarktes, welche insbesondere im Hinblick auf die weitere Konsolidierung der Milchwirtschaft und der Volatilität der Milchpreise relevant sind.

Schlagwörter: unvollkommener Wettbewerb, oligopsonistische Märkte, Käufer Marktmacht, exklusive Verträge, conjectural variation, räumliche Regressionsmodelle

Contents

List of Tables

List of Figures

Abbreviations

AMI	Agrarmarkt Informations-Gesellschaft mbH
ARC	Act against Restraints of Competition
BB	Berlin and Brandenburg
FCO	Federal Cartel Office
BSE	Bovine Spongiforme Enzephalopathie
BW	Baden-Wuerttemberg
BY	Bavaria
CAP	Common Agricultural Policy
COOP	Cooperative
Ct.	Cent
DG AGRI	EC Directorate General on Agriculture
EC	European Commission
EMB	European Milk Board
EPRS	European Parliament Research Service
EU	European Union
FADN	Farm Accountancy Data Network
FOB	Free on Board
HE	Hesse
IOF	Investor-Owned firm
Kg	Kilogram
LS	Lower Saxony
MC	Marginal Costs
MIV	Milchindustrieverband
MRP	Marginal Revenue Product
MV	Mecklenburg-Western Pomerania

NW	North Rhine-Westphalia
PDO	Protected Designation of Origin
PGI	Protected Geographical Indication
RP	Rhineland Palatinate
SH	Schleswig-Holstein
SL	Saarland
SLX	Spatially Lagged Explanatory Variable
SN	Saxony
ST	Saxony-Anhalt
TH	Thuringia
UD	Uniform Delivered

Chapter 1

Introduction and overview of the thesis*

The European Union (EU) is the world's leading exporter of dairy products and the milk market as a whole provides one of the most important agricultural goods in terms of value, representing about 15% of the total agricultural output in 2014 (EPRS 2015). Within the EU, Germany is the largest milk producer accounting for 20% of EU milk production (EUROSTAT 2015). The competitiveness of the European dairy sector is driven by the abolition of the quota regime, higher productivity and increasing concentration and is consequently undergoing substantial changes. Furthermore, recent developments like less demand for milk products from China, the Russian embargo and the weak purchasing power of oil exporting countries lead to increasing uncertainty and price volatility.

Imperfect competition is generally a topic of high interest on the milk market. The increasing concentration of dairy processing facilities (AMI 2014) and farmers' access limited to only those dairy processors within a certain radius around the farm, raise concerns regarding buyer market power of dairy processors (FCO 2009; FCO 2012).

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After the raw milk price crisis in 2009, and in order to prepare the market for the time following the milk quota regime towards a market-oriented future, the European Commission (EC) has launched the so called “milk package” in 2012. Apart from other measures targeting the dairy supply chain, compulsory written contracts between dairy processors and raw milk farmers are supposed to strengthen the farmers’ position on the market (EC 2014). However, long-term contracts can also limit farmers’ flexibility and lead to imperfect competition. Addressing concerns about imperfect competition in the German dairy sector, the German federal cartel authority (FCO) initiated a sector inquiry on the milk market in 2008. Regarding imperfect competition on the raw milk market, it is claimed that long-term contracts in combination with the obligation to supply the whole production quantity to a dairy processor leads to a lack of freely available raw milk on the market which could lead to a market foreclosure (FCO 2012).

1.1 Research objective and structure of the thesis

The overall objective of this thesis is to investigate imperfect competition on the raw milk market in Germany. Therefore, the potential market foreclosing effects of exclusive contracts are analyzed in a game theoretic framework. Further, market power is estimated in two empirical studies. In the first study, market power of the dairy industry is estimated on the national and federal state level. The second empirical study investigates the effects of space on dairies’ pricing, also giving evidence on potential market power. The underlying research questions and their contribution to the literature are presented in the following. The methodologies to answer these research questions are described in detail in chapter 1.3.2.

1.1.1 Research questions

To address the objective of this thesis three research questions are specified, each contributing to a different strand of the literature.

(I) *Can long-term contracts between dairy processors and farmers result in entry barriers for rival dairy processors?*

The “milk package” provided by the EC suggests to use compulsory written contracts to strengthen farmers’ bargaining position (for further details on EU dairy policy see chapter 1.2.1) (EC 2014). Since contracts in the past had not been clearly specified, contracts should now include specific criteria that support farmers and help to achieve fair prices (e.g. details on price, volume and duration of contract). However, the German cartel authority raises concerns on the market foreclosing effects of such long-term contracts in combination with the farmers’ obligation to deliver the whole production amount (FCO 2012).

The antitrust literature analyzes anti-competitive effects of exclusive contracts, mostly in a game theoretic model setting (Aghion and Bolton 1987; Bork 1978; Rasmusen et al. 1991; Segal and Whinston 2000). Applying this theory to the milk market provides a way to analyze the effects of imperfect competition that may result from entry deterring effects of exclusive contracts between dairy farmers and processors on the structure of the raw milk market. While most of the literature focusing on entry deterring effects of exclusive contracts analyzes seller market power (e.g. Aghion and Bolton 1987; Bork 1978; Rasmusen et al. 1991; Segal and Whinston 2000), literature discussing exclusive contracts in an oligopsonistic setting is sparse (MacDonald et al. 2004; Vavra 2009). In addition, risk behavior of farmers has not been analyzed in the framework of entry deterring effects of exclusive contracts (Innes and Sexton 1994 only discuss its implication). Therefore, chapter 2 of this thesis contributes to the literature by presenting a game theoretic model, which contrasts the models of the antitrust literature and is able to explain the signing of an exclusive contract with uncertainty of rival's entry and risk aversion of the signer.

(II) Does the German dairy industry exercise buyer market power?

The estimation of dairy industry's buyer market power on a national and federal state level addresses the concerns regarding buyer market power of the dairy industry and the positive correlation of market power and industry concentration (a.o. FCO 2009; FCO 2012; Tribl and Salhofer 2013).

To estimate buyer market power, the conjectural variation approach has been frequently used (e.g. Muth and Wohlgenant 1999; Gohin and

Guyomard 2000, Anders 2008, Sckokai 2009, Mérel 2009 and 2011, Soregaroli et al. 2011, Sckokai et al. 2013). This approach estimates the degree of imperfect competition as the deviation from perfect competition (Bresnahan 1989; Appelbaum 1982). Studies specifically analyzing buyer market power of the dairy industry have been conducted by Perekhozhuk et al. (2011) for Hungary, Perekhozhuk et al. (2014) for Ukraine and Scalco and Braga (2014) for Brazil. Chapter 3 contributes to the literature by providing the first national and federal state level analysis of buyer market power for the German dairy industry.

(III) How does the spatial restriction of a dairy's input market area influence pricing behavior?

Due to raw milk being highly perishable and high transportation costs, a dairy can only source from a geographically limited area. Farmers, on the other hand, can only deliver to selected dairies. Therefore, a dairy might have the opportunity to exercise buyer market power when there are only few competitors in their spatial environment. It is of interest how space, representing distance to competing dairies and transportation cost, influences raw milk price setting. Further, it is worth analyzing the effects of competing dairies' characteristics, such as their legal form, on raw milk pricing.

The literature provides studies that theoretically and empirically analyze the effects of space on price setting (see Sexton 1990; Rogers and Sexton 1994; Alvarez et al. 2000; Zhang and Sexton 2001; Fousekis 2011a and b; Tribl 2012 for a theoretical analysis and Alvarez et al. 2000; Huck et al. 2006, Graubner et al. 2011 and Koller 2012 for an empirical investigation). Chapter 4 summarizes possible effects of space on price setting offered in the literature. Adding to the relevant empirical literature, a spatial economics approach is conducted that distinguishes between legal forms of dairies while incorporating neighboring dairies' characteristics and the different market structures in the North and the South of Germany. Furthermore, the competitive yardstick theory that suggests a positive effect of cooperatives' (COOPs) prices on investor-owned firms' (IOFs) pricing (Cotterill 1987; Sexton 1990; Fousekis 2011a; Hanisch et al. 2013) is investigated in this spatial framework.

1.1.2 Structure of the thesis

Following a brief description of the characteristics of the German dairy sector, the remainder of this introductory chapter gives an overview on the methodologies employed to answer the research questions and concludes with a summary of the main findings as well as an outlook on potential for future research. Chapters 2-4 constitute the main part of the thesis, addressing the research questions and the objective of this thesis in independent analyses.

Chapter 2 answers research question (I) by analyzing anti-competitive effects of contractual relations in the dairy sector in a theoretical analysis. This chapter contains the published article Zavelberg, Y., T. Heckelei and C. Wieck (2016). Entry deterring effects of contractual relations in the dairy processing sector, *Bio-based and Applied Economics* 5(1): 83-98. The article in chapter 3 estimates market power of the dairy industry on the national and federal stat level, addressing research question (II). An earlier version, published as Zavelberg, Y., C. Wieck and T. Heckelei (2015): “Conjectural variations on the German raw milk market – An empirical investigation of oligopsony power”, has been presented at the 2015 AAEA & WAEA Joint Annual Meeting in San Francisco. Finally, incorporating the spatial dimension of the market and the different market structure in North and South Germany, a spatial regression approach is used to analyze research question (III) in chapter 4. It is based on the paper by Zavelberg, Y. and H. Storm (2015): “Pricing behavior of cooperatives and investor-owned dairies in a spatial market setting”, which is currently under review at the German Journal of Agricultural Economics.

1.2 The German dairy sector: Policy and structure

In order to analyze imperfect competition on the German raw milk market a profound understanding of the dairy sector including market characteristics and policy regulations is essential. This section first presents the relevant policy regulations and then describes the data set that is used for the analysis of the structure of the milk market with respect to the dairy industry and dairy farmers as well as the development of raw milk prices. This data set is also used for the empirical studies of this thesis (chapters 3 and 4).

1.2.1 Policies relevant for the EU dairy sector

Milk quota

With the “Health Check” reform in 2008, the EU took the decision to abolish the milk quota regime, which has been in place since 1984 (EC 2009). This restriction on production quantities had been implemented to reduce the imbalance between supply and demand. A period of increasing price support led to a large surplus of raw milk towards the end of the 1970s and the beginning of the 1980s. The intervention system underlying the price support scheme made the EC buy and store large volumes of butter and skimmed milk powder leading to the so called “butter mountains”. Therefore, the milk quota system was introduced, that specified a maximum production quantity for each member state. In Germany, this national quota quantity was broken down to each dairy farmer. If the national quota was exceeded, a levy (“superlevy”) had to be paid. Addressing the increasing demand for dairy products in recent years which is assumed to continue in the future, the quota regime was abolished in 2015. The deregulation of the market shall liberalize trade and improve the competiveness of the sector such that the EU dairy sector is able to respond to the increased world market demand. In order to prepare the market for the abolishment of the quota a soft phasing out of the quota was applied that increased the quota by 1% every year until 2015. (EC 2009; EPRS 2015; EC 2015)

Milk package

Responding to the milk price crisis in 2009 and considering the future competitiveness and sustainability of the milk market, the EC has launched the "milk package" in October 2012 (EC 2012). The "milk package" aims at strengthening producers' market position by setting criteria for the formation of producer organizations and specifying possibilities for Member States to regulate protected designation of origin (PDO)/protected geographical indication (PGI) cheese supply. Further, the milk package contains suggestions for Member States to establish compulsory written contracts between milk farmers and IOFs to ensure an equal distribution of risks between farmers and processors. Contractual agreements should not only become compulsory but also contain a minimum standard of specified criteria (e.g. details on price, volume and duration of contract). Due to their specific ownership structure, COOPs are exempted from this policy. The milk package will be applied until October 2020. (EC 2014)

CAP reform 2014-2020

Over the last few years, volatile global dairy prices have influenced the domestic price developments. After a price peak in January 2014, prices dropped strongly due to low world market demand and the Russian embargo. The Russian embargo on European products since August 2014 revealed that the market needs to be prepared for sudden shocks and crises. Adding to the low world the low world market demand, the Russian embargo further limits export possibilities for dairy processors, which is detrimental for raw milk prices (EPRS 2015). With the latest reform of the Common Agricultural Policy (CAP) for the period 2014-2020, dairy farmers are provided with a safety net that offers support in case of external uncertainties. Further, the public intervention and private storage aid systems shall be improved to be more reactive and efficient (EC 2013a). In addition, a milk observatory was established in April 2014 to improve transparency of the market by collecting market data and providing analyses for the milk supply chain. Attempts to implement subsidies for those farmers who voluntarily reduce their production have been rejected by the EU Council in 2015 (EPRS 2015).

Act against restraints of competition

When analyzing imperfect competition, it is also important to understand how competition is protected in Germany. The act against restraints of competition (ARC) builds the legal framework. The ARC is enforced by the federal cartel office (FCO), an independent higher federal authority. The main task of the FCO is to keep competition on the markets and to prevent entities from gaining or strengthening power positions. Therefore, it monitors the compliance with the ban on cartels, controls mergers and abusive practices of dominant entities. Furthermore, the FCO has a public procurement tribunal to analyze award proceedings of public contracts by the Federation. (FCO 2015)

Regarding contractual relations between dairy farmers and processors, the final report of the sector inquiry on milk concludes that an abuse of a dominant position on the milk market could be found when dairy processors deter competition or entry of new firms on the market for raw milk due to long-term contract binding in addition to the delivery obligation of producers (section 106, FCO 2012). The abuse of a dominant position is prohibited according to § 19 GWB (Gesetz gegen Wettbewerbsbeschränkungen, act against restraints of competition). § 19 paragraph 2 no. 4 GWB regulates that an abuse of a dominant position exists if "a dominant undertaking as a supplier or purchaser of certain kinds of goods or commercial services refuses to allow another undertaking access to its own networks or other infrastructure facilities against adequate consideration, provided that without such joint use the other undertaking is unable for legal or factual reasons to operate as a competitor of the dominant undertaking on the upstream or downstream market; this shall not apply if the dominant undertaking demonstrates that for operational or other reasons such joint use is impossible or cannot reasonably be expected".

Due to price drops below 20 ct. per litre in spring 2016, the latest policy discussions are dealing with how to coordinate supply and demand of raw milk and how to support dairy farmers. Farmers shall be supported financially and intervention stocks for milk products increased. The German farmer's federation requires subsidies for those farmers who voluntarily reduce their production. Other suggestions are to improve communication between dairies and farmers about demanded raw milk quantities and sales opportunities of dairies. (ZEIT online 2016a, ZEIT online 2016b)

1.2.2 The structure of German dairy sector

Data set

For the analysis of the structure of the German dairy sector and the empirical estimations in chapter 3 and 4, a panel data set is used containing yearly information on the German milk market for the period 2001-2012.

Regarding the farmers' side, data on raw milk quantities and number of cows are available from EUROSTAT (EUROSTAT 2015), feed costs from the Farm Accountancy Data Network (FADN 2015) and the prices for young bulls from the Directorate-General for Agriculture and Rural Development (DG AGRI 2015).

Annual information on dairies' type of production (organic or conventional), processing quantity, legal form, postal address and raw milk prices is obtained from "Agrarmarktinformationsgesellschaft mbH" (AMI)[1] (AMI 2014). The raw milk prices are for milk of grade one with 4.2% fat and 3.4% protein including additional payments, such as boni for large delivered quantities or loyalty, net of costs like quality assessment or storage costs so that the milk prices of the dairy processors in the data set are comparable. Additionally, a performance index is constructed by using the awards for the best products from the German magazine "Milch Marketing" (Milch Marketing (years 2001-2012)). The index is calculated

[1] A German institution that collects data of agricultural entities.

as the sum of award points over the observed period and is used as a proxy for the quality of the output. Since dairy specific wholesale prices are unavailable, the national prices for skim and whole milk powder, whey powder, butter and cheese are used as an index for prices of processed dairy products (Milchtrends 2015). Data on wages in the dairy industry is gathered from the statistical offices of the federal states in Germany upon request. Missing data points are filled with the growth rate of wages in neighboring or structurally similar federal states or with the growth rate of wages in the food and fodder production industry in the respective states. Yearly national interest rates for corporates with a rate fixation up to 1 year are obtained from the European Central Bank (European Central Bank 2015) and data on transportation costs are sourced from the Association of the German Petroleum Industry (Mineralölverband e.V. (2015) (see table 1.1 for an overview of the data used).

Table 1.1: Data used

Data*	Description	level	source
raw milk price	€/kg average price for raw milk paid by dairies	dairy specific	AMI
processed quantities	kg of procured raw milk by dairies	dairy specific	AMI
legal form	dairy is organized as IOF or COOP	dairy specific	AMI
production form	organic or conventional production	dairy specific	AMI
location of facility	address of a dairy	dairy specific	AMI
performance index	sum of award points for innovative dairy products over the observed period	dairy specific	Milch Marketing
wage	€/h hourly wage for workers in the dairy industry	federal state	destatis
produced raw milk quantities	kg sum of raw milk quantities produced by dairy farmers in federal states	federal state	EUROSTAT
number of dairy cows	sum of dairy cows in federal states	federal state	EUROSTAT
feed costs	€/cow average feed costs per cow	federal state	FADN
transportation costs	yearly average price per litre diesel fuel	federal state	Mineralöl-verband e.V.
output price	€/kg price index containing the national average selling price for butter, cheese, skim milk, whole milk and whey powder	Germany	Milchtrends
price for young bulls	€/100 kg carcass weight	Germany	DG AGRI
interest rate	yearly national interest rate for corporates, rate fixation up to 1 year	Germany	European Central Bank

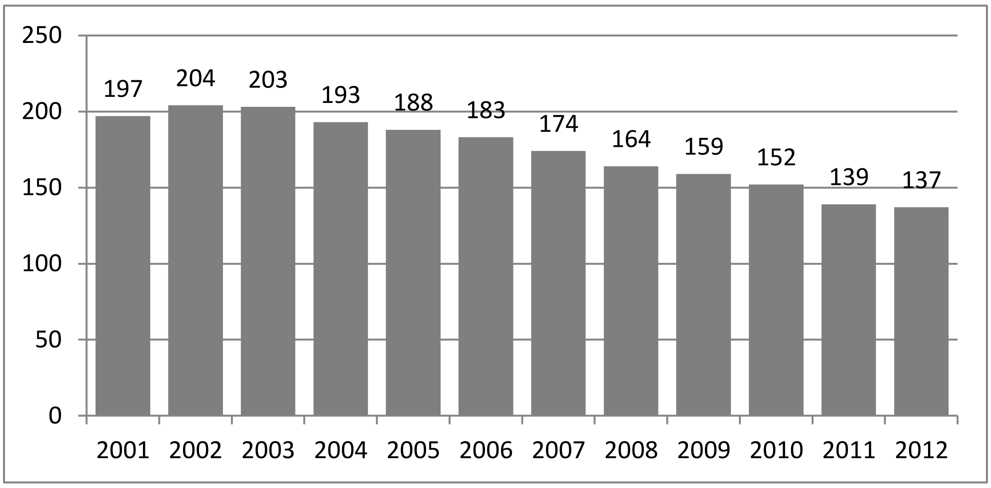
**all data is on annual level.*

Structure of the market

The dairy processing industry is the biggest food sector in Germany responsible for a turnover of 26 billion Euro, and is one of the most important employers in the food sector providing more than 33,000 jobs in 2014 (MIV 2015).

The German milk market has undergone a strong structural change in the last years. On dairy farmers' side, raw milk production has increased in the years following the decision to abolish the milk quota accompanied by a decrease in number of dairy farms (EUROSTAT 2015). On dairy processors' side, we observe a decrease in number of facilities (see figure 1.1) and an increase in average processing quantity (AMI 2014).

Figure 1.1: Number of dairy facilities

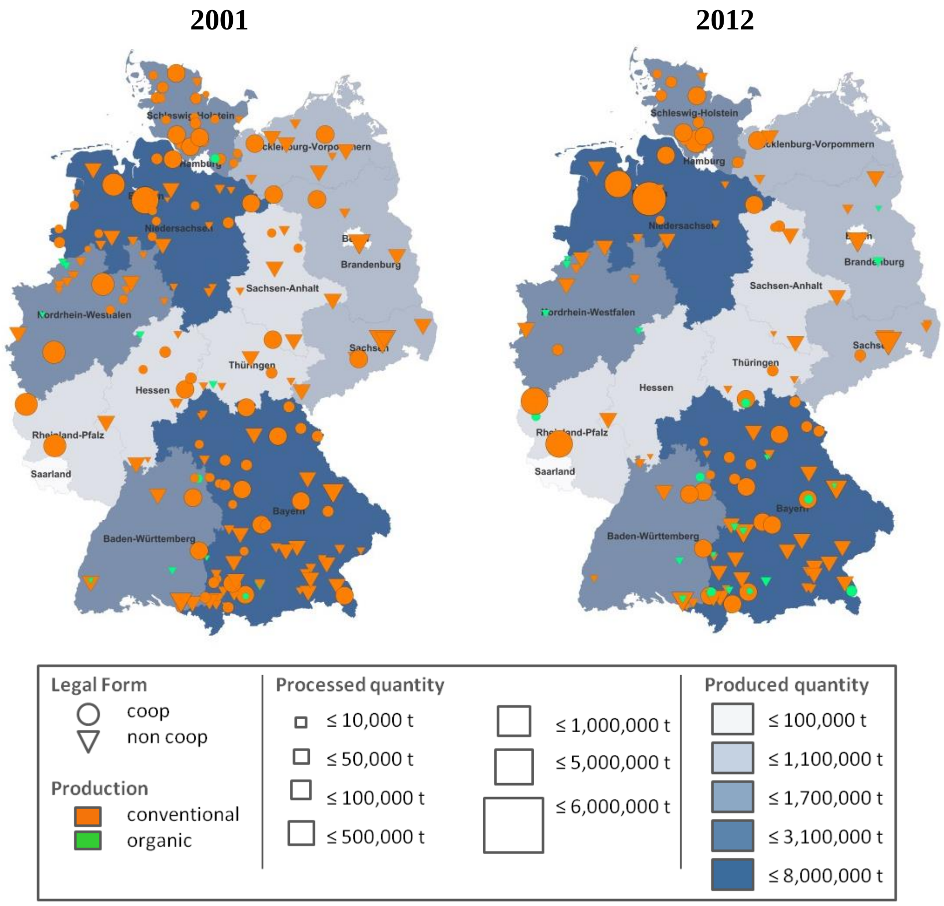


The number of dairy facilities decreased from 197 in 2001 to 137 in 2012 (see figure 1.1). These 137 dairies divide into 107 conventional and 30 organic dairies. The number of organic dairies more than doubled from 14 in 2001 to 30 in 2012 with an increase in production of 60%. Regarding conventional dairies, total production only increased by 3% over the time span, but the average processing quantity increased by 40% from approximately 140.000 tons to 240.000 tons.

In 2012, regarding the legal form of conventional dairies, 58% are organized as IOFs and 42% as COOPs. The average processing quantity (organic and conventional) in this year is higher in COOPs, due to the contribution of the "Deutsche Milchkontor" processing the overall largest quantity of approximately six million tons. In contrast, the maximum processed quantity of IOFs is one million tons by the "Molkerei Alois Müller GmbH & Co. KG". In total, 27 Million tons of milk are processed in 2012, with 2% being organic and 98% being conventional production.

To illustrate spatial dispersion of dairies and structural change, the map in Figure 1.2 represents the market structure in 2001 and 2012 and shows major milk processing and production areas in Germany.

Figure 1.2: Dairy processing facilities' structural change



The two maps show that milk processing has concentrated in the areas with high raw milk production. Bavaria and Lower Saxony account for 43% of total raw milk production quantity. It is expected that milk production will further shift from mountainous and disadvantaged areas to the North[2] following the abolition of the

[2] The South comprises the federal states Bavaria and Baden-Wuerttemberg, the North the remaining federal states.

quota system (Gira 2012). Our dataset shows that structural change is stronger in the North. The market in the North is characterized by a few large dairies in contrast to the South with a high density of small dairies. From 2001 to 2012 the number of conventional dairy plants changed from 111 to 58, a decrease of 48% in the North. The structural change in the South was not as strong with the number of plants decreasing from 70 to 52, i.e. by 26%, in the same period. This change occurred at rather stable processing quantities overall. Consequently, the processing quantity per dairy increased by 104% in the North and 30% in the South leading to processors having an 89% larger average size in the North. Generally, the increase in average processing quantity is higher for COOPs (AMI 2014).

Raw milk prices

Raw milk prices fluctuated strongly in the last years. In 2001, the producer raw milk price peaked at 39.29 cents, likely influenced by low supply, high domestic demand and high world market prices. The prices subsequently fell until 2007, due to the bovine spongiforme enzephalopathie (BSE) crisis and low demand. As demand for milk products increased faster than supply, all inventories were consumed by 2007. Due to bad weather conditions, supply from Australia and South America was low, increasing world prices resulting in the price peak in 2007. After 2007, the prices fell sharply and led to the milk price crisis in 2009 fostered by the financial crisis. Since 2010, international demand increased and as the supply could not cover the increased demand, prices increased again. However, this also increased production worldwide and thereby increased exports which led prices to drop again in 2012. (AMI 2011, Fahlbusch et al. 2009, 2011)

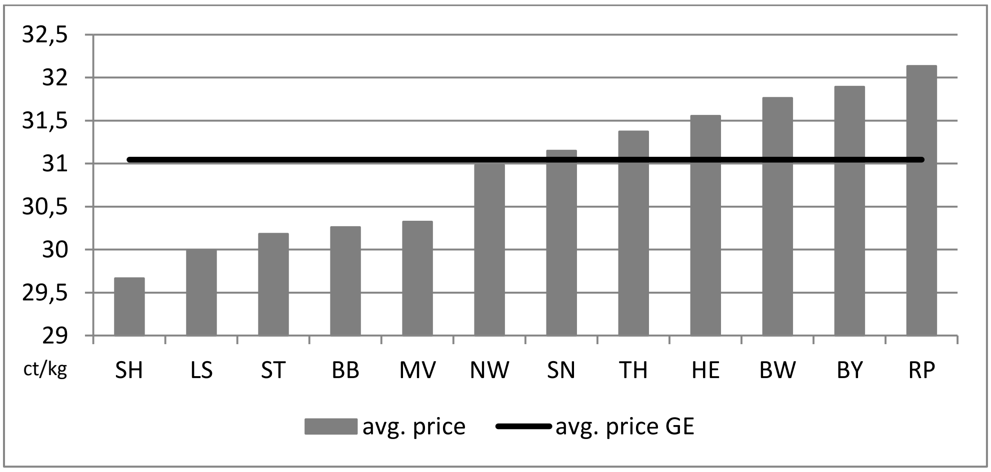
Figure 1.3: Conventional raw milk price developments

Figure 1.3 shows that raw milk prices are generally higher in the South comprising the federal states Bavaria (BY) and Baden-Wuerttemberg (BW). This may result from lower production costs in the North compared to the South (EMB 2013). Further, the performance index of the small structured dairy industry in the South is higher than the performance index of the rather large cooperative dairies in the North.

Comparing the conventional raw milk prices of the federal states to the average raw milk price of 31.05 ct/kg over the data period, Rhineland Palatinate

(RP) shows the highest milk price (+1.09 ct/kg) followed by Bavaria (+0.85 ct/kg). The federal states with the lowest prices are Schleswig Holstein (SH) (-1.38 ct/kg) and Lower Saxony (LS) (-1.05 ct/kg) (see figure 1.4).

Figure 1.4: Federal states' raw milk price differences



Several factors influence raw milk prices. They depend on the quality of milk and processor characteristics (high quality, innovative products vs. standard products like skimmed milk powder etc.) (FCO 2009). At the same time, it is assumed that the density of processors influences the raw milk prices as a high density of processors means more selling alternatives for farmers and thus more competition for raw milk. Addressing selling alternatives, Table 1.2 measures the concentration of dairies in the federal states as processing shares of the largest dairy (Conc.1) up to the three largest dairies (Conc.3) in the federal states.

Table 1.2: Concentration of dairies in terms of processing quantities in 2012

state	**C1**	**C2**	**C3**	**No. dairies**	**Proc. quantity** *in Mio. tons*	**avg. raw milk price** *in ct/kg*
HE	0.83	0.99	1	3	0.1439	0.3189
SN	0.72	0.82	0.89	6	1.5270	0.3169
BB	0.7	0.94	1	6	1.1164	0.3099
LS	0.69	0.85	0.89	12	5.7000	0.3188
RP	0.57	0.99	1	3	2.7928	0.3119
TH	0.49	0.8	1	3	0.1527	0.3183
MV	0.44	0.86	0.94	4	1.4131	0.3282
SH	0.41	0.52	0.63	12	1.5459	0.3152
BW	0.4	0.58	0.75	15	1.8533	0.3240
ST	0.32	0.6	0.81	6	0.5397	0.3153
NW	0.29	0.52	0.64	11	2.9113	0.3221
BY	0.08	0.15	0.2	59	6.7631	0.3282

With HE=Hesse, SN=Saxony, BB=Berlin and Brandenburg, LS=Lower Saxony, RP=Rhineland Palatinate, TH=Thuringia, MV= Mecklenburg-Western Pomerania, SH=Schleswig-Holstein, BW=Baden-Wuerttemberg, ST=Saxony-Anhalt, NW=North Rhine-Westphalia, BY= Bavaria

Table 1.2 shows that selling alternatives are the highest in Bavaria, the state with the highest dairy density and an above average raw milk price (AMI 2014).

Legal form of dairy processors

When analyzing the milk market, the different legal forms of the dairies have to be considered because of their implications on firm behavior. A general problem of the entrepreneurial form of a COOP is the free rider problem and the short investment horizon. The free rider problem is supported by the law of a COOP. All members receive the same price and a COOP may not differentiate between its members. Therefore, old members that have abstained from reimbursements in order to invest into the COOP get the same payment as new members that did not carry the risk of the investment from the beginning on. Hence, it is difficult to find members that are interested in long-term rather than short-term investments (Cook 1995; Schramm et al. 2005; EMB 2012). Further, the different interests and heterogeneous risk levels of its members influence the investment decisions of a COOP which may influence producer prices negatively (Gerlach et al. 2006, BKA 2009; Steffen et al. 2009). Regarding profit maximization of COOPs, the literature discusses different objective functions of COOPs and IOFs. Mainly total member welfare maximization is assumed for COOPs (Cotterill 1987; Sexton et al. 1990). But also net average revenue product (NARP) pricing is analyzed (Sexton 1990; Fousekis 2011a). Furthermore, it is discussed whether large COOPs just maximize firm profits in the same manner as IOFs do (maximizing net earnings) as single farmers cannot exert a significant influence on the decisions of large COOPs (EMB 2012).

1.3 Measuring market power

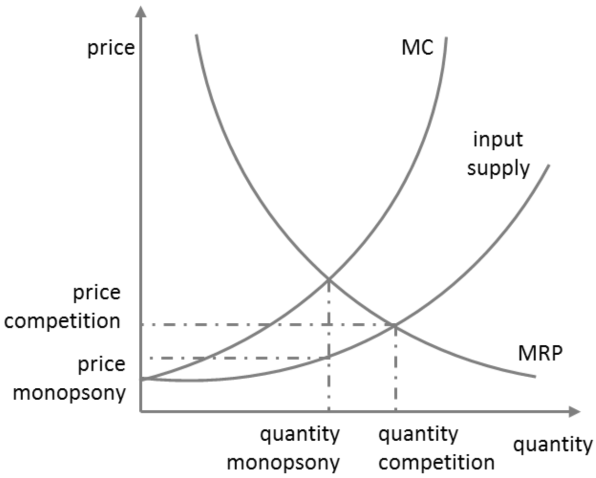
To answer the research questions of the thesis, appropriate methodologies have been identified that measure market power in theoretical and empirical settings. Before these are explained in more detail (section 1.3.2), the following sub-section first defines the term market power from an economic perspective.

1.3.1 A definition of market power

In economic theory, most often seller market power is analyzed where a firm's price exceeds marginal cost (Motta 2004, p.41). Buyer market power, on the other hand, refers to the ability to set the price for an input below the competitive level. Nearly all firms have a certain margin when setting prices resulting for example from product quality and differentiation, cost efficiency and high fixed costs in the industry that provide a barrier for rivals to enter the market (Kaplow and Shapiro 2007). Hence, prices that somewhat diverge from the competitive level are not necessarily evidence for market power. When investigating dominance of firms, the EC defines the relevant product and geographical market. The market share of the considered firm serves as the first indicator for dominance. A market share below 40% is assumed unlikely to be dominant. When competition authorities like the EC measure market power, they investigate whether a firm has abused its dominant position by increasing/decreasing prices over/below the competitive level for a significant period of time, distorting competition (EC 2013b).

An oligopsony is characterized by a few large buyers facing a high number of smaller suppliers. In general, the price spread between input price and marginal product is essential for the measurement of buyer market power. If marginal revenue product equals the input supply function, the market is perfectly competitive (see figure 1.5). The most extreme form of an oligopsony is a monopsony, where only one purchaser of the good exists (Wildmann 2007). The monopsonist maximizes its profit so that marginal revenue product (MRP) is equal to its marginal cost (MC). The input price is then determined on the input supply curve. The competitive price is higher than the monopsony price and results from supply equal to MRP (see figure 1.5). All combinations of prices and quantities lying between the competitive market and the monopsony solution with a price spread between input price and marginal product, are interpreted as oligopsonistic markets.

Figure 1.5: Monopsony market



Source: Own representation following Manning (2013).

The analysis of buyer market power is central to assess imperfect competition on agricultural markets (Sexton, 2013; MacDonald et al., 2004). Agricultural food markets are often characterized by a low concentration of farmers and a high concentration of processors and retailers (Sexton, 2013; McCorriston, 2002, Rogers, 2001; Rogers and Sexton, 1994). Further, the input markets for agricultural raw products are usually local or regional resulting from high transportation costs or high perishability of the products, especially for raw milk. Therefore, also the spatial aspects of the raw milk market and its effects on raw milk pricing are highly important when analyzing imperfect competition.

1.3.2 Methodologies applied

This chapter gives a short overview and literature categorization of the methodologies used to answer the research questions. They can be divided into a theoretical approach and two empirical approaches. Each methodology applied is described in more detail in the respective chapters.

(I) Game theoretic modelling

Building on the literature dealing with exclusive contracts (Aghion and Bolton 1987; Bork 1978; Rasmusen et al. 1991; Segal and Whinston 2000, Fumagalli and Motta 2006), a game theoretic model that incorporates the specific features of the raw milk market is used to answer research question (I). It is assumed that an incumbent dairy processor and a representative dairy farmer are active on the market. A rival dairy processor with lower marginal production costs wants to enter the market. Perfect competition is assumed for the downstream market for dairy products so that dairies compete only on the input market. Whether a contract is signed depends on the compensation the incumbent dairy is able to offer and the compensation the farmer demands. The demanded compensation is depending on the profit the farmer obtains if the rival enters the market and the profit he gets if the incumbent deters rival's entry. When the contract between the incumbent and the farmer is signed, it requires the farmer to deliver his whole production of milk. This type of an exclusive contract hinders the rival from entering the market, as there is no freely available milk. The approach calculates the compensation a dairy can offer and the compensation a farmer demands for two different model settings: In a basic model, the farmer is risk neutral and rival's entry is certain. Then the model is expanded by incorporating farmer's risk attitude and uncertainty of rival's entry. The effects of exclusive contracts investigated analytically and numerically in both model settings to investigate when entry deterrence with exclusive contracts is possible.

(II) *Conjectural variation approach*

With the conjectural variation approach, market power is measured as the deviation from the competitive level, incorporating strategic interactions between firms (Bresnahan 1989; Appelbaum 1982; Lau 1982). Market power is usually estimated in a homogeneous good industry, where a conjectural variation parameter gives information on the degree of market power in the industry. This parameter measures the wedge between price and marginal product and is derived from the firm's profit maximization problem.

For the analysis of buyer market power, the conjectural variation approach incorporates that the demand of a manufacturer influences the supply of the input good. This is modeled in the profit maximization procedure, resulting in a first order condition that also depends on the supply elasticity of the input good (ε) and the conjectural variation parameter (θ).

$$w = P \cdot \frac{\partial f_q(x,I)}{\partial x} \Big/ \left(1 + \frac{\theta}{\varepsilon}\right), \tag{1.1}$$

where *w* is the price for the input *x* while $f_q(x,I)$ represents the production function to produce output *q* with input *x* and other inputs *I*. The elasticity of supply is given by $\varepsilon = (\partial x/\partial w)(w/x)$ while $\partial f_q(x,I)/\partial x$ reflects the marginal product. $\theta = (\partial x/\partial x_i)(x_i/x)$ represents the conjectural variation parameter which measures the conjectural elasticity of firm *i* on the input market. It comprises how the available input quantity x changes when firm *i* changes its quantity $(\partial x/\partial x_i)$ and the firm's market share (x_i/x). The wedge between price and marginal product is measured with the conjectural variation parameter and gives information on the degree of market power on the input market for raw milk (Bresnahan 1982; Hyde and Perloff 1998). If $\theta = 0$, input price equals marginal product, pointing at a perfectly competitive market. $\theta = 1$ indicates a monopsony (or cartel behavior) on the factor market. $0 < \theta < 1$ suggests the existence of an oligopsonistic market structure.

Due to scarce data availability, the specification of the conjectural variation approach developed by Muth and Wohlgenant (1999) is applied in the article presented in chapter 3. This specification needs fewer data requirements and uses a modification of a reduced-form value marginal product specification to represent the derivative of a generalized Leontief production function as follows:

$$w_M = P \cdot \left(\beta_0 + \beta_M x_M^{1/2} + \beta_L w_L^{1/2} + \beta_K w_K^{1/2} + \beta_P P^{1/2} \right) \Big/ \left(1 + \frac{\theta}{\varepsilon} \right), \tag{1.2}$$

where the raw milk price of a dairy, w_M, is estimated. Variables w_L and w_K are input prices for labor and capital, P is an index for dairy output prices and ε represents the elasticity of raw milk supply. In order to account for dairy fixed effects, we reformulate equation (1.2) to construct nonlinear fixed effects panel estimation (see chapter 3.5).

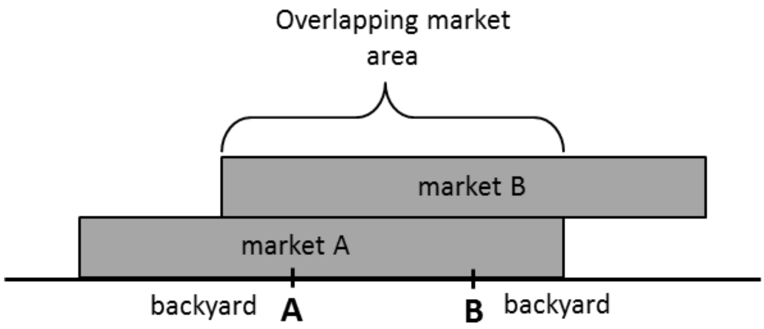
Ideally equation (1.2) and the raw milk supply function are estimated simultaneously in a three-stage least squares estimation. As this was however not feasible with the available data, a reduced form approach is used for the market power estimation to address endogeneity problems of raw milk prices and quantities.

(III) Spatial regression

The theoretical literature on spatial pricing behavior finds the price-space relationship to be an inverted U-shape, a monotone negative or a monotone positive relationship. Which relation is found depends on the type of market actors (mixed or pure IOF or COOP markets), pricing (uniform delivered pricing (UD) where the dairy pays the shipping or free on board shipping (FOB) where the farmer pays the shipping), competition (Hotelling-Smithies (H-S) or Löschian Competition) and COOPs objective function and membership policy (net average revenue product pricing (NARP) or total member welfare maximization (TMW), open membership (OM) or restricted membership (RM)).

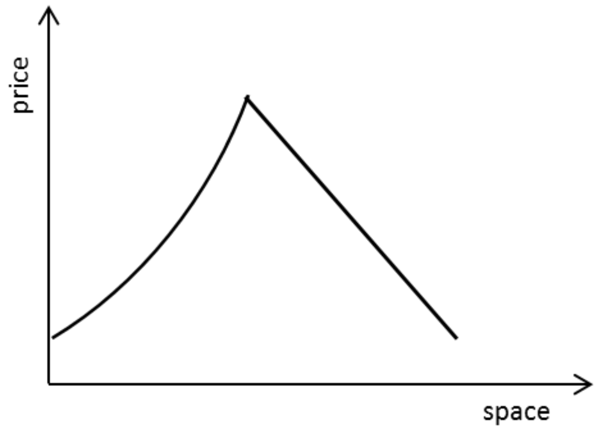
Only few empirical studies analyze pricing behavior on milk markets in a spatial setting. Alvarez et al. (2000) focuses on the analysis of milk pricing of IOFs in the Asturias region in Spain while Huck et al. (2006) analyze COOP pricing in the German federal state Schleswig Holstein. Koller (2012) conducts an analysis for Germany without differentiating between dairies' legal form. All three studies verify an inverted U-shaped relation of price and space that is theoretically derived by Alvarez et al.'s (2000). In an IOF market under the assumption of an unbounded line market, Alvarez et al. (2000) find that when space is relatively unimportant (i.e. firms are located close to each other or transportation cost are low) competition in the backyard can occur where the market areas of a rival firm (B) extend beyond the firms' location (A) (see figure 1.6).

Figure 1.6: Illustration of competition in the backyard



The assumptions of UD pricing and Löschian competition lead to the so-called price matching behavior of dairies. Given UD pricing, shipping costs are paid by dairies and dairies increase their market area until profits are zero. Consequently, a price increase reduces the market area and the dairy loses farmers at the boundary. The assumption of price-matching behavior leads the rival's price to increase as well resulting in a reduced market area of the rival losing farmers in the backyard of the considered firm which can then capture the abandoned farmers of its rival. Those are more profitable compared to the ones it loses at its market boundary, leading to higher profits under UD pricing. Therefore, given unimportance of space and thus competition in the backyard, prices are increasing in space. If space gets more important (due to higher transportation costs or a higher distance to neighboring dairies), prices decrease in space leading to the inverted U-shaped function (see figure 1.7).

Figure 1.7: Inverted U-shaped relation of price and space



Source: Own illustration derived from Alvarez et al. (2000).

In the decreasing part of the function in figure 1.7 competition takes place only between the firms' locations. The inverse relationship between transportation costs and market area between firms leads to this negative relation between price and space and may result in separated monopsonistic markets (Alvarez et al. 2000). Such a negative relation is also found in other theoretical studies (see Sexton 1990; Zhang and Sexton 2001; Tribl 2012; Fousekis 2011a and 2011b).

In contrast to former empirical studies on spatial pricing, chapter 4 provides a spatial regression analysis that differentiates between the effects of space on the pricing of IOF and COOP dairies while incorporating characteristics (such as legal and production form) of neighboring competitors. Results allow to relate the shape of the relationship between price and space to the theoretically derived relations provided in the literature (Sexton 1990; Rogers and Sexton 1994; Alvarez et al. 2000; Zhang and Sexton 2001; Fousekis 2011a and b; Tribl 2012). Therefore, a spatially lagged explanatory variable model (SLX) of the general form $y = X\beta + WX\theta + \varepsilon$ is estimated with y being a vector of the dependent variable, X a matrix of explanatory variables, W a row standardized spatial weighting matrix, β and θ coefficients to be estimated and $\varepsilon \sim N\left(0, \sigma^2 I\right)$ with I being an identity matrix. In addition, the competitive yardstick effect is verified with the regression results.

1.4 Summary of main findings and conclusion

For each of the articles forming chapters 2-4, the main findings are summarized in this section. Afterwards conclusions and limitations are presented.

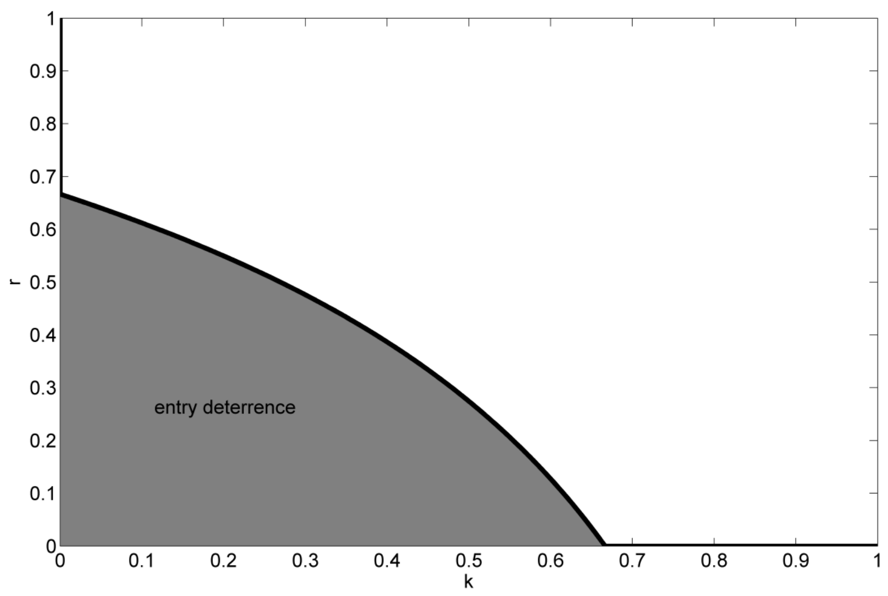
1.4.1 Summary of main findings

(I) Entry deterring effects of contractual relations in the dairy processing sector

Concerning research question (I) the game theoretic model shows that the entry of a rival dairy processor into the market can be deterred under certain assumptions on farmer's risk aversion and rival's probability of entry.

The basic scenario assuming a risk neutral farmer and certainty of rival's entry shows that the incumbent dairy cannot offer a suitable compensation for the farmer to accept the contract. This changes when introducing risk attitude and probability of a rival's entry. The analytical analysis reveals the following relation between entry probability *k* and farmers' risk attitude *r* specifying farmers' utility function $u = \pi^r$.

Figure 1.8: Effective entry deterrence depending on k and r



Entry can be deterred for all combinations of *r* and *k* that lie on and underneath the curve in figure 1.8. In this case, the compensation the incumbent dairy can offer is higher than the one the farmer requires.

In terms of profits, the farmer is better off in case of the rival's market entry. However, due to risk aversion he is willing to accept the compensation the incumbent dairy offers and accepts the contract. Due to higher profits in a monopsonistic market, the incumbent dairy has the incentive to deter a rival's entry in all analyzed scenarios.

The model shows that entry deterrence depends on the entry probability of the rival and farmers' risk attitude. Regarding the concerns of the German sector inquiry about the abuse of a dominant position with long-term contracts, the study emphasizes the importance of the flexibility of farmers to change processor.

(II) Conjectural variations on the German raw milk market – An empirical investigation of oligopsony power

The market power estimation to answer research question (II) finds evidence of an oligopsonistic market structure in six out of twelve analyzed federal states and also on the national level. Even though most of the conduct parameter values are close to zero, indicating to a small impact of a single dairy's input demand change on the whole dairy industry input, the price distortions resulting from market power range between 1% and 14%.

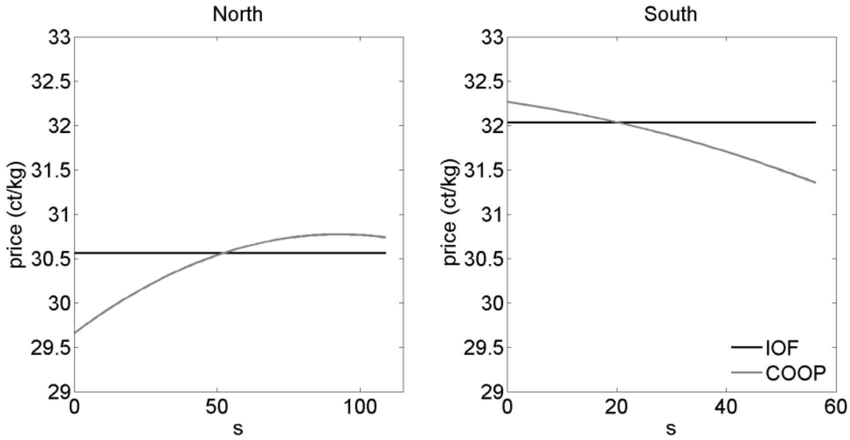
No significant evidence for market power is found in four federal states suggesting a competitive market.

Regarding the correlation between market power and concentration of dairy processors, the study provides low correlation coefficients. Here, concentration is measured relative to processing quantities as data to calculate the Herfindahl Hirschmann Index was not available. However, the market power parameter estimates have to be regarded with caution. The estimation of the market power parameters crucially depends on the estimate of the raw milk supply elasticity whose underlying parameters were not statistically significant.

(III) *Pricing behavior of cooperatives and investor-owned dairies in a spatial market setting*

With regard to research question (III) addressing the influence of space on raw milk prices, opposite effects for North and South Germany are found that are only significant for COOPs (see figure 1.9).

Figure 1.9: Relation between price and space of COOPs and IOFs in the North and the South



Note: For 2012. All other variables are at means.

In contrast to other empirical studies (Alvarez et al. 2000; Huck et al. 2012 and Koller 2012) the results do not show an inverted U-shaped relation between price and space.

The negative relation in the South can be explained by competition between the dairies' locations. If dairies are responsible for the transportation costs (uniform delivered (UD) pricing), increasing space is equivalent to increasing transportation cost. Hence, market areas are decreasing when transportation cost are too high, resulting in less competition between firms with more separated markets and corresponding room for monopsonistic pricing.

The positive relation between price and space in the North can be explained with the theory of UD pricing, price matching behavior (where a firm expects its rival to react in the exact same way) and competition in the backyard (competition that reaches behind the firms' locations (Alvarez et al. 2000). If space is relatively unimportant and assuming price matching, a dairy that increases its price expects its rival to also increase its price. The higher prices lead to a reduction in the market area (due to the need to cover transportation cost) so that dairies gain farmers in their own backyard.

The spatial pricing literature does not provide explanations for the finding that space does not significantly affect the pricing of IOFs. A possible explanation could be the membership policy of a COOP. Under open membership as currently practiced by German COOPs (FCO 2009), COOPs cannot reject farmers that want to participate. Hence, COOPs cannot efficiently choose their market area but have to consider the whole market as their area of operation.

Finally, the study does not find clear evidence for the competitive yardstick effect. In the South, an increase in the share of neighboring COOPs increases prices whereas the exact opposite effect occurs in the North. As COOPs in the North pay a significant lower price than IOFs this is not a surprising result. However, even though significant, the effects are rather small from an economic perspective in both the North and the South.

Regarding the concerns about the positive relation of concentration and market power, the study suggests that a further concentration of the milk processing sector does not necessarily lead to an increase in market power and a decrease in prices.

1.4.2 Conclusion and limitations

Regarding the overall objective of this thesis, to investigate imperfect competition on the German raw milk market, the findings of this thesis have to be divided into the theoretical and the two empirical analyses.

The theoretical analysis of entry deterring effects of exclusive contracts has elaborated on research question (I), showing that under certain conditions of farmer’s risk aversion and rival’s entry probability, exclusive contracts lead to market foreclosure. The challenges of the theoretical approach involved the abstraction of the market while still depicting the most important characteristics of the market. However, regarding the concerns about market foreclosing effects of long-term contracts between farmers and dairies, the study emphasizes that exclusive contracts may serve as a market entry barrier. Hence, flexibility of farmers to change processor contributes to a competitive market.

The market power estimation of the dairy industry in the federal states (research question II) confirms an oligopsonistic market structure for six federal states and also on the national level. For four federal states the null hypothesis of perfect competition is not rejected. The spatial competition analysis (research question III) has shown different pricing behaviors of COOPs and IOFs in the North and South of Germany, which are only significant for COOPs. In the South, prices are decreasing in space indicating the existence of market power. With respect to the low concentration of the dairy industry in the South, this result was, however, not expected. Referring to the results of the market power estimation, this result is in line with the finding of an oligopsonistic market structure in Bavaria. However, for Baden-Wuerttemberg the market power estimation suggests a perfectly competitive market. For the North, the relation between price and space is positive. Hence, an increasing concentration of the dairy industry and thereby the increasing space between dairies' location does not necessarily result in market power and decreasing prices. Reasons for a competitive raw milk market can be the high share of cooperatives, the bargaining power from producer organizations or market power at another stage of the supply chain, which restricts dairies to use market power even in a concentrated market. These findings are in line with the significantly negative conduct parameters that are found for Schleswig-Holstein and Saxony-Anhalt. However, for other federal states of the North, the market power estimation provides evidence for an oligopsonistic structure, like Lower Saxony, North Rhine-Westphalia, Rhineland-Palatinate, Saxony and Thuringia.

With respect to ongoing discussions about low raw milk prices, imperfect competition and concentration of the dairy industry, the findings from the empirical studies suggest that the cause for low raw milk prices might result from dairy processors buyer market power which leads to price distortions between 1% and 14%. Furthermore, market power at another stage of the supply chain might also be a cause for low raw milk prices that are not only prevalent in federal states where market power was found with the conjectural variation approach. Also, the low world market demand, the Russian embargo and the high raw milk production after the quota abolition in Germany are certainly factors decreasing raw milk prices. Regarding policy discussions about the prospects of the milk market, the causes for low milk prices have to be investigated more closely. If market power is not the cause for low raw milk prices, the large supply of raw milk in combination with weak demand conditions for milk products is certainly a strong factor.

Regarding future research, especially the market power estimation of the dairy industry could be improved on the data side. Detailed information on the output performance of a dairy, i.e. data on prices and quantities for specific product categories, will contribute to get a better picture of the market behaviour. Further, precise data on the market area of dairies, where they collect milk and who their competitors are, would be beneficial for spatial analyses which are highly relevant for geographically limited markets as the raw milk market. With such data also concentration indices could be calculated more precisely. This would contribute to the analysis of correlation between concentration and buyer market power of dairies to get insights on the effects of a further concentration of the milk market. Regarding the future of the raw milk market, the question is whether a new market regulation after the quota abolition solves the problem of low prices at the expenses of competitiveness, postponing structural change and the associated economies of scales.

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Chapter 2

Entry deterring effects of contractual relations[*]

Abstract

The European Commission has launched the so-called "milk package" in October 2012 that allows Member States to require compulsory written contracts between milk producers and investor-owned processors. We argue that compulsory contracts have anticompetitive effects when they are exclusive in the sense that they comprise the obligation to supply to the contractor only. The objective of this paper is to set up a game theoretic model to analyze imperfect competition on the raw milk market that may result from entry deterring effects of exclusive contracts between dairy producers and processors. Building on the antitrust literature, the model incorporates the specific characteristics of the milk market and considers the risk attitude of milk producers and uncertainty of a rival dairy's market entry. Under certain combinations of probability of the rival's market entry and risk aversion of the producer, an incumbent can deter market entry by offering an exclusive contract.

Keywords: entry deterrence, imperfect competition, buyer power, exclusive contracts, dairy processing

JEL classification: L13, L14, L41

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2.1 Introduction

In the EU-27, milk is one of the most important agricultural goods, representing about 13% of the total turnover of the European food and beverage industry (EDA 2013). In the past years, structural changes on both producer and processor side, innovations in milk production and the decision of the EU Commission to abolish the quota regime changed the milk market. The increasing concentration of dairy processing[3] facilities raise concerns regarding buyer market power of dairy processors (BKA 2009; BKA 2012). Addressing producers' position on the market, the European Commission launched the so-called "milk package" in October 2012 which aims at strengthening producers' market position by improving their bargaining power and the transparency of the market. The "milk package" sets criteria for the formation of producer organizations and specifies rules for the regulation of PDO/PGI cheese supply. Further, it allows Member States to imply compulsory written contracts between milk producers and investor-owned processors. Due to their specific ownership structure, cooperatives are exempted from this policy. As contracts used in recent years were often not well specified, the recommendation is that contractual agreements should not only become compulsory but also contain a minimum standard of specified criteria (e.g. details on price, volume and duration of contract). Currently, 12 Member States have introduced compulsory contracts (Bulgaria, Croatia, Cyprus, France, Hungary, Italy, Latvia, Lithuania, Portugal, Romania, Slovakia and Spain) with minimum

[3] Own calculation based on data from the Agrarmarkt Informationsstelle (AMI) (2014), a German institution that collects data of agricultural entities.

contract durations of 6 months in most states, 1 year in Spain and even 5 years in France. Other Member States have not introduced compulsory contracts but agreed on codes of good practice between producers and processors (Belgium, United Kingdom). In Germany, contracts between farmers and investor-owned dairies are usually negotiated by producer organizations. These contracts usually contain details on quality, price parameters and specify the length of the contracts. In addition to these criteria, contracts shall be more precise about the contracted milk volume in the future. (EC 2014)

In the sector inquiry of the German milk market the question arose how long-term contracts in combination with the obligation to supply the whole production quantity to processors affect competition (FCO 2012). The concern is that by tying up milk producers through long-term contracts without appropriate cancellation periods, strong or dominant processors may use their market power to deter competition or entry to the market for raw milk. Combined with the producer's obligation to supply the full production quantity, this could lead to an abuse of a dominant position, which is prohibited by law (article 102 of the treaty for the Functioning of the European Union (TFEU)) (FCO 2012, section 106). According to the sector inquiry, 45% of the contracts between private dairies and milk producers have durations longer than two years. Furthermore, 85 % of German producers delivering milk to private dairy processing facilities are obliged to supply their entire production and the processing facility is likewise obliged to accept the whole amount (FCO 2009). In 2012, 60% of milk is processed in cooperatives mainly due to the largest dairy cooperative in Germany, the "Deutsche Milchkontor". In terms of number of processing facilities, only approximately 40% of the 137 active processing facilities in 2012 were cooperatives, the remaining ones are investor owned firms (AMI 2014).[4]

The frequent use of contracts on the milk market may be explained by their ability to reduce price risks and to secure delivery quantities for dairy producers and input quantities for processors. However, they may also empower processors to exercise buyer market power by binding dairy producers and reducing delivery flexibility, which may even lead to entry deterrence of other dairy processors. We argue that compulsory contracts have anticompetitive effects as they are exclusive given the obligation to deliver to the contractor only. This is usually the case between milk producer and processor (FCO 2009) and holds likewise for investor-owned and cooperative dairies.

Anticompetitive effects of exclusive contracts have been scarcely studied under the specific characteristics of agricultural markets (exception e.g.: Xia and Sexton 2004 for the U.S. cattle industry), and only in the context of the antitrust literature focusing on seller market power (e.g. Segal and Whinston 2000; Rasmusen et al. 1991; Aghion and Bolton 1978). The analysis of seller market power is however of limited relevance on agricultural markets. Although they are

[4] Concerning the EU, the importance of investor-owned companies is even more pronounced: Among the top ten of Europe's largest dairy processors in terms of turnover, six firms are organized as investor-owned dairies and four as cooperatives. Among the top three only investor-owned dairies can be found (Nestlé, Danone, Lactalis) (MIV 2012). Even though investor-owned dairies process only about 36% of European raw milk, this highlights the importance of investor-owned firms in the European dairy market.

often assumed to be perfectly competitive, the structure of agricultural markets is more precisely characterized by a low concentration of producers and a high concentration of processors and retailers (Sexton 2013; McCorriston 2002; Rogers 2001; Rogers and Sexton 1994). Therefore, the analysis of buyer market power is central (Sexton 2013; MacDonald et al. 2004). However, oligopsony competition or monopsony behavior in an input market are rarely treated in the agricultural economic literature (exceptions are Sexton 2013; Mérel 2011; Crespi et al. 2012; Sexton 2013; Graubner et al. 2011; Alvarez et al. 2000).

Given the high adoption rate of compulsory contracts and in light of the concern of the German sector inquiry about resulting anticompetitive effects on the milk market, the aim of this paper is to analyze if exclusive contracts between dairy processor and producer restrict competition on the raw milk market[5]. This paper goes beyond the existing literature (1) providing a game theoretic analysis of the competitive effects of exclusive contractual relations based on the antitrust literature but in the framework of a monopsonistic market structure and (2) motivating the signing of an exclusive contract with the uncertainty of rival's entry and risk aversion of the signer - in contrast to former models of exclusive contracts.

[5] Germany, as the largest milk producer in Europe, stays in the focus of our analysis, motivated by the sector inquiry of the German milk market conducted by the German national competition authority (BKA 2012). However, the analysis may also be relevant for other Member States with a similar market structure.

Competitive effects of exclusive contracts are modelled between an incumbent investor-owned dairy processor on the milk market and one representative raw milk producer. We assume that a rival (investor-owned) dairy processor with lower marginal production costs threatens to enter the market. A short-term equilibrium in which the incumbent dairy offers an exclusive contract to the producer in order to deter the rival dairy's market entry is analyzed. After the producer decided whether to accept the contract with the incumbent, the rival decides upon entry. By incorporating uncertainty of rival's entry and producer's risk attitude, we show that exclusive contracts can indeed be used to deter entry of a rival processor into a downstream market when the upstream producer is risk averse. Most raw milk producers nowadays are highly specialized farms where the main income source results from milk production (EU Commission 2014). Not a lot is known about the real "level" of risk aversion among dairy producers, but some evidence exists that dairy farmers are generally risk averse (Loughrey et al. 2014; Melhim and Shumway 2011). This may lead farmers to sign exclusive contracts with a dairy to reduce the income risk related to their main production activity.

The paper is organized as follows: The next section gives an overview on the relevant literature. Section 2.3 presents the game theoretic model. In a baseline model, an exclusive contract between dairy producer and processor is analyzed without incorporating uncertainty about the rival's entry and producer's risk attitude, resulting in failure to deter entry. In a next step, we show how the inclusion of risk attitude and uncertainty may allow to deter rival's entry.

Subsequently, a numerical example underlines the theoretical results. Section 2.4 discusses the model while section 2.5 concludes.

2.2 Literature review

The analysis of contractual relations in the dairy processing sector requires the consideration of the contract design and the competitive effects. Empirical studies find that producers strongly favor a redesign of raw milk contracts in terms of contract length and cancellation periods (Steffen et al. 2009; Schlecht et al. 2013). Further, releasing producers of their supply obligation and allowing them to sell to more than one dairy processor is seen as an improvement in terms of both producers’ flexibility and bargaining position (Steffen et al. 2009; Schlecht et al. 2013; FCO 2012; Schaper et al. 2008).

Concerning the competitive effects of contracts, entry deterring effects of exclusive contracts are analyzed in the antitrust literature focusing on seller market power (e.g. Aghion and Bolton 1987; Bork 1978; Rasmusen et al. 1991; Segal and Whinston 2000). Roger and Sexton (1994) and Sexton (2013) emphasize the importance of oligopsony power in agricultural markets. However, there is little work on exclusionary effects of contracts in the context of the specific oligopsonistic structure between agricultural producers and food processors. MacDonald et al. (2004) and Vavra (2009) analyze the use of contracts in agricultural markets and discuss the possibility to deter entry of buyers into local markets. To our knowledge, none of the existing studies explicitly models risk behavior of producers and its effects on entry deterrence of exclusive contracts (although Innes and Sexton (1994) discuss at least the implication).

The models used in the antitrust literature for the analysis of seller market power are usually designed in the following way: An incumbent seller contracts a buyer who is usually a consumer with an exclusive supply contract. The contract specifies a compensation for the buyer to accept the contract and to not purchase from the incumbent's rival, which leads to entry deterrence in the upstream market. The "Chicago School" view (Director and Levi 1956; Posner 1976; Bork 1978) criticizes the entry deterring effects of contracts and argues that an incumbent confronted with buyers preferring entry of a rival due to increased competition and potentially better prices, would have to pay more for the rival's exclusion than to be gained from it. The reason is that the incumbent has to compensate buyers for the additional consumer surplus they would have gained in case of entry, which they lose by signing the contract. It has been shown that entry deterrence is not profitable in this case as the lost consumer surplus is higher than the monopoly profit in case of entry deterrence. Therefore, the Chicago School explained the observable use of exclusive contracts with efficiency reasons rather than anticompetitive behavior (Director and Levi 1956; Posner 1976; Bork 1978).

Since the 1980s, economists have developed game theoretic models that analyze anticompetitive effects of exclusive contracts. Aghion and Bolton (1987) developed a model where exclusive contracts are used to extract some of the surplus a potential rival would gain in case of market entry. They analyze the optimal contract length and differentiate between symmetric and asymmetric information about the probability of the rival's entry and their impacts on entry deterrence. Furthermore, the entrant endures fixed costs for entry. They find that entry deterrence leads to a lower economic welfare. Later, Rasmusen et al. (1991) used buyer's lack of information to explain the existence of exclusive contracts and their entry deterring effects. If a buyer expects other buyers to sign an exclusive contract, he will also sign the contract without considering the overall economic effect, which leads to entry deterrence and a lower welfare. Segal and Whinston (2000) reconsidered Rasmusen et al.'s (1991) model and showed that market entry is profitable when the rival can sell his product to a minimum number of buyers to cover fixed costs. If buyers sign exclusive contracts, it is difficult for the entrant to get the minimum scale needed and thus entry is deterred. Segal and Whinston (2000) show that when the incumbent makes discriminatory offers to the buyers, the externalities present between buyers lead to a profitable exclusion of rivals. These analyses explain the signing of exclusive contracts with market disorganization (Rasmusen et al. 1991; Segal and Whinston 2000) or complex contract terms (Aghion and Bolton 1978), even though the signer would be better off without contracts.

Fumagalli and Motta (2006) point out that the above mentioned models assume that buyers are final consumers whereas typically exclusive agreements are rather signed amongst producers or producers and processors or wholesalers. They consider the case where buyers procure a good from an upstream firm that is either from an incumbent producer or a rival producer and then sell it in a final market. In the case of buyers being final consumers, the demand and the payoff of a buyer depend only on the price of the good. But when buyers compete in a downstream market, their market share, the input price and the rival buyer's price are relevant for demand and affects the possibility of entry deterrence.

In recent years, a separate strand of literature emerged where raw milk pricing behavior and the implications for competition are analyzed in a spatial market setting (Alvarez et al. 2000; Huck et al. 2006; Graubner et al. 2011). In our analysis, the spatial dimension is not explicitly considered.

2.3 The Model

On the upstream market one representative[6] dairy producer takes the price for raw milk w as given. The (inverse) supply function for raw milk is defined as an inelastic function with $w = x^2$, defined for $x > 0$, implying that the producer is able to extend production at increasing marginal cost in the short to medium term.

Dairies accept the entire production quantity x of the producer and cannot choose the quantity they would like to procure. Therefore, we assume that processors compete in prices for raw milk à la Bertrand. On the intermediate stage of the market, an incumbent dairy (dairy A) is procuring the milk quantity x_A from the representative milk producer (producer P). A rival dairy (dairy B) with lower

[6] We do not consider a specific number of dairy producers and as we assume that producers take the price for raw milk is given, we just speak about a producer in the following.

marginal production costs than the incumbent, $c_B < c_A$, threatens to enter the market. To enter the market, the rival dairy has to consider fixed costs *F*. We assume that *F* is too large for the entrant to offer a compensation for signing an exclusive contract.[7] We abstain from incorporating spatial characteristics of the market and assume that the raw milk price offered to the producer is independent of the transport costs or distance between producer and processor. Regarding the final dairy product *q*, we assume a processing relation of $x = q$ for both dairies.

If dairy B entered, both processors would be competitors on the market for raw milk and compete in milk prices. Due to Bertrand price competition, the producer delivers milk to the highest bidder. In order to deter rival dairy B's entry, the incumbent dairy A can offer an exclusive contract to the producer. The exclusive contract comprises a compensation θ_A for selling all the produced milk to the incumbent and not to the rival. In case of a signed contract, the fact that the whole amount of raw milk is delivered to the incumbent dairy deters entry as the potential entrant can only procure milk from a free producer. If entry is successfully deterred, monopsony prices and profits are realized.

The marketing of the final dairy product is not restricted to a regional market but can be sold on the national or even on the world market, which allows the

[7] It would become more difficult for the incumbent to deter a rival's entry if we would remove the assumption that rival's fixed costs of entry are too high to also offer a compensation for an exclusive contract. However, the assumption is justified as the entry into a new market involves high entry costs.

assumption of a competitive downstream market. Hence, dairies take the output price *p* as given.

A short-term equilibrium in which the incumbent dairy offers an exclusive contract to the producer in order to deter the rival dairy's market entry is analyzed. The timing of the game is as follows: At stage one, the incumbent dairy A can offer an exclusive contract that specifies a compensation and an exclusive delivery obligation for the producer for the whole production amount. The producer decides whether to accept the contract. At stage two, the rival dairy B decides upon entry. At stage 3, active processors set prices.

First of all, a basic model demonstrates the effects of exclusive contracts in a framework with a risk neutral producer and certainty of rival's entry in absence of an exclusive contract. Then, these restrictions are relaxed and producer's risk attitude and uncertainty of rival's entry are incorporated in the model.

2.3.1 The basic model

In order to discuss the implications of exclusive contracts we analyze two scenarios. In scenario 1, a basic monopsony model structure without contracts is constructed. Here, only dairy A and the producer are active on the market. Scenario 2 analyzes market entry of dairy B.

Let us assume that $c_i < 1$, $c_i < p$ and $w_{is} < p$, where subindices $i = A, B$ represent the market actor and $s = 1, 2$ the scenario. In scenario 1, the monopsony scenario, dairy A maximizes its profit over the price for raw milk offered to the producer. The raw milk price that maximizes dairy A's profit is given by w_{A1} and leads to a profit of π_{A1}. The corresponding profit for the producer is denoted by π_{P1} (see table 2.1).

In scenario 2, the case of dairy B's market entry, dairies compete à la Bertrand. The highest price dairy B can offer is $\bar{w}_B = p - c_B$, whereas dairy A's highest price is $\bar{w}_A = p - c_A$. Since $c_B < c_A$, processor B is able to offer a higher price for raw milk, $\bar{w}_{B2} > \bar{w}_{A2}$. In case of market entry, dairy B will offer a slightly higher price than dairy A, $w_{B2} = p - c_A + \varepsilon$ with $\varepsilon > 0$.[8] Consequently, the producer will sell to the rival and dairy A will lose its market share resulting in a positive profit π_{B2} for dairy B and a zero profit for dairy A (see table 2.1). In this setup, there exists no equilibrium in which both dairies are active on the market. However, we assume that dairy A will not exit the market but is still present in the region with its production facility. In this case, dairy B's market entry will not result in another monopsony situation, as dairy B has to keep its pricing strategy to prevent dairy A from re-entering the market.

[8] If $w_A = w_B$, the producer will not split its milk quantity between the two dairies but will sell the entire production to dairy B.

Table 2.1: Comparison of scenario 1 and 2

	Sc.	Price for raw milk	Raw milk quantity	Profit
Dairy A	1	$w_{A1} = \frac{p-c_A}{3}$	$x_{A1} = (\frac{p-c_A}{3})^{1/2}$	$\pi_{A1} = \frac{2}{3\sqrt{3}}(p-c_A)^{3/2}$
	2	$\bar{w}_{A2} = p-c_A$	$x_{A2} = 0$	$\pi_{A2} = 0$
Dairy B	1	$w_{B1} = 0$	$x_{B1} = 0$	$\pi_{B1} = 0$
	2	$\bar{w}_{B2} = p-c_A+\varepsilon$	$x_{B2} = (p-c_A+\varepsilon)^{1/2}$	$\pi_{B2} = (c_A-c_B+\varepsilon)(p-c_A+\varepsilon)^{1/2}-F$
Producer	1	$w_{A1} = \frac{p-c_A}{3}$	$x_{A1} = (\frac{p-c_A}{3})^{1/2}$	$\pi_{P1} = \frac{2}{9\sqrt{3}}(p-c_A)^{3/2}$
	2	$w_{B2} = p-c_A+\varepsilon$	$x_{B2} = (p-c_A+\varepsilon)^{1/2}$	$\pi_{P2} = \frac{2}{3}(p-c_A+\varepsilon)^{3/2}$

The comparison of the two scenarios demonstrates the incentive for dairy A to deter dairy B's market entry. In case of market entry, dairy A achieves a zero profit, whereas the profit in the monopsony case, π_{A1}, is positive. The producer, on the other hand, is better off in case of dairy B's market entry as $\pi_{P2} > \pi_{P1}$.

Without taking producer's risk aversion and uncertainty of rival's entry into account, the compensation that dairy A needs to offer to the producer for an exclusive contract must compensate for the producer's surplus lost when accepting the contract. This is the difference between the profits in the two scenarios, $\theta_P \geq \pi_{P2} - \pi_{P1}$, which is equal to

$$\theta_P \geq \frac{2}{3}(p-c_A+\varepsilon)^{3/2} - \frac{2}{9\sqrt{3}}(p-c_A)^{3/2}. \quad (2.1)$$

The maximum compensation dairy A is willing to offer is $\theta_A = \pi_{A1} - \pi_{A2}$ which leads to

$$\theta_A \leq \frac{2}{3\sqrt{3}}(p - c_A)^{3/2}. \tag{2.2}$$

Comparing (2.1) with (2.2) we observe that the compensation the producer requires is higher than the one dairy A is able to offer, i.e. $\theta_P > \theta_A$. Therefore, offering an exclusive contract is not beneficial for dairy A in this setup. Consequently, if a lower cost producing dairy B enters the market, dairy A is not able to keep its raw milk source, as the compensation dairy A is able to offer does not offset the higher price dairy B is able to pay.

2.3.2 Risk attitude and uncertainty of entry

In order to incorporate producer's risk attitude, producer's utility function is defined as $u = \pi_p^{\ r}$, where the exponent r determines the risk attitude of the producer. If $r > 1$, the utility function implies a risk loving producer, if $r = 1$ risk neutrality and if $0 < r < 1$ absolute risk aversion.

Exogenous determinants lead dairy B to enter the market. Depending on dairy A's assumptions on the probability of dairy B's market entry, dairy A offers an exclusive contract to the milk producer. The probability of entry is denoted by k such that $1-k$ is the probability of no entry, both for the case of no contract. If successful, the signing of the exclusive contract deters entry of dairy B and thus, probability of entry is zero.

Whether the offering of an exclusive contract leads to entry deterrence depends on the compensation that dairy A can pay, which depends on the entry probability of the rival and producer's risk attitude. Is the compensation high enough for the producer to accept, the contract will be signed and entry of the rival is deterred. The market is in a monopsony situation with prices and quantities being as in scenario 1 of the basic model. If the contract with dairy A is not accepted, the producer will sell the entire production quantity to dairy B. The compensation the producer requires for signing a contract with dairy A depends on the payoff required for not staying free on the market. This payoff is equal to the certainty equivalent (CE_P) and the payoff under contract $\left(\pi_{P1}\right)$. Therefore, the compensation that leads to an exclusive contract has to be equal to the difference between the certainty equivalent and the profit in the monopsony situation, $\theta_P^{risk} = CE_P - \pi_{P1}$, which is equal to

$$\theta_P^{risk} = \left[k\left(\pi_{P1}\right)^r + \left(1-k\right)\left(\pi_{P2}\right)^r\right]^{1/r} - \pi_{P1}. \tag{2.3}$$

The highest compensation that dairy A is able to offer under uncertainty is equal to

$$\theta_A^{risk} = \pi_{A1} - \left[k\pi_{A2} + (1-k)\pi_{A1}\right]. \tag{2.4}$$

For simplicity we define the margin of dairy A as $p - c_A = m$ and assume that $\varepsilon = 0$. Then, inserting the findings from table 2.1 yields

$$\theta_P^{risk}(\rho, r, m) = \left[k\left(\frac{2}{3}m^{3/2}\right)^r + (1-k)\left(\frac{2}{9\sqrt{3}}m^{3/2}\right)^r \right]^{1/r} - \frac{2}{9\sqrt{3}}m^{3/2} \tag{2.5}$$

$$\theta_A^{risk} = k\left(\frac{2}{3\sqrt{3}}m^{3/2}\right). \tag{2.6}$$

Rival's entry can be deterred if $\theta_P^{risk} \leq \theta_A^{risk}$ $((2.5) \leq (2.6))$. Hence, dairy A can offer a compensation that induces the producer to sign the contract and thus deters entry if $\theta_A^{risk} - \theta_P^{risk} \geq 0$.

To better understand under which conditions this is valid, rearranging leads to

$$m^{3r/2}\left[\left(k\frac{2}{3\sqrt{3}} + \frac{2}{9\sqrt{3}}\right)^r - k\left(\frac{2}{3}\right)^r - (1-k)\left(\frac{2}{9\sqrt{3}}\right)^r\right] \geq 0\,. \tag{2.7}$$

Whether this inequality holds depends on the values of *k*, *r* and *m*. The margin $m = p - c_A$ is by definition positive. Therefore, entry can only be deterred if the term in brackets in equation (2.7) is larger than zero, which depends on the variables *k* and *r*.

Figure 2.1: Effective entry deterrence depending on k and r

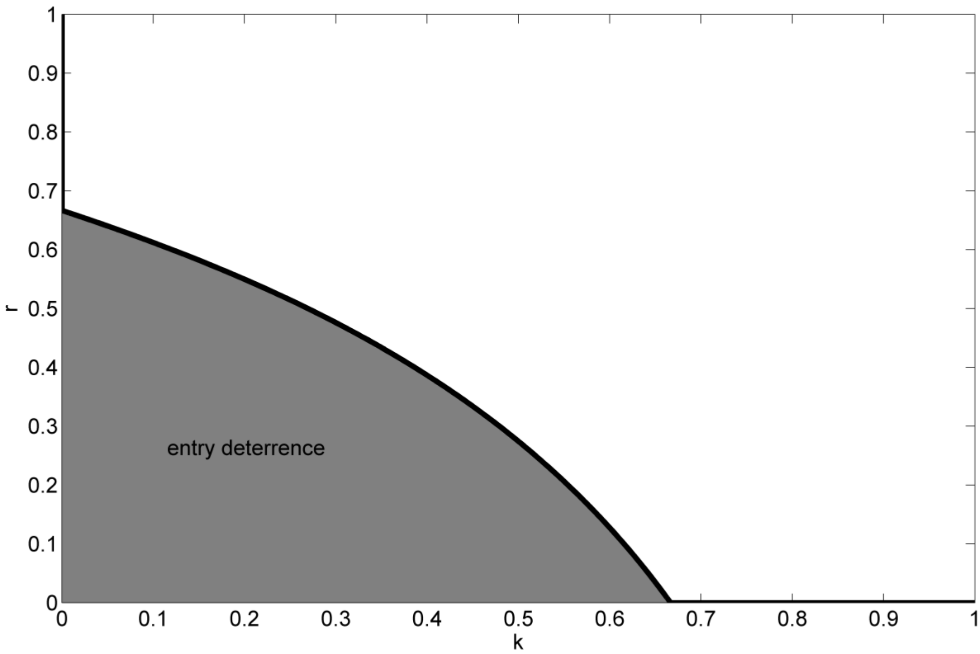


Figure 2.1 shows levels of *k* and *r* that lead to a positive term in equation (2.7) i.e. a situation where entry deterrence is possible. This is valid for all combinations of *k* and *r* that lie on the curve and underneath the curve in figure 2.1. A highly risk averse producer would even accept the contract when the entry probability is high, enabling dairy A to maintain the monopsony situation on the market. If, on the other hand, the entry probability is relatively high and risk aversion only moderate dairy A has no possibility to deter entry.

Contrary to the basic model, it is now possible to deter rival's entry for certain levels of producer's risk aversion and the probability of rival's entry. If the market entry is deterred, the market is in a monopsony situation, resulting in prices and profits of the basic scenario 1 and providing the incentive for dairy A to sign an exclusive contract with the producer. If deterrence is possible, then the level of compensation dairy A has to pay to maintain the monopsony position increases with the probability of market entry by dairy B and decreases with the increasing risk aversion of the farmer.

2.3.3 Numerical example

Using a numerical example roughly reflecting the current situation on the German dairy market, we assume that the marginal costs of the rival are $c_B = 0.18$ ct/kg and the marginal costs of the incumbent are 20 % higher, $c_A = 0.22$ ct/kg. The downstream price p for one unit of a (not further specified) dairy product is assumed to be $p = 0.48$ ct/kg[9].

Basic model

Based on these numbers, the price that dairy A offers in Scenario 1 of the basic model is equal to 9 ct/kg (see table 2.2). This is a rather low price for raw milk, which results from our crude assumptions and the monopsonistic market structure.

[9] Data derived from a cost figure provided by the German dairy association (MIV 2011).

Table 2.2: Numerical example of the basic model

	Sc.	Price for raw milk	Demanded raw milk	Profit
Dairy A	1	$w_{A1}=0.09$	$x_{A1}=0.29$	$\pi_{A1}=0.0510$
	2	$w_{A1}=0$	$x_{A1}=0$	$\pi_{A1}=0$
Dairy B	1	$w_{B1}=0$	$x_{B1}=0$	$\pi_{B1}=0$
	2	$w_{B2}=0.27$	$x_{b2}=0.52$	$\pi_{B2}=0.0156-F$
Producer	1	$w_{A1}=0.09$	$x_{A1}=0.29$	$\pi_{P1}=0.0170$
	2	$w_{B2}=0.27$	$x_{b2}=0.52$	$\pi_{P2}=0.0935$

For scenario 2 of the basic model, the highest price dairy A is able to offer when dairy B enters the market equals $\overline{w}_A = p - c_A = 0.26$ and dairy B's highest price is given by $\overline{w}_B = p - c_B = 0.30$. If dairy A has not contracted the producer and rival B enters the market, dairy B is able to outbid dairy A by offering a slightly higher price for raw milk, say $w_B = 0.27$, given Bertrand competition. Then, dairy A has a profit of zero and dairy B achieves π_B. The producer's expected payoff is given by π_P (see table 2.2).

Comparing the two scenarios shows that the Bertrand price competition leads to a higher price in scenario 2 compared to scenario 1 and a higher quantity of raw milk. This results in more than a fivefold producer's profit. The example demonstrates dairy A's incentive to deter rival B's market entry due to the higher profit that can be achieved in the monopsonistic case. From the producer's perspective, it would be better if the rival processor enters the market, as this results in higher competition for raw milk and thus in a higher price.

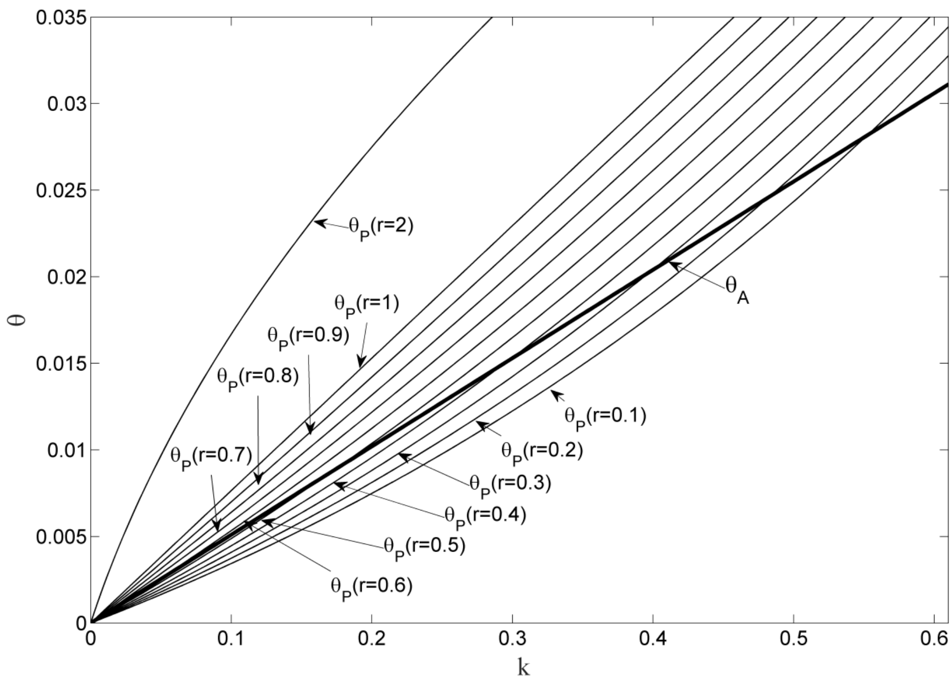
For dairy A, holding the monopsony position on the market can only be achieved with an exclusive contract that obliges the producer to deliver the full production of raw milk. For the producer to accept, the contract must enclose a compensation for not being able to negotiate/contract with dairy B. Therefore, the compensation must at least contain the difference between producer's profit in Scenario 2 and 1. Consequently, the compensation must be $\theta_P \geq 0.0765$. Dairy A's profit in scenario 1 is $\pi_A = 0.051$ and zero in scenario 2, therefore the highest compensation dairy A is able to offer equals $\theta_A \leq 0.051$. This compensation is not high enough for the producer to accept, therefore market entry of dairy B will take place. Without taking risk aversion into consideration, dairy A cannot deter market entry of dairy B. Dairy B will enter the market and Bertrand competition for raw milk occurs.

Risk attitude and uncertainty of entry

The compensation that dairy A is able to offer depends on the expected entry probability of the rival. Producer's required compensation also depends on the entry probability and further on the risk attitude. Consequently, both affect the possibility to deter the rival's entry. The relationship of affordable and required compensations for entry deterrence depending on entry probability and the risk attitude is presented in figure 2.2. The bold line represents the compensation dairy

A is able to offer (θ_A-line). The thin lines represent the compensation that the producer requires under a given level of risk attitude (θ_P-lines).

Figure 2.2: Development of compensations depending on probability



Generally, the figure shows that given our numeric assumptions and if risk aversion of the producer is not lower than $r = 0.1$, entry cannot be deterred if the entry probability is higher than $k = 0.552$. All compensation lines of the producer (θ_P-lines) lie above dairy A's compensation line (θ_A-line) after this point. If k=0.522 and r=0.1 then $\theta_P^{risk} = \theta_A^{risk} = 0.02815$. Therefore, if $r = 0.1$, an exclusive contract and an entry probability of $k \leq 0.552$ lead to an effectively deterred entry. Addressing the risk attitude of the producer, rival's entry can only be deterred if

$r \leq 0.6$ and if the entry probability is low enough respectively. Starting from a risk behavior of $r > 0.6$, entry cannot be deterred (all θ_P-lines lie above the θ_A-line there). For a risk averse producer with $r = 0.6$ the entry probability would need to be very low ($k < 0.018$) to effectively deter rival's entry with an exclusive contract. With increasing risk aversion of the producer and with decreasing entry probability, the required compensation of the producer is decreasing. However, at the same time, the compensation that dairy A is able to offer decreases with decreasing entry probability. This shows that under our assumptions regarding marginal costs of production and processing, there are certain ranges of interaction between entry probability and risk attitude where the incumbent dairy A can use an exclusive contract to deter rival dairy B's entry.

2.4 Discussion

Even though the concentration of dairy processors is increasing, the entry of rivals into an incumbent's market area is still relevant. In the dairy concentration process, processing quantities are continuously increasing which leads to larger market areas (AMI 2014). Hence, a rival's entry can also be interpreted as an existing dairy who wants to increase its market area.

Certainly, the above presented model covers a complex market structure and therefore relies on abstract assumptions. The complexity of the market presents itself in the different relations along the supply chain. On the one hand, considering the relation between producers and dairies, the model does not take into account the possible existence of producer organizations. These might exert bargaining power in contrast to the model assumption of the producer being a price taker. On the other hand, regarding the relation between dairies and the downstream market, the model lacks to cover the possible existence of buyer power of downstream firms. However, in order to focus the analysis on the relation between the producer and the dairy, perfect competition on the downstream market was assumed. Nevertheless, both assumptions might be worth to relax in future studies.

As cooperatives are exempted from the policy of compulsory and exclusive written contracts, our analysis focused on investor-owned dairies. However, the theory of exclusive contracts can also be applied to cooperatives. The literature provides three possible profit maximizing objectives for cooperatives (Royer and Matthey, 1999). First, cooperatives act like investor-owned firms, they maximize profit and afterwards split profit between members. Second, cooperatives maximize total member welfare by maximizing profit over quantities. However, this is not applicable to the milk market due to the obligation to supply the entire production amount to the same dairy. Third, cooperatives maximize the price paid to their members and generate a zero profit. Therefore, our theory can be applied to cooperatives if we assume that the cooperative e maximizes its profit like an investor-owned firm. Then, the compensation corresponds to the shared profit of a cooperative. The model does also not change for the entrant, who can then either be an investor-owned dairy or a cooperative. If we stick to the assumption that the fixed costs of market entry are too high for the entrant to offer a compensation, the theory can completely be translated to the case of cooperatives that maximize profits like investor-owned firms.

2.5 Conclusion

In this article, we analyzed entry deterring effects of exclusive contracts in an oligopsonistic market. The model is based on the framework of studies analyzing exclusive contracts in the literature (e.g. Segal and Whinston 2000; Rasmusen et al. 1991; Aghion and Bolton 1978, Fumagalli and Motta 2006). In contrast to these models on exclusive contracts, we incorporate risk aversion of the producer and uncertainty of rival's entry. In our model, we assume increasing marginal cost of the raw milk producers and an exogenous downstream market price. The rival's entry can effectively be deterred under certain combinations of the rival's entry probability and producer's level of risk aversion. Increasing farmer's risk aversion reduces the compensation the producer requires to sign an exclusive contract. This implies that producer foregoes uncertain higher prices in a competitive market environment for the compensation paid.

Generally, the producer is better off in terms of profit in case of market entry of the rival dairy. Only for rather high values of producer risk aversion and low entry probability of the rival, the incumbent dairy can use an exclusive contract to deter market entry. According to empirical studies, the majority of producers prefer a short-term contract period up to two years (Schlecht et al. 2013) and the possibility to change the processor on a short notice. In addition, short cancellation periods and extraordinary termination clauses are preferred by the majority of producers which is perceived as a strong bargaining instrument for a better milk price (Steffen et al. 2009). These requests are reflected by our model, which shows that the possibility to change the processor is beneficial for the producer as he can achieve a higher milk price when the rival dairy processor enters the market. Long-term contracts combined with the obligation to supply and long cancellation periods reduce competition on the raw milk market. To assure decision flexibility for farmers regarding their contractual relationship and to improve their ability to change processors in case of unsatisfactory raw milk pricing, we conclude that contracts should have appropriate cancellation periods.

From the perspective of the dairy processor there is always an incentive to keep the monopsonistic position on the market. This occurs because market entry of the rival results in market foreclosure for the incumbent as the producer will offer all production to the rival who can pay the better price. The market entry of the rival does not lead to another monopsony as we assume that the incumbent is still active with its processing facilities and wants to regain its market share on the market. Therefore, the rival has to maintain its competitive pricing strategy in order to prevent the incumbent from re-entering the market.

Reflecting our results in light of the German sector inquiry on milk, we find that it is possible that a dairy processing company abuses its dominant position with long-term contracts, long cancellation periods and the obligation to supply. Therefore, from a competitive standpoint, it is essential to consider these findings in the contract design so that the flexibility of farmers to change processor at least in the medium term is not completely erased.

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Chapter 3

Conjectural variations on the German raw milk market– an empirical investigation of buyer market power*

Abstract

Addressing the increasing concentration of dairy processors in Germany, this paper investigates imperfect competition on the German raw milk market. Using a panel data set of dairy processors' price and processing data as well as related market information for the years 2001-2012, the conjectural variation approach allows analyzing market power of dairy processors towards raw milk producers. In six out of the twelve federal states analyzed, significant results indicating to an oligopsonistic market structure of the dairy industry are found, where price deviations from perfect competition range between 1% and 14%. Also on the national level, the null hypothesis of a perfectly competitive dairy industry has to be rejected.

Keywords: market power, imperfect competition, conjectural variation, dairy industry

JEL classification: D43, C51, L13

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3.1 Introduction

The competitiveness of the dairy sector in Europe is driven by the abolition of the quota regime, increasing productivity and structural change on both dairies' and farmers' side. In the last years, following the decision to abolish the milk quota, raw milk production in Germany increased, accompanied by a continuing decrease in number of dairy farmers and processors (BLE 2013; ZMB 2013). Due to the high perishableness of the good, farmers' access is limited to only those dairy processors within a certain radius around the farm. The high concentration of dairy processors and the rather inelastic supply of raw milk might foster the possibility of dairy processors to exercise market power.

To estimate market power, the conjectural variation approach in the framework of the New Empirical Industrial Organization (NEIO) (Appelbaum 1982, Bresnahan 1982 and Lau 1982) has been frequently used in various industries, mainly assessing retailer market power (e.g. Gohin and Guyomard (2000) for the French food retailing considering milk, Anders (2008) for the German food retailing considering meat, Sckokai et al. (2009) for the cheese market in Italy). Regarding buyer market power estimation on milk markets, the literature provides several studies that use the conjectural variation approach to analyze seller or buyer market power. Relevant research on buyer market power of dairy processors has been conducted by Perekhozhuk et al. (2011), Cakir and Balagtas (2012), Scalco and Braga (2014) and Perekhozhuk et al. (2014). Evidence has been found for some regions of the Ukrainian dairy industry (Perekhozhuk et al. 2014) and the

Hungarian dairy industry (Perekhozhuk et al. 2011). No evidence on the contrary has been found for regional milk markets in Brazil (Scalco and Braga 2014) and for US dairy cooperatives (Cakir and Balagtas 2012).

Being the first study estimating market power of the German dairy industry, the objective of this paper is to investigate potentially existing imperfect competition on the national and federal state level. We use plant-level data covering all German dairies from 2001 to 2012 providing information on their geographical location, raw milk prices, processing quantities, legal and production specifics as well as relevant farm related data. The geographical limitation of the market is incorporated by estimating market power on the federal state level (similar to Perekhozhuk (2014) and Scalco and Braga (2014) who also estimate on a regional level). Due to non-availability of labor and capital quantities we use the approach proposed by Muth and Wohlgenant (1999) and adopted by Scalco and Braga (2014) using only prices for these inputs.

The remainder of the article is organized as follows. First, the paper gives an overview on the German milk market and its developments. Then, related literature and methodology applications are presented. Section 3.4 presents the theoretical background of the conjectural variation approach while section 3.5 provides the empirical model. Estimation results are then presented and finally discussed in section 3.8. Section 3.9 concludes.

3.2 The German raw milk market

When analyzing competition on the German raw milk market, it is important to incorporate the spatial nature of the market into the model. Raw milk is a highly perishable good leading to an economically acceptable transportation radius of at maximum 200 km (FCO 2012). Hence, farmers' selling alternatives are limited to the processors located close to their farm which can lead to strong dependencies deterring competition and optimal price setting (IFH 2009). Therefore, increasing concentration of dairy processors leads to concerns regarding market power (FCO 2009). Further, federal states' differences in raw milk prices might result from different market power intensity of the embedded dairy industry.

Figure 3.1 gives an overview of the regional distribution of raw milk production and dairy processing facilities in Germany in 2012. The map shows differences in dairies' concentration that are different in North and South Germany. In the North, structural change was strong, reducing the number of dairy facilities from 111 to 58, a decrease of 48% between 2001 and 2012. In the South, structural change was not as strong with the number of plants decreasing by 26% from 70 to 52. This change was not accompanied by a decrease in the total amount of milk processed but instead by a massive increase of average processing quantity by 104% in the North and 30% in the South. The average processing quantity of a dairy has, on the other hand, strongly increased from 133,600 tons to 199,863 tons as well as the sum of the processing quantity (26.3 Mio tons in 2001 to 27.4 Mio tons in 2012).

Figure 3.1: Regional distribution of milk production and dairy processing facilities in 2012

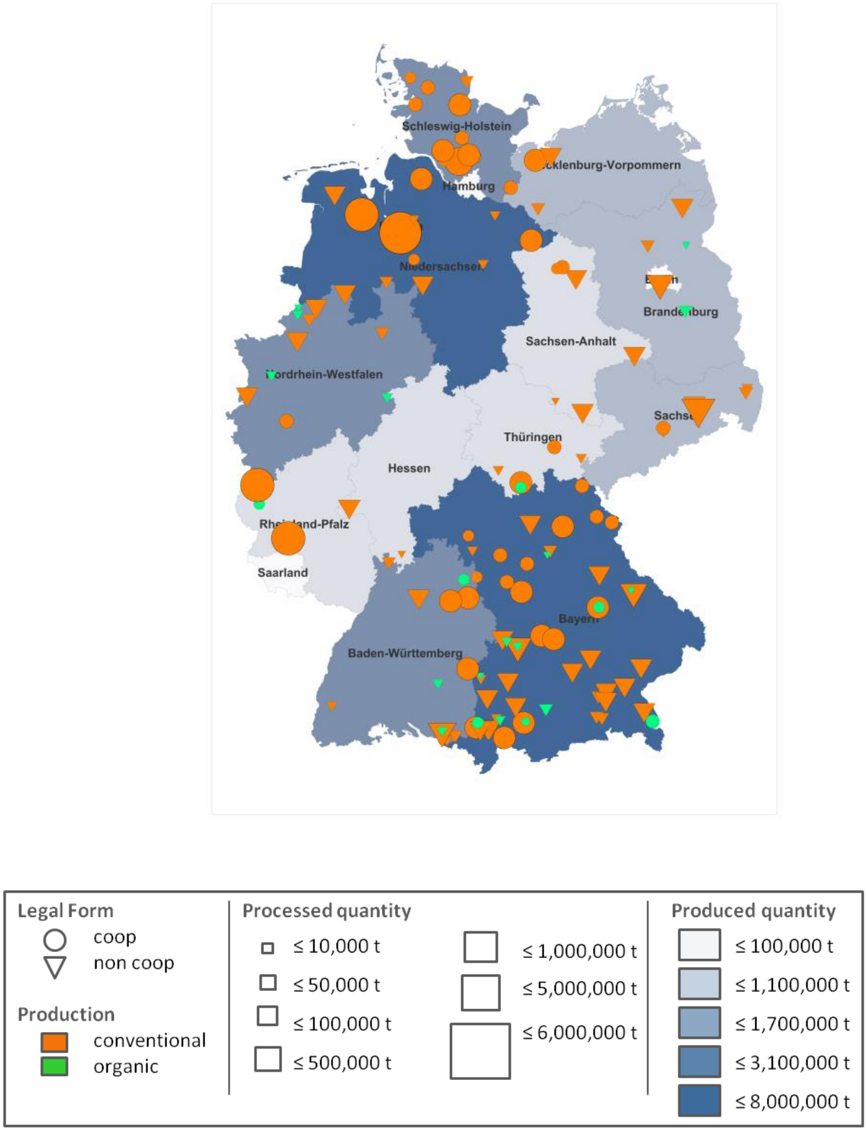

Table 3.1 shows a high variance of German dairies' concentration in the federal states measured as processing quantity of the top 1 (C1) to 3 (C3) biggest processors relative to total processing quantity in the corresponding federal state. Further, the processing quantities and the average milk price are summarized.

Table 3.1: Dairies' concentration according to processing quantities in 2012

state	C1	C2	C3	no. dairies	proc. quantity *in Mio. tons*	avg. raw milk price *in ct/kg*
HE	0.83	0.99	1	3	0.1439	0.3189
SN	0.72	0.82	0.89	6	1.5270	0.3169
BB	0.7	0.94	1	3	1.1164	0.3099
LS	0.69	0.85	0.89	12	5.7000	0.3188
RP	0.57	0.99	1	3	2.7928	0.3119
TH	0.49	0.8	1	3	0.1527	0.3183
MV	0.44	0.86	0.94	4	1.4131	0.3282
SH	0.41	0.52	0.63	12	1.5459	0.3152
BW	0.4	0.58	0.75	15	1.8533	0.3240
ST	0.32	0.6	0.81	6	0.5397	0.3153
NW	0.29	0.52	0.64	11	2.9113	0.3221
BY	0.08	0.15	0.2	59	6.7631	0.3282

With HE=Hesse, SN=Saxony, BB=Berlin and Brandenburg, LS=Lower Saxony, RP=Rhineland Palatinate, TH=Thuringia, MV= Mecklenburg-Western Pomerania, SH=Schleswig-Holstein, BW=Baden-Wuerttemberg, ST=Saxony-Anhalt, NW=North Rhine-Westphalia, BY= Bavaria

Concentration and raw milk price are negatively correlated (-0.61). Bavaria (BY) paid the highest price in 2012 and is also the state with the lowest concentration and the biggest processing state, followed by Lower Saxony. The highest concentration can be observed in Hesse (HE), Rhineland-Palatinate (RP) and Berlin and Brandenburg (BB). As illustrated in figure 3.1, compared to Bavaria (BY) in the south of Germany, federal states in the North show a much higher level of concentration (Lower Saxony (NI) 0.69, Mecklenburg-Western Pomerania (MV) 0.44, Schleswig Holstein (SH) 0.41).

3.3 The conjectural variation approach

Generally, market power refers to the extent to which an entity is able to influence the price of a good. Economic theory primarily analyses seller market power where under imperfect competition firms output price exceeds marginal costs (Motta 2004). Buyer market power opposed to input suppliers on the other hand, has not been analyzed as fiercely but is highly relevant for agricultural markets due to the oligopsonistic structure of the food processing industry (MacDonald et al. 2004; Sexton 2013). Buyer market power refers to the ability to set the price for an input below the competitive level (Clarke et al. 2002).

With the conjectural variation approach, the deviation from the competitive level of raw milk prices can be measured while incorporating strategic interactions between firms (Bresnahan 1982; Appelbaum 1982; Lau 1982). Conjectural variation models usually incorporate the analysis of a homogeneous good industry, where a conjectural variation or conduct parameter gives information on the degree of market power in the industry. Generally, for the estimation of oligopsony power, a supply function of the input good and the first order profit maximizing function of the analyzed industry are simultaneously estimated.

Concerning studies that analyze market power on dairy markets, a study that analyzes oligopoly power of dairy processors has been conducted by Mérel (2009). Evidence for seller market power of the French comté cheese processing dairies is not found in this study. Estimating both, oligopoly and oligopsony power, Sckokai et al. (2009) estimate market power in the Italian cheese market, finding stronger evidence for oligopoly than oligopsony power.

Notable studies specifically analyzing oligopsony power of dairy processors are Perekhozhuk et al. (2009), Perekhozhuk et al. (2011), Cakir and Balagtas (2012), Perekhozhuk et al. (2014) and Scalco and Braga (2014). The main difference between these studies is the availability of the data and the therefore different estimation possibilities. As Perekhozhuk et al. (2014) and Perekhozhuk et al. (2011) have data on output and input quantities of the dairy industries, they can estimate a translog production function of dairies. Perekhozhuk et al. (2014) estimate the production function, a farmers' supply function and a first order profit maximization function of dairies simultaneously in a nonlinear three-stage least squares estimation. They analyze plant level data and find evidence for oligopsony power of dairy processors in three of 25 administrative regions in Ukraine. Keeping milk supply elasticity constant, Perekhozhuk et al. (2011) use industry level data and find evidence for oligopsony power in the Hungarian dairy industry.

In contrast to Perekhozhuk et al. (2011) and Perekhozhuk et al. (2014), Muth and Wohlgenant (1999) and Scalco and Braga (2014) do not have data on output and input quantities except for the product analyzed (beef in Muth and Wohlgenant's case and raw milk in Scalco and Braga's case). They use the profit maximizing amounts of these quantities expressed in prices. Scalco and Braga (2014) simultaneously estimate raw milk supply and the first order profit maximizing condition of dairies, derived from a translog production function with a nonlinear Generalized Method of Moments procedure. They find evidence for market power of the dairy industry in some of the analyzed regions in Brazil. Muth and Wohlgenant (1999) use three alternative production functions for the derivation of the first order profit maximization function which is estimated simultaneously with the supply function in a nonlinear least squares procedure. Concerning the production function, they derive a reduced-form expression of a marginal product function which they transform to represent a translog production form and a generalized Leontief production form. All three specifications do not reveal evidence for oligopsony power in the beef packing industry in the US.

Our model is based on the specification developed by Muth and Wohlgenant (1999) and adopted by Scalco and Braga (2014) to estimate a model with fewer data requirements. As Muth and Wohlgenant (1999) and Scalco and Braga (2014), we do not have data on output and other input quantities except for raw milk. Therefore, we follow the theoretical framework developed by Muth and Wohlgenant (1999) and substitute optimal profit maximizing inputs depending on output and input prices. For the production function of dairies, we derive a reduced-form expression of a marginal product function, which we transform to represent a generalized Leontief production form.

3.4 Theoretical framework

Assume that the inverse supply of raw milk a dairy faces is given by

$$w_M = f_W(X_M^a, Z^a) \tag{3.1}$$

where w_M represents the raw milk price and $X_M^a = x_{Mj}^a(x_{Mi}) + x_{Mi}$ the demand in the competitive area *a* of dairy. This demand depends on the demand of dairy *i* and on the demand of all other dairies *j* in that area whose demand is also depending on the demand of dairy *i*. Z^a are factors that influence the supply capacities of the farms like number of dairy cows, price for young bulls and feed costs in the respective area. The competitive area is defined with a spatial weighting matrix which will be explained in the empirical model

Each dairy produces a homogeneous output q. Consequently, the profit function of a representative dairy *i* can be written as

$$\pi = P \cdot f_q(x_M, x_L^*, x_K^*) - f_W(X_M^a, Z^a)x_M - w_L x_L^* - w_K x_K^* \tag{3.2}$$

where $x_L^* = x_L(x_M, w_L, w_K, p)$ and $x_K^* = x_K(x_M, w_L, w_K, p)$ represent the optimal values of the input quantities labor and capital conditional on the input of raw milk, x_M. Dairies are assumed to be price takers on the markets for labor (w_L), capital (w_K) and also on the output market for dairy products (P). The first order condition for profit maximization is given by

$$w_M = P \cdot \frac{\partial f_q(x_M, x_L^*, x_K^*)}{\partial x_M} \bigg/ \left(1 + \frac{\theta}{\varepsilon}\right) \tag{3.3}$$

where $\varepsilon = \left(\partial x_M / \partial w_M\right)\left(w_M / x_M\right)$ represents the market price elasticity of raw milk supply a dairy is facing and $\partial f_q(x_M, x_L^*, x_K^*) / \partial x_M$ reflects the marginal product of raw milk input. θ is the conduct parameter which measures the conjectural elasticity. As we estimate the federal states' dairy industries' market power, this parameter can be interpreted as the average of conjectural elasticity of the firms in the industry of the federal state *s*, $\theta_s = \frac{1}{n}\sum_{i=1}^{n \in s}\left(\partial x_M^a / \partial x_{Mi}\right)\left(x_{Mi} / x_M^a\right)$. It comprises how other dairies' quantity x_M^a in area *a* changes when dairy *i* changes its quantity $\left(\partial x_M^a / \partial x_{Mi}\right)$ and the relation of dairy *i*'s quantity to the other dairies in the area $\left(x_{Mi} / x_M^a\right)$. The wedge between price and marginal product is measured with the conduct parameter and gives information on the degree of market power on the input market for raw milk (Appelbaum 1982, Bresnahan 1982; Hyde and Perloff 1995). Following Muth and Wohlgenant (1990), the conjectural variation parameter measures the response to a percentage increase in total industry input to a 1% increase of a certain firm's increased input purchase. A conjectural elasticity of $\theta_s = 0$ hints to a perfectly competitive input market where the price for raw milk equals marginal revenue product, whereas a $\theta_s = 1$ indicates to a monopsonistic market. Intermediate values, $0 < \theta_s < 1$, suggest the existence of an oligopsonistic market structure.

3.5 Empirical model

We estimate a reduced form model to address the endogeneity of raw milk prices and quantities by instrumentalizing both variables. Ideally, raw milk supply and the first order condition are estimated simultaneously (Muth and Wohlgenant 1999, Perekhozhuk 2014; Scalco and Braga 2014). However, a simultaneous nonlinear three-stage least squares estimation was not feasible in our case.

For our reduced form approach, we estimate the supply elasticity first which is then used in the estimation of the first order condition. The supply of raw milk is estimated in a two stage least squares estimation to address the endogeneity of raw milk quantity and price. A lagged raw milk price, wage, capital costs, output price and fuel prices serve as instruments. The fitted values of the instrumentalized raw milk price are then used to estimate the raw milk supply a dairy is confronted with (equation (3.1)):

$$\begin{aligned}\ln x_M = {} & \alpha_0 + \alpha_{priv} priv + \sum_{s=1} \alpha_s stateDum_s + \alpha_M \ln w_M + \alpha_F \ln afeed \\ & + \alpha_B \ln apbulls + \alpha_{FM} \ln afeed \times \ln w_M + \alpha_{BM} \ln apbulls \times \ln w_M \\ & + \alpha_{FB} \ln afeed \times \ln apbulls + \alpha_{MM} \ln w_M \times \mathrm{n}\, w_M + \alpha_{TM} t \times \ln wm \\ & + \alpha_C acows + \alpha_T t + \alpha_L \ln aw_l + \alpha_K \ln aw_k \end{aligned} \quad , \qquad (3.4)$$

where the variable *priv* indicates whether a dairy is organized as cooperative or investor–owned firm, *stateDum* are dummies for the federal states, *afeed*, *apbulls* and *acows* contain information on feed prices, prices for young bulls and number of cows in the competitive area of a dairy, respectively. As the conjectural variation approach measures interactions between firms, this supply is also depending on the quantities and prices competing dairies offer. In contrast to other studies (Muth and Wohlgenant 1999; Perekhozhuk 2014; Scalco and Braga 2014) we therefore incorporated the labor (aw_l) and capital costs (aw_k) of dairies in dairy *i*'s competitive area as indicators for their demand.

The competitive area is defined, following Zavelberg and Storm (2015), with a spatial weighting matrix W_t of size $(N_t \times N_t)$ with N_t being the number of dairies in year *t*. The elements of W_t are defined as $w_{ijt} = 1$ if farm i and j are neighbors and $w_{ijt} = 0$ otherwise (also $w_{ijt} = 0$ if $i = j$). Competitors are defined as the nearest dairies that together produce at least as much as the considered dairy.

The supply elasticity is given by

$$\begin{aligned} \varepsilon &= \frac{\partial \ln x_M}{\partial \ln w_M} \\ &= \alpha_M + \alpha_{FM} \ln afeed + \alpha_{BM} \ln apbuls + \alpha_{MM} \ln w_M + \alpha_{TM} T \end{aligned} \quad . \qquad (3.5)$$

By using the data of the competitive area, we ensured that we get a unique supply elasticity for each dairy *i*. This elasticity is then used for the estimation of the first order condition (equation (3.3)) where x_M is instrumentalized with the fitted values of x_M of the supply equation.

Following Muth and Wohlgenant (1999), we assume a reduced-form marginal product specification and assume a fixed proportion technology such that $q = x_M$:

$$\frac{\partial f_q(x_M, x_L^*, x_K^*)}{\partial x_M} = \beta_0 + \beta_M x_M + \beta_L w_L + \beta_K w_K + \beta_P P \,. \tag{3.6}$$

Muth and Wohlgenant (1999) assume first, this reduced form specification, second, a translog and third, a generalized Leontief production function. We tested all three specifications and got similar parameter estimates. The best model fit is achieved with the partial derivative of a generalized Leontief production function where the variables in equation (3.6) are substituted by their square roots. Using the partial derivative of a generalized Leontief production function in the first order condition (equation(3.3)) leads to

$$w_M = P \cdot \left(\beta_0 + \beta_M x_M^{1/2} + \beta_L w_L^{1/2} + \beta_K w_K^{1/2} + \beta_P P^{1/2}\right) \Big/ \left(1 + \frac{\theta}{\varepsilon}\right). \tag{3.7}$$

To estimate this function, nonlinear fixed effects panel estimation is used. Reformulation of equation (3.7) leads to

$$\text{diff}w_M = \frac{\beta_0 \text{diff}\left(P\right) + \beta_M \text{diff}\left(P x_M^{1/2}\right) + \beta_L \text{diff}\left(P w_L^{1/2}\right) + \beta_K \text{diff}\left(P w_K^{1/2}\right) + \beta_P \text{diff}\left(P P^{1/2}\right)}{\left(1 + \frac{\theta}{\varepsilon}\right)} \tag{3.8}$$

where all variables are defined as the difference from their ID specific mean, $\text{diff}\left(var\right) = var - \text{mean}(var)$ with $var = P, Px_M^{1/2}, Pw_L^{1/2}, Pw_K^{1/2}, PP^{1/2}$.

To estimate market power for the dairy industry in each of the federal states analyzed, the market power parameter in equation (3.8) is defined as follows:

$$\theta = \sum_{s=1}^{n} \theta_s stateDum_s \,. \tag{3.9}$$

3.6 Data Description

We use a panel data set containing yearly information for the time span 2001-2012 and focus on conventional processing dairies. The data on dairies' type of production, processing quantity, legal form and raw milk prices was gathered by the AMI (Agrarmarkt Informations-Gesellschaft mbH). As we were not able to obtain data on product portfolios and the wholesale prices received by dairy processors, P serves as a price indicator for the national average selling price for butter, cheese, skim milk, whole milk and whey powder (Milchtrends 2015). Information on wages in the dairy industry was collected from the statistical offices of the federal states in Germany. Yearly national interest rates for corporates with a rate fixation up to 1 year was obtained from the European Central Bank (European Central Bank 2015). Regarding variables for milk supply, number of cows are available from EUROSTAT (EUROSTAT 2015), feed costs from the Farm Accountancy Data Network (FADN 2015) and the prices for young bulls from the Directorate-General for Agriculture and Rural Development (DG AGRI 2015). Data on transportation costs (*fuel*) are sourced from the Association of the German Petroleum Industry (Mineralölverband 2015).

The data that is used for the estimation is summarized in the following table.

Table 3.2: Description of model variables

variable	Description	unit	descriptive statistics*
x_M	Yearly quantity of procured raw milk by dairy processors in Germany	kg	mean: 1.85e+08, SD.: 3.28e+08 min: 908000, max: 3.15e+09
w_M	Yearly average price for raw milk paid by dairy processors	ct/kg	mean: 0.31, SD.: 0.03 min: 0.22, max: 0.41
Priv	Dummy variable. Dairy is cooperative or privately owned	-	-
stateDum	Dummy variable for location of dairy	-	-
w_L	Hourly wage for workers in the dairy industry on federal states basis	€/h	mean: 15.30, SD.: 2.72 min: 10.91, max: 21.06
Feed	average feed costs per cow in federal states	€/cow	mean: 642.90, SD.: 182.06 min: 349.90, max: 1610.83
Cows	sum of dairy cows in federal states	-	mean: 721,454,2, SD.: 469,889.4 min: 107,950, max: 1,384,600
Fuel	yearly average price per litre diesel fuel in federal states basis	€/l	mean: 115.85, SD.: 15.71 min: 94.58, max: 143.04
w_K	Yearly national interest rate for corporates, rate fixation up to 1 year	%	mean: 4.31, SD.: 0.76 min: 2.99, max: 5.67
P	price index containing the national average selling price for butter, cheese, skim milk, whole milk and whey powder	€/kg	mean: 2.31, SD.: 0 .28 min: 1.85, max: 2.94
Pbulls	National price for young bulls	€/100 kg carcass weight	mean: 302.22, SD.: 42.05 min: 249.07, max: 397.09

**Descriptive statistics are calculated for the whole dataset across all observations.*

3.7 Estimation results

Several specifications of the supply function were tested to obtain the best model fit ($R^2 = 0.174$, see Appendix for full results). The displayed federal states' supply elasticities are the aggregation of firm specific supply elasticities (see table 3.3). However, as the coefficients used for the calculation of the supply elasticities are not statistically significant, they have to be regarded with caution.

Table 3.3: Supply elasticity

BB	LS	HE	NW	MV	ST
0.722	0.725	0.790	0.793	0.803	0.808
SN	TH	SH	BY	BW	RP
0.810	0.957	0.961	1.049	1.133	1.191

The aggregated supply elasticities are all close to unity and positive, reflecting a rather elastic supply function.

Table 3.4: National market power parameter

	Estimate		Std. Error	t value	Pr(>|t|)
θ	0.0100	***	0.0009	10.7620	< 2e-16
β_P	-0.5191	***	0.0136	-38.0480	< 2e-16
β_M	0.0000	***	0.0000	6.0960	0.0000
β_L	0.0159	***	0.0007	22.7190	< 2e-16
β_K	0.0309	***	0.0009	36.3150	< 2e-16
β_0	1.1450	***	0.0305	37.5760	< 2e-16
$R^2 = 0.6565$					

*Signif. Codes: *** 0.001, ** 0.01, * 0.05, . 0.1*

The estimation of a national market power parameter for the whole dataset results in a conduct parameter that is statistically different from zero at the 0.001 level of significance (see table 3.4). Hence, we can reject the null hypothesis of a perfectly competitive market. The estimate suggests the existence of an oligopsonistic market structure. However, the parameter value is close to zero. The response to a 1% increased raw milk input demand of a certain firm leads to a 0.01 % increase of the whole dairy industry's input. The price distortion reflected by $D = \theta / \varepsilon$, measures the price deviation from marginal revenue product. The national price deviation is equal to 1%. Hence, the price is 1% lower than in a perfectly competitive market.

Table 3.5: Market power parameters for the federal states

	Estimate		Std. Error	t value	Pr(>|t|)
θ_{SH}	-0.0690	***	0.0050	-13.7590	< 2e-16
θ_{LS}	0.0131	.	0.0077	1.7150	0.0866
θ_{NW}	0.0192	***	0.0055	3.5060	0.0005
θ_{HE}	-0.0301		0.0363	-0.8290	0.4070
θ_{RP}	0.1725	***	0.0136	12.6500	< 2e-16
θ_{BW}	0.0537		0.0350	1.5340	0.1252
θ_{BY}	0.0233	**	0.0074	3.1720	0.0015
θ_{BB}	-0.0236		0.0188	-1.2540	0.2099
θ_{MV}	0.0014		0.0047	0.3020	0.7625
θ_{SN}	0.0441	***	0.0038	11.7230	< 2e-16
θ_{TH}	0.0452	***	0.0095	4.7660	0.0000
θ_{ST}	-0.0315	**	0.0119	-2.6450	0.0083
β_P	-0.5220	***	0.0140	-37.2890	< 2e-16
β_M	0.0000	***	0.0000	6.2100	0.0000
β_L	0.0158	***	0.0008	20.4960	< 2e-16
β_K	0.0305	***	0.0009	33.9970	< 2e-16
β_0	1.1510	***	0.0312	36.9330	< 2e-16

$R^2 = 0.8508$

With HE=Hesse, SN=Saxony, BB=Berlin and Brandenburg, LS=Lower Saxony, RP=Rhineland Palatinate, TH=Thuringia, MV= Mecklenburg-Western Pomerania, SH=Schleswig-Holstein, BW=Baden-Wuerttemberg, ST=Saxony-Anhalt, NW=North Rhine-Westphalia, BY= Bavaria

*Signif. Codes: *** 0.001, ** 0.01, * 0.05, . 0.1*

The estimation of the conduct parameters for the federal states' dairy industries shows non-significant results for Hesse, Baden-Wuerttemberg, Berlin and Brandenburg and Mecklenburg-Western Pomerania, proofing the null hypothesis of perfect competition (see table 3.5). For Schleswig-Holstein (SH) and Saxony-Anhalt (ST) the parameter estimates are significantly negative. Evidence for an oligopsonistic market structure is provided in six federal states (LS, NW, RP, BY, SN, TH). Except for Rhineland-Palatinate ($\theta_{RP} = 0.1725$), the parameter values show a rather low response of the dairy industry's input with respect to a single dairy's input change, the parameters are close to zero.

Table 3.6: Oligopsonistic price distortion

BY	LS	NW	RP	SH	SN	ST	TH
0.0222	0.0164	0.0242	0.1448	-0.0718	0.0545	-0.0390	0.0472

Accordingly, Rhineland-Palatinate shows the highest price distortion (see table 3.6).

3.8 Discussion

Due to the non-significant impact of explanatory variables of the supply estimation that enter the supply elasticity calculation, the estimates of the market power parameters have to be regarded with caution. A specification of the supply function similar to Perekhozhuk et al. (2014), without incorporating the reactions of other dairies in the competitive area, does not improve the model fit of the supply function. Resulting elasticities are more inelastic, however, with respect to the results, different specifications of the supply function do not lead to major changes of the conduct parameters. Expressing variables as differences from the mean could also not improve the model fit of the supply estimation. Generally, we do not have a high correlation between the raw milk price w_M and the processed quantity x_M $\left(corr(x_M, w_M) = -0.12\right)$. This might influence the validity of the supply function and the solving of the three-stage least squares estimation negatively.

The estimation results show that not all conjectural variation parameters are in the theoretical meaningful range $(0 \leq \theta \leq 1)$, but almost all are close to zero. These results are in line with those found by Scalco and Braga (2014) who found market power parameters for Brazilian regional dairy industries ranging between -0.02 and 0.08. They reject the hypothesis of a monopsony for all regions and the hypothesis of perfect competition for some of the regions. However, as the parameters are close to zero, they conclude that the distortion from oligopsony power is rather small and that the market is close to perfect competition.

Our results provide evidence for an oligopsonistic market structure in six federal states and also on the national level. However, the market power parameter estimates indicate to a small impact of oligopsony power of a single dairy on the whole dairy industry. Except for Rhineland-Palatinate where we find the highest market power parameter. Rhineland-Palatinate is also a state with a high concentration of dairies (see table 3.1). Concerning the correlation between the market power parameter and the concentration indices, we find a small positive correlation with the C2 (share of the two largest processing dairies in the corresponding state) and the C3 indicator (share of the largest three dairies) that we presented in table 3.1 (see table 3.7).

Table 3.7: Correlation coefficients between conduct parameter and concentration

	C1*	C2	C3
θ	-0.0003	0.218478307	0.1750

* *Concentration classes measured as quantities of largest processors relative to total processing quantity in the corresponding federal state, adapted from Table 3.1*

These findings are especially important with respect to the assumed positive effects of concentration on market power as stated in the milk market survey of the cartel authority (BKA 2012) and also in empirical literature (Jank, Farina and Galan 1999; Martins and Faria 2006). However, we have to keep in mind that we can only measure concentration with respect to processing quantities and not as usually practiced with the Herfindahl Hirschmann Index. Furthermore, the results reveal that the hypothesis of perfect competition is rejected for Bavaria, a state with a high number of dairies and low concentration. Furthermore, the results suggest a perfectly competitive market for Mecklenburg-Western Pomerania, a federal state with a high concentration of dairies.

Even though most of the significant conduct parameters are close to zero, the price distortions for the low conduct parameters range between -7% (SH) and 5% (SN). Hence, our results indicate that the raw milk price is 5% lower than it would result under perfect competition in Saxony. Even for Bavaria the price distortion is 2%. The highest price distortion is observed in Rhineland-Palatinate with 14%.

3.9 Conclusion

This study contributes to the ongoing discussions about low raw milk prices, market power and further concentration of dairy processors, especially in light of the quota abolition. Evidence for an oligopsonistic market structure is found in six federal states (LS, NW, RP, BY, SN, TH), while the results suggest a perfectly competitive market in four federal states (HE, BW, BB, MV). On a national level, the null hypothesis of perfect competition needs also to be rejected. Even though most of the significant market power parameters are close to zero, price deviations from perfect competition range between 1% and 14%. However, these findings have to be regarded with caution as the estimation of the supply elasticity parameters was not significant.

Regarding future research, there are several data requirements that may improve the estimation of market power and bring more insights on the German raw milk market behavior. A production function of the dairies that comprises output quantities and prices on dairy plant level would be beneficial for the estimation. With such data, the market power parameters could be estimated more precisely incorporating the different marketing channels and product portfolios of single dairies. As we could not obtain this kind of data, we used a national price index for dairy output and had to assume a fixed proportion technology. However, a variable proportion technology would be more appropriate. Further, more detailed information on input quantities or prices other than raw milk would be helpful to incorporate specific characteristics and economies of scales. As the market power parameter crucially depends on the elasticity of supply, it is highly important for future research to improve this estimation with appropriate data. The estimation with the competitive area of dairies is used to depict the supply a dairy is facing. However, the size of the competitive area may be underestimated. The competitive area crucially depends on the size of a dairy and its neighbors. The raw milk collection area might however be larger. Further, cross border effects are not incorporated. Hence, the estimation would benefit from more detailed information on the competitive area that would really give an idea how large the competitive areas of dairies are and how many competitors they have. This would also provide a more accurate measure for concentration. With our rather crude measure for concentration, depending on the processing quantities of dairies in the federal states, we find only a small correlation between concentration and buyer market power.

3.10 References

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3.11 **Appendix**

Table 3.8: Estimation of supply function

	Estimate		Std. Error	t value	Pr(>|t|)
α_0	-1578.000		1389.000	-1.136	0.256
α_{priv}	-0.225	***	0.060	-3.772	0.000
α_{SH}	-0.721	***	0.172	-4.198	0.000
α_{LS}	0.049		0.125	0.389	0.697
α_{NW}	0.525	**	0.161	3.267	0.001
α_{HE}	-0.275		0.250	-1.097	0.273
α_{RP}	2.861	***	0.290	9.879	< 2e-16
α_{BW}	0.702	***	0.165	4.264	0.000
α_{BB}	0.566	*	0.238	2.379	0.018
α_{MV}	0.781	***	0.204	3.839	0.000
α_{SN}	0.385	.	0.209	1.839	0.066
α_{TH}	-0.423	*	0.200	-2.112	0.035
α_{ST}	-0.233		0.206	-1.132	0.258
α_M	-1069.000		1133.000	-0.944	0.345
α_F	-7.262		7.447	-0.975	0.330
α_B	-14.720		19.710	-0.747	0.455
α_C	0.000	**	0.000	3.047	0.002
α_T	0.844		0.742	1.137	0.256
α_{MM}	1.381		3.414	0.405	0.686
α_L	-2.002	***	0.477	-4.198	0.000
α_K	0.301		0.348	0.863	0.388
α_{FM}	-0.916		1.810	-0.506	0.613
α_{BM}	-5.002		11.650	-0.429	0.668
α_{TM}	0.551		0.595	0.926	0.354
α_{FB}	1.094		1.185	0.923	0.356
$R^2 = 0.1714$					

*Signif. Codes: *** 0.001, ** 0.01, * 0.05, . 0.1*

Chapter 4

Pricing behavior of cooperatives and investor-owned dairies under spatial competition*

Abstract

This paper analyses differences in the pricing behavior between cooperatives and investor-owned dairies for raw milk in a spatial market setting. We systemize the theoretical literature concerning the relations between price and space in oligopsonistic markets. This provides the foundation for empirically analyzing the price-space relationship in the German raw milk market. Space represents the distance to competing dairies and transportation cost. We differentiate between cooperatives and investor-owned dairies in North and South Germany. Specifically, the impact of a dairy's own legal form and that of neighboring competitors on the pricing behavior is assessed. For the South of Germany, a negative relationship between space and raw milk price is found while for the North the relationship is positive. In both North and South, the effect is stronger for cooperatives compared to investor-owned firms. Overall, our findings do not necessarily suggest an increase in market power and a decrease in raw milk prices when the concentration process of the dairy sector is progressing. Further, this paper provides the first spatial analysis of the competitive yardstick effect, for which we find weak evidence in the South. For the north, the theory of the competitive yardstick effect cannot be supported empirically. The estimation is based on a panel-data set covering all German dairies from 2001 to 2012 providing information on raw milk prices, processing quantities, legal and production form.

Keywords: imperfect competition, spatial competition, competitive yardstick

JEL classification: D43, R32, C51

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4.1 Introduction

Raw milk markets are typically spatially limited due to the high perishableness of the commodity. Therefore, dairy processors compete for raw milk in a certain market area. Understanding the effects of a spatial market setting on raw milk prices is getting more important as the ongoing concentration process among processors may increase their local monopsony power.

The literature provides several theoretical studies deriving positive, negative and inverted U-shaped relations between price and space[10]. In the analysis of mixed markets, the competitive yardstick effect is also evaluated suggesting a procompetitive effect of neighbouring COOPs on IOFs' pricing (Cotterill 1987; Sexton 1990; Rogers and Sexton 1994; Alvarez et al. 2000; Zhang and Sexton 2001; Fousekis 2011a and b; Tribl 2012). However, only few studies conduct an empirical analysis on spatial pricing behaviour. The pioneer in this field is the empirical analysis of Alvarez et al. (2000) which focuses on the relation between price and space on the milk market in the Asturias region. Following this study, Huck et al. (2006), Graubner et al. (2011)[11] and Koller (2012) focus on the German milk market. Alvarez et al. (2000) theoretically derive an inverted U-shaped relationship between price and space[12], which they could verify in their empirical estimation with data on investor-owned firms (IOFs). Based on Alvarez et al.'s

[10] Usually defined as distance to competing firms multiplied by transportation costs.

[11] Graubner et al. (2011) use a vector error correction model and find low price transmission. This methodology is however not relevant for our study.

[12] Also defined as the distance to neighboring dairies multiplied by unit transportation costs.

(2000) framework, Huck et al. (2000) focus on the analysis of a cooperative (COOP) market only. They theoretically derive an inverted U-shape relationship between price and space that lies above the one of IOFs, implying a higher raw milk price of COOPs. The empirical results for a region in Northern Germany support the shape of the curve but they do not empirically analyse the price spread between COOPs and IOFs. Koller (2012), also building upon Alvarez et al. (2000), empirically shows an inverted U-shaped relationship between price and space for Germany. However, as they use a panel model with fixed effects, they cannot differentiate between effects of legal forms of dairies. The competitive yardstick effect has been evaluated mostly theoretically (Cotterill 1987; Sexton 1990; Fousekis 2011a; Tribl 2012). Empirically, Hanisch et al. (2013) find evidence for Germany in a national-level analysis of the European dairy market.

Besides (i) providing a literature review categorizing the existing findings on relations between price and space, this paper, in contrast to former empirical studies on spatial pricing, (ii) differentiates between the effects of space on COOPs and IOFs in the North and the South of Germany while incorporating effects of neighbouring dairies' characteristics on raw milk pricing in a spatial regression analysis. Additionally, (iii) the competitive yardstick is analysed on firm-level in this spatial setting.

To investigate to what extent dairies can exercise monopsony power, we explore the relationship between price and space, defined as the average distance to neighbouring dairies multiplied by unit transportation costs. We employ a spatial regression approach to analyse if and how raw milk prices are influenced by space and by neighbouring dairies' characteristics, such as legal and production form. The results allow comparing the shape of the relationship between price and space to the theoretically derived relationships in the literature. In this spatial context, we analyse the competitive yardstick effect. Therefore, and to incorporate the different objectives of COOPs and IOFs, we differentiate between the pricing behaviour of these two legal forms in our empirical analysis. Additionally, we distinguish between North and South Germany to account for different market structures. The estimation is based on a data set covering all German dairies from 2001 to 2012 providing information on dairies' location, raw milk prices, processing quantities, legal and production form.

4.2 Relevant literature on spatial pricing

To asses to what extent monopsony power can be exercised in a spatial market, the investigation of the relation between price and space is essential. In order to systemize the relevant literature, table 4.1 summarizes the identified relationships between price and space and the main underlying assumptions. The price-space relationship may have an inverted U-shape, a monotone negative or a monotone positive relationship. The relationship depends on the type of market actors (mixed or pure IOF or COOP markets), pricing (uniform delivered pricing (UD) where the dairy pays the shipping or free on board shipping (FOB) where the farmer pays the shipping), competition (Hotelling-Smithies (H-S) or Löschian Competition) and

COOPs objective function and membership policy (net average revenue product pricing (NARP) or total member welfare maximization (TMW), open membership (OM) or restricted membership (RM)).

Table 4.1 also reports whether the competitive yardstick was confirmed. This theory states that COOPs have a procompetitive effect in a mixed market. It builds on the assumption that COOPs, which are owned by farmers and do not have to deal with shareholders, will not accept prices below average cost. This pricing will serve as a yardstick for other market actors and thus influence the prices of competing IOFs, which leads to market prices equal to average costs in the long run (Cotterill 1987). Hanisch et al. (2012) validate the competitive yardstick effect in a country level analysis of the European dairy industry. They find that the higher the market share of COOPs, the higher the milk farm price. In a theoretical framework of spatial competition, the competitive yardstick could also be confirmed (Sexton 1990; Tribl 2012; Fousekis 2011a).

Table 4.1: Summary of relevant literature

Author Year	Market actors	Pricing/ conjecture	theory: relation price - space	Empirical estimation	CYE	comment
Sexton (1990)	IOF & COOP[1,2,3]	FOB H-S, Lösch, Cournot	bounded line market no explicit relation derived	/	confirmed	focus on farm-retail price spread depending on the different assumptions on competition, market actors and NARP function
Rogers & Sexton (1994)	IOF & COOP	FOB H-S, Lösch, Cournot	bounded line market positive relation: Lösch, IOF negative relation: H-S, Cournot, IOF negative relation: Lösch, H-S, mixed market	/	confirmed	focus on farm-retail price spread, space measured as transport cost
Alvarez *et al.* (2000)	IOF	UD Lösch	unbounded line market inverted U-shape	confirms theory	/	
Zhang & Sexton (2001)	IOF	FOB, UD H-S	bounded line market negative relation	/	/	focus on strategic choice of FOB or UD
Fousekis (2011a)	IOF & COOP[1,3]	UD, FOB H-S	bounded line market negative relation	/	partially confirmed	CYE depends on pricing
Fousekis (2011b)	COOP	UD , FOB H-S	bounded line market negative relation	/	/	
Huck *et al.* (2012)	COOP[1,4]	UD Lösch	unbounded line market inverted U-shape	confirms theory	/	assumptions as Alvarez et al. (2000), inverted U-shape for COOPs, lying above IOF
Koller (2012)	IOF & COOP	UD Lösch	unbounded line market inverted U-shape	confirms theory	/	review of Alvarez et al. (2000), no theoretical analysis of spatial pricing in a mixed market, no differentiation between legal forms due to fixed effects
Tribl (2012)	IOF & COOP[1,3]	UD Lösch	bounded line market negative relation of price and space for all scenarios	/	confirmed	analysis of simultaneous and sequential games under different assumptions on COOPs choice of market radius

[1]*open membership*, [2]*restricted membership*, [3]*NARP*, [4]*TMW*

Table 4.1 shows that only few studies prove their theoretical findings empirically. These studies are conducted on the milk market in Spain by Alvarez et al. (2000), in Germany by Koller (2012) and in the German federal state Schleswig Holstein by Huck et al. (2012). All three studies are based on the theoretical framework of Alvarez et al. (2000) who derive a U-shaped relationship of price and space based on the assumptions of an IOF market and an unbounded line market, which allows for competition in the backyard. In this setting, when space is relatively unimportant (i.e. firms are located close to each other or transportation cost are low), the market areas of rival firms may extend beyond the other firms' location leading to increasing prices in space. According to Alvarez et al. (2000), this follows from UD pricing and Löschian competition leading to a price matching behavior of dairies. Under UD pricing, dairies are responsible for the shipping costs such that they are willing to increase market area until profits are zero for the most distant farm. Consequently, if a dairy raises its price, it will reduce its market area losing some farmers at the boundary. Due to price-matching behavior, the dairy expects its rival to increase its price as well. Hence, the market area of the rival is also decreasing and the dairy can capture the farmers in the own backyard abandoned by the rival. Those are more profitable compared to the ones it loses at its market boundary, leading to higher profits under UD pricing. If space gets more important (due to higher transportation costs or a higher distance to neighboring dairies), competition takes place only between the firms' locations and implies a negative relation between price and space in line with the theory of a bounded line market applied in other studies (see Sexton 1990; Zhang and Sexton 2001; Tribl 2012; Fousekis 2011a and 2011b). The negative relation between price and space is explained by the inverse relationship between transportation costs and market area between firms, which may result in separated monopsonistic markets. In the empirical studies of Alvarez et al. (2000), Huck et al. (2012) and Koller (2012), the inverted U-shape is shown for an IOF market, a COOP market and a mixed market, respectively. Even though Koller (2012) did an empirical analysis for Germany there is no differentiation between legal forms as a panel model with fixed effects is used.

The inverted U-shape mainly stems from the assumption of the unbounded line market. Studies that assume a bounded line market mainly derive a negative relationship, independent of assumptions on market actors, pricing and conjecture (Zhang and Sexton 2001; Fousekis 2011a & 2011b; Tribl 2012). However, Rogers and Sexton (1994) find a positive relation between price and space (defined as transportation costs) for an IOF market under FOB pricing and Löschian competition. The reasoning is that firms' market radius does not overlap under FOB pricing. In combination with Löschian competition firms try to keep their market areas and match price changes of their competitors. Hence, the relation between price and transportation costs is positive as firms increase prices with market area to cover farmers' transportation costs. In Rogers and Sexton's (1994) analysis, this positive relation is only valid for the competition of IOFs. In a mixed market, they only consider the case of a COOP facing an upward sloping NARP curve. In this scenario, the relation between price and space gets negative. This negative relation can be explained as follows. If the IOF gains a larger market area due to a price increase, the COOPs sales are decreasing, which leads to an increase in average fixed costs. Hence, the price the COOP can pay to its members decreases. This leads to separate markets of the COOP and the IOF, hence lower competition and a negative relation between price and space. Furthermore, Rogers and Sexton (1994) analyze IOF markets with FOB pricing and Hotelling or Cournot behavior and a mixed market with Hotelling behavior which all result in a negative relation between price and space.

4.3 Data and Empirical Model

We use a panel data set containing yearly information on the German milk market for the time span 2001-2012. The data provides information on dairies' type of production, processing quantity, legal form and raw milk prices and was gathered by the AMI[13]. The raw milk prices are for milk of grade one with 4.2% fat and 3.4% protein including additional payments, such as boni for large delivered quantities or loyalty, net of costs like quality assessment or storage costs allowing for comparability of the raw milk prices. Additionally, we compose a performance index (*perf*) by using the awards for the best dairy products from the German magazine *Milch Marketing* (Milch Marketing (years 2001-2012)). The index calculates as the sum of award points over the observed period and used as a proxy

[13]Agrarmarktinformationsstelle, a German institution that collects data of agricultural entities

for the output performance. Data on transportation costs (*t*) are sourced from the Association of the German Petroleum Industry[14].

Following Alvarez et al. (2000), Huck et al. (2012) and Koller (2012), we define neighbors as the nearest dairies that together produce at least as much as the considered dairy[15]. Our analysis is restricted to conventional dairies; however, for the neighboring definition, also organic dairies are included. The reasoning is that organic milk prices might influence conventional prices as farmers in the long run could switch to organic production when the price spread gets too high. As in Alvarez et al. (2000), we use the neighboring definitions in order to calculate the average distance of a dairy to its neighbors (*nDist*) and the importance of space as product of average distance to neighbors and transportation cost, $s = t \cdot nDist$[16]. Further, we use the neighboring definition to setup a spatial weighting matrix W_t of size $(N_t \times N_t)$ with N_t being the number of dairies in year *t*. The elements of W_t are defined as $w_{ijt} = 1$ if farm i and j are neighbors and $w_{ijt} = 0$ otherwise (also $w_{ijt} = 0$ if $i = j$). The spatial weighting matrix is row standardized and used to calculate the neighboring share of COOPs (*wCoop*) and organic dairies (*wOrganic*) as well as the number of neighbors (*numNeig*).

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[14]Data is published at www.mwv.de.

[15]Due to the identification of the location with postal codes we observe a zero distance to neighbours for some dairies. However, this does not mean that they have zero number of neighbours which is not possible according to our neighbourhood definition.

[16]Transportation cost are measured as the yearly average price per litre diesel fuel. This is in line with Alvarez et al. (2000). Huck et al. (2012) and Koller (2012). This definition implicitly assumes constant fuel consumption per kilometre over the sample period. To deviate from this assumption is not possible, however, as we have no information about changes in fuel efficiency over time.

In 2012, 41 % of the German milk processors were organized as COOPs, processing 59 % of total milk supplied to dairies, the remaining are privately owned. As we focus on the differences between IOFs and COOPs while differentiating between North and South, table 4.2 summarizes the key facts for the year 2012.

Table 4.2: The milk market in 2012 – key facts

		IOF		COOP	
		North	**South**	**North**	**South**
Number of processing facilities	total	37	45	29	29
	conv.	31	32	27	20
	org.	6	13	2	9
Conventional raw milk price *in ct/kg*	mean	30.92	32.19	30.59	32.12
	min	22.32	24.15	21.84	24.08
	max	37.19	38.65	37.68	40.85
Organic raw milk price *in ct/kg*	mean	38.31	39.72	39.26	39.21
	min	32.13	33.19	33.75	32.70
	max	49.61	50.34	47.16	51.57
Conv. raw milk production *in tons*	sum	5.6 Mio	5.2 Mio	12.4 Mio	3.3 Mio
	mean	183,848	165,476	460,873	166,057
Org. raw milk production *in tons*	sum	173,994	241,179	18,004	188934
	mean	28,999	18,552	9,002	20993
Perf	sum	75	648	82	46
	mean	5.32	20.25	3.04	2.3
*nDist**	mean	38.5022	20.9388	37.0619	24.2491
	min	0	0	0	2.6426
	max	91.2841	68.0515	116.1928	39.7549
*numNeig**	Mean	2.42	2.44	3.15	2.40
	min (freq.)	1 (14)	1 (10)	1 (9)	1 (5)
	max	11	12	16	6

Taking a closer look at the market structures in the North and South[17] reveals that the market in the North is characterized by few large dairies opposed to the South with a high density of small dairies. From 2001 to 2012, the number of conventional dairy plants in the North changed from 111 to 58, a decrease of 48%, whereas the structural change in the South was not as strong with the number of

[17] The South comprises the federal states Bavaria and Baden-Wuerttemberg, the North the remaining federal states.

plants decreasing by 26% from 70 to 52. This change was not accompanied by a decrease in the total amount of milk processed but instead by a massive increase of average processing quantity by 104% in the North and 30% in the South. This results in an 89% higher average processing quantity in the North compared to the South. The differences in dairies' sizes and concentration of plants are also reflected in the market areas that we calculated. The average distance to neighbors is 33.92 km with a maximum distance of 91.28 km in the North compared to an average distance of 20.18 km with a maximum distance of 41.68 km in the South. Differences between North and South can also be observed in the prices that are lower in the North. Differences in COOP's and IOF's pricing cannot be seen clearly from table 4.2, this issue will be further analyzed in a multivariate regression in to following. Overall, a comparison of the descriptive statistics indicates substantial differences in the competitive conditions in the North and South leading to fundamental difference in the market structure and diverse developments over time.

In our empirical analysis we estimate a spatially lagged explanatory variable model (SLX)[18] of the general form $y = X\beta + WX\theta + \varepsilon$ with y being a vector of the

[18] The SLX model is an alternative to the more commonly use spatial lagged dependent variable model (SAR). In principle we could also use the SAR model in order to assess the effect on neighboring prices on own prices. However, Gibbons and Overman (2012) argue in a paper provocatively entitled "Mostly Pointless Spatial Econometrics?" that the SAR model suffers from an identification problem that is not appropriately addressed in the applied literature. Instead they proposed the SLX model as one appropriate alternative.

dependent variable, X a matrix of explanatory variables, W a row standardized spatial weighting matrix, β and θ coefficients to be estimated and $\varepsilon \sim N\left(0, \sigma^2 I\right)$ with I being an identity matrix. As a first step, we estimated a model including cross terms of all variables with the South dummy variable (*SouthDum*). In effect, this results in two different regressions for North and South. In a next step, we apply a model selection approach based on the Akaike information criterion (AIC). Specifically, we split our explanatory variables in two sets, where the first includes all variables related to *s* while the second includes all remaining variables[19]. Then, model specifications are estimated that can be formed from all possible combinations of the variables in the first set. The variables from the second set are always included. We then select the model specification with the lowest AIC. Following, a Wald test is used to test if all remaining insignificant variables from the second set can be jointly excluded. This selection process results in the following specification[20] estimated with OLS,

[19] Specifically, the variables related to *s* include s, s^2, $s \times southDum$, $s^2 \times southDum$, $s \times COOP$, $s \times COOP \times southDum$, $s^2 \times COOP$, $s^2 \times COOP \times southDum$

$$\begin{aligned} price_{it} &= const + \alpha_1 s_{it} \times COOP_i + \alpha_2 s_{it}^2 \times COOP_i \\ &+\alpha_3 s_{it} \times COOP_i \times southDum_i + \alpha_4 COOP_i \\ &+\alpha_5 COOP_i \times southDum_i + \alpha_6 quant_{it} \times COOP_i \\ &+\alpha_7 wOrganic_{it} + \alpha_8 wCOOP_i + \alpha_9 wCOOP_i \times southDum_i \\ &+\alpha_{10} perf_{it} + \alpha_{11} perf_{it} \times southDum_i + \alpha_{12} numNeig_{it} \\ &+\alpha_{13} numNeig_{it} \times southDum_i \\ &+\sum_{j=1}^{12} \phi_j year_{itj} + \sum_{j=1}^{12} \delta_j year_{itj} \times southDum_i + \varepsilon_{it}, \end{aligned} \tag{4.1}$$

where $southDum_i$ and $COOP_i$ are dummy variables equal to one when a dairy *i* in year *t* is located in the South and a COOP respectively. Interaction terms between $south_i$ and $coop_{it}$ are used to find significant differences between North and South and between the legal forms respectively. The spatial lagged explanatory variables are $wCoop_{it} = \sum_{j=1}^{N} w_{ijt} Coop_{jt}$ and $wOrganic_{it} = \sum_{j=1}^{N} w_{ijt} Organic_{jt}$ with w_{ijt} being elements of W_t.

4.4 Results

The regression results are presented separately for North and South in table 4.3. The columns for South are constructed from the regression results by adding the estimated coefficients of the cross term between the south dummy and the respective variable to the estimated coefficients of the main effect of the variable. The p-value corresponds to the p-value from a Wald test, testing if the sum of the coefficient from the main effect and the coefficient from the cross term is significantly different from zero. In cases where the cross term with the south dummy is dropped during the model specification the results for South and North are the same.

Table 4.3: Regression results

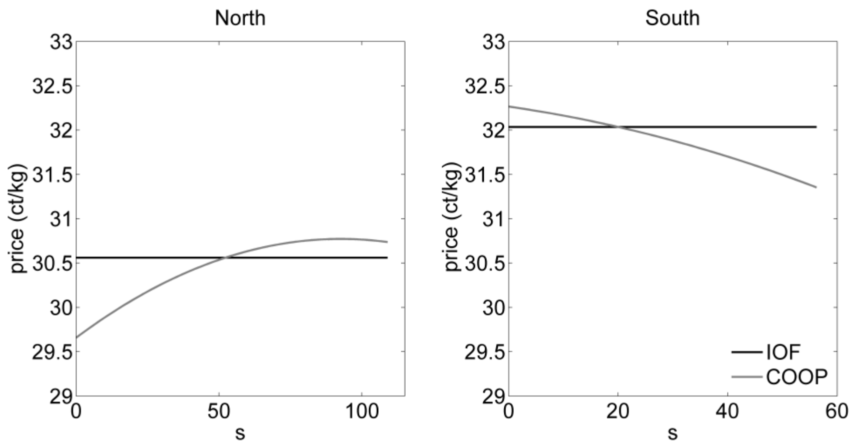
	North		South[a]	
	Coefficient	**P-value**	**Coefficient**	**P-value**
const	24.90	0.00	26.81	0.00
COOP	-1.03	0.00	0.15	0.21
wCOOP	-0.25	0.00	0.25	0.00
wOrganic	0.71	0.00	0.71	0.00
perf	0.02	0.00	0.00	0.01
numNeig	-0.10	0.00	-0.03	0.23
$s \times COOP$	0.02	0.00	-0.01	0.05
$s^2 \times COOP$	-0.00	0.02	-0.00	0.00
$quant \times COOP$	0.00	0.01	0.00	0.00
*yearDum*2001	14.29	0.00	13.24	0.00
*yearDum*2002	10.05	0.00	9.40	0.00
*yearDum*2003	8.39	0.00	7.25	0.00
*yearDum*2004	7.37	0.00	5.97	0.00
*yearDum*2005	6.14	0.00	5.28	0.00
*yearDum*2006	5.43	0.00	4.41	0.00
*yearDum*2007	11.59	0.00	9.80	0.00
*yearDum*2008	9.51	0.00	10.32	0.00
*yearDum*2010	6.28	0.00	4.85	0.00
*yearDum*2011	9.58	0.00	8.07	0.00
*yearDum*2012	5.92	0.00	5.05	0.00

$R^2 = 0.93$; R^2-adj. = 0.92, $\sigma^2 = 0.99$; N = 1761

[a] *In cases where a cross term is included in the model, the reported coefficient is equal to the sum of the coefficient of the main effect and the coefficient of the cross term. The p-value is then the p-value from a Wald test, testing if the sum of the coefficients from main effect and cross term is significantly different from zero.*

The estimated effect of space on price is plotted in figure 4.1 differentiating between North/South and IOF/COOP. Changes in *s* can result either from a change in transportation costs, from a change in density of neighbours, or simply from a change in production quantity. For the interpretation of the relationships, however, it is important to keep in mind that we control for production quantity in our regression[21]. The figure thus shows the relationship between price and space while keeping production quantity (and all other variables) constant.

Figure 4.1: Relation between price and space of COOPs and IOFs in the North and the South



Note: for 2012. All other variables are at means.

Figure 4.1 reveals opposite effects between price and space for North and South. However, the effects of a positive relation in the North and a negative relation in the South are only significant for COOPs. In contrast to Alvarez et al. (2000), Huck et al. (2012) and Koller (2012), we did not find a full inverted-U-shaped function

[21] In the presented results the $quant \times COOP$ is included. However, the variable $quant$ was considered in the model selection process. Excluding the $quant$ variable has almost no effect on the estimated coefficients related to s. The interpretation is therefore unchanged.

but rather the first increasing part for the North and the decreasing part of the function for the South.

The negative relation between price and space in the South is in line with the theory of competition between firms' locations (Sexton 1990; Alvarez et al. 2000; Zhang and Sexton 2001; Tribl 2012; Fousekis 2011a and 2011b). In Germany, the dairy pays for the transportation costs and farmers receive the same price independent of their location (BKA, 2009), hence theoretical relations between price and space resulting under UD pricing are of interest. The theory finds that under UD pricing in combination with either Löschian or Hotelling-Smithies competition between firms' location, prices are decreasing in space. Increasing space is equivalent to increasing transportation costs or increasing distance between firms' locations. Market areas are decreasing resulting in less competition between firms which can lead to separated markets that allow for monopsonistic pricing. This negative relationship between price and space is supported by our empirical findings for COOPs in the South.

The positive relation between price and space in the North could be explained with Alvarez et al.'s (2000) assumption of UD pricing, price matching behaviour and competition in the backyard (see section 2). The theory implies that when space is relatively unimportant, a firm increases its price and expects its rival to also increase its price (price matching behaviour). Higher prices lead to a reduction in the market area so that dairies gain farmers in their backyard. The assumption of competition in the backyard can be supported for the North as dairies maximum collection area is 170 km (BKA, 2009) which is larger than our derived maximum distance to neighbours equal to 116 km (with an average distance to neighbours of 37 km, see table 4.2). An alternative explanation for a positive relation between price and space is provided by Rogers and Sexton (1994) under the assumption of FOB pricing and Löschian competition, implying that dairies have to increase their prices so that farmers can cover the transportation cost. However, there is no evidence that FOB is practiced in the North.

It is remarkable that the relationship between price and space is stronger for COOPs than for IOFs[22]. The literature reviewed does not provide an obvious explanation for this effect. However, a possible explanation is that under the open membership policy, which is currently practiced in Germany (BKA, 2009), COOPs cannot reject farmers that want to participate. Hence, the COOP must consider the available market as its market area and cannot choose the optimal market area as an IOF. Therefore, it is possible that COOPs tend to have a larger market area than IOFs (despite the same average distance to neighbours calculated here) and thus space has a stronger effect on COOPs.

We observe that prices are generally higher in the South. This could stem from the general difference in the market structure of dairy farms resulting in lower raw milk production costs in the North (EMB 2013). Further, we find a positive relation between our performance variable and the South indicating that dairies in the South are producing more innovative and popular products that lead to higher output

[22] Despite the fact that there is a bit more variation in s for IOFs (std.=24.1) than for COOPs (std.=22.6).

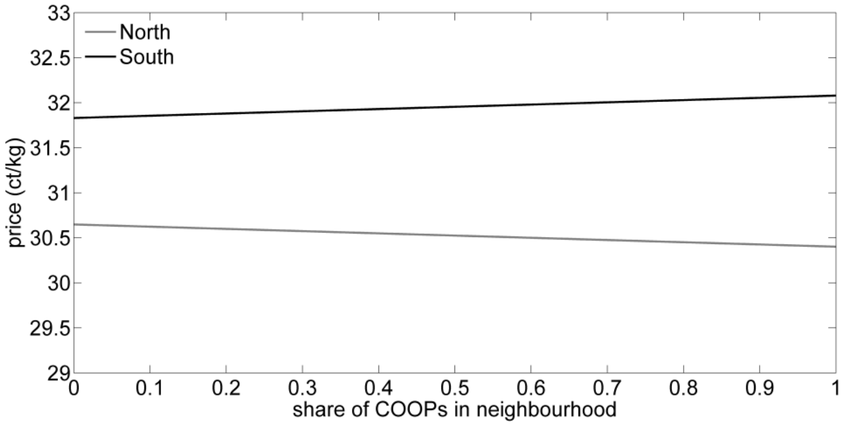
prices. In the North, large dairies might benefit from economies of scale. Further, the market structure can influence the price differences between North and South. As already observed, the market in the South is much denser, potentially intensifying competition between processors. Farmers have more selling alternatives, which might influence the price positively. The higher concentration of dairies in the North leads to only limited selling alternatives likely supporting market power of dairies and a generally lower price. Lower prices in the North hint at lower competition. However, this is a contradiction to the theory of competition in the backyard. If competition would be low, there is no incentive for a dairy to raise its price under UD pricing. Anyway, based on the results it is difficult to draw conclusion about the fierceness of competition which is also not the objective. Nevertheless, what we can conclude is that space has opposing effects on COOPs in the South and the North and no significant effects on IOFs.

Our regression results in table 4.3 show that COOPs pay a significant lower price than IOFs in the North (-1.03 ct/kg). In the South, COOPs pay a slightly higher price than IOFs (0.15ct/kg), however the effect is statistically not significant. These findings do not clearly support the general idea that COOPs pay higher prices as discussed in the competitive yardstick theory (Cotterill, 1987) and in Huck et al.'s (2012) theoretical analysis. However, other authors such as Cook (1995) Schramm et al. (2005) and EMB (2012) point out that the general idea of a COOP to maximize the welfare of members is debatable. As all members receive the same price and a COOP must not differentiate between members there is a free-rider problem. Furthermore, the heterogeneous risk levels of members influence investment decisions which in turn may negatively influence producer prices (Gerlach et al. 2006, BKA, 2009; Steffen et al. 2009). Hence, the lower price of COOPs may result from the fact that COOPs produce rather basic milk products like fresh milk and milk powder instead of innovative brand products (BKA, 2009; Steffen et al., 2009). We aim to control for such effects using our performance indicator (see section 4.3). This indicator is indeed on average higher for IOFs (see table 4.2) supporting the notion of IOFs being more innovative. We also find a positive effect of the performance index on the raw milk price. However, it might well be that the rather crude indicator does not fully capture product differences between COOPs and IOFS such that the COOP dummy still picks up some of these effects.

We checked the robustness of the model with respect to different neighbouring definitions. Specifically, we defined neighbours as all dairies that together produce at least a multiple of the own production quantity (e.g. all neighbours that together produce at least twice as much as the own quantity). Changes in the neighbouring definitions did not lead to a meaningful change of the results with respect to the main conclusions.

In order to analyse whether COOPs are beneficial for competition as suggested by the competitive yardstick effect, we use the neighbouring share of COOPs (*wCoop*) to test the hypothesis that a higher share has a positive effect on raw milk prices. This hypothesis is only supported in the South, where we find a significant positive influence of the share of COOPs in the neighbourhood on the price (see figure 4.2). For the North we find a significant negative effect. The negative effect for the North is consistent with the finding that COOPs in the North pay a significantly lower price as IOFs (-1.03 ct/kg). In both cases, however, the effect of the share of COOPs in the neighbourhood are rather small from an economic perspective as prices change by only -0.25/+0,25 ct/kg from zero COOP share to full COOP share in the North and South, respectively. Cross terms of the neighbouring shares of COOPs with the legal form could not improve the model. Hence, we observe no significant differences of the effects of *wCOOP* on the legal form. Hanisch *et al.*'s (2013) national analysis finds support for the competitive yardstick theory in Germany. In contrast to their study, we conducted a firm level analysis. However, we find no clear empirical support for the competitive yardstick theory in Germany.

Figure 4.2: Relation between price and share of COOPs in neighbourhood



Note: Estimated relationship for the year 2012. All other variables are at means.

Furthermore, our regression results show a positive influence of a high share of organic dairies in the neighbourhood. To our knowledge, there is no study that analyses the effects of organic prices on conventional prices. We find this effect to be higher in the North than in the South.

4.5 Conclusion

Unlike other empirical studies on milk markets (Alvarez et al. 2000; Huck et al. 2012; Koller 2012) we empirically estimate the relation between price and space in a mixed market, differentiating between different market structures. In contrast to these studies, we could not find a complete inverted U-shape of the relation between price and space. However, our empirical study reveals significantly different effects between price and space in the North and South of Germany that could result from the same effects as the inverted U-shape discussed in the literature. For the North, the relation between price and space is positive which can be explained by the effects of competition in the backyard. In the South, the relation between price and space is negative which is in line with the theory of competition on a bounded line market or an unbounded line market without competition in the backyard. Hence, both empirical findings can be interpreted in line with the theory. However, it is not clear why competition in the backyard should not exist in the South. Unfortunately, our results do not allow drawing conclusions in this respect.

Remarkably, significant effects of space on price are only found for COOPs. A possible explanation for this can be that due to the open membership policy, COOPs cannot discriminate between members preventing them from serving an optimal market radius as IOFs do. Hence, space is more important for COOPs.

Generally, we observe that prices are higher in the South which might result from the higher density of dairies fostering competition, a higher performance of dairies and higher production costs of farmers. In the North, large dairies may profit from economies of scales and lower production costs of farmers.

An interesting finding is that COOPs’ prices in the North are significantly lower than IOFs’ prices while in the South, COOPs’ prices are not significantly higher than IOFs’ prices. This does not confirm the general idea of COOPs that maximizes member welfare resulting in high prices for farmers. An explanation for the lower prices of COOPs in the North could be that the single farmer’s voting right in large COOPs is very small. This may lead COOPs behaving more like shareholder maximizing IOFs. Additionally, COOPs are on average less innovative than IOFs, potentially explaining the lower COOP price in the North. These findings underline the fact that we do not find clear empirical evidence for the competitive yardstick effect. Even though an increase in the share of neighbouring COOPs in the South increases prices, this effect is rather small from an economic perspective. For the North we found the exactly opposite effect, which is in line with our finding that the COOPs in the North pay significantly lower price than IOFs. In both cases however, even though the effects are significant, they are rather small from an economic perspective.

Overall, our findings suggest that a further concentration of the milk processing sector does not necessarily lead to an increase in market power and a decrease in prices. Our analysis, differentiating between legal forms, reveals that space is irrelevant for IOFs. Only for COOPs space matters for pricing behaviour with opposing effects for North and South.

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