How can differences in German raw milk prices be explained? An empirical investigation of market power asymmetries

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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 and related market information for the years 2001-2012, the conjectural variation approach allows analyzing market power of dairy processors towards raw milk producers. The paper contributes to the literature by providing an empirical up to date analysis of imperfect competition across and regions in Germany. The estimation results indicate an oligopsonistic market structure in Germany.

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

1 Introduction

The competitiveness of the dairy sector in Europe is driven by the abolition of the quota regime, increasing productivity, product innovation and is consequently undergoing substantial changes. Raw milk production in Germany increased in the last years following the decision to abolish the milk quota accompanied by a continuing decrease in number of farmers and dairy processors (BLE 2013 and ZMB 2013). Due to the high concentration of the dairy processing sector and farmers' access limited to only those dairy processors within a certain radius around the farm, the effects of imperfect competition on raw milk prices is of considerable interest.

There is a growing interest to analyze imperfect competition on agricultural markets which is important with respect to further research especially in terms of

policy implications (McCorrsiton 2002). The conjectural variation approach in the framework of the New Empirical Industrial Organization (NEIO) (Bresnahan 1989 and Lau 1982) has been frequently used to study oligopoly and oligopsony power on agricultural markets. Studies that are concerned with oligopsony power often focus on the retailing stage (e.g. Anders 2008, Mérel 2009 and 2011, Soregaroli et al. 2011, Sckokai et al. 2013) and use national industry level data. Notable studies specifically analyzing oligopsony power of dairy processors are Perehozhuk et al. (2009), Perehozhuk et al. (2011), Cakir and Balagtas (2012) and Perehozhuk et al. (2014). The papers by Perehozhuk study the Ukrainian dairy industry on a regional level as well as in the Hungarian dairy industry on plant level. Evidence for oligopsony power is found by both studies. The paper by Cakir and Balagtas focuses on the US market analyzing if dairy cooperatives may exert market power. Their main finding is that these co-operative are able to raise the farm milk price by 9% above marginal costs. Further studies that focus on regional market power are Wann and Sexton (1992) and Koontz and Garcia (1997) that found evidence of market power in the pear and meat packing industries.

The objective of this paper is to reveal potentially existing imperfect competition across Germany in the years 2001-2012 at the regional level. A conjectural variation approach serves as the theoretical basis for analyzing market power of dairy processors towards raw milk producers. Using a panel of dairy processors' price and processing data and related market data, the paper contributes to the literature by (1) analyzing market power in spatial markets applying the conjectural variation approach and (2) providing an empirical up to date analysis of imperfect competition across regions in Germany. This may constitute interesting information for the discussion about power asymmetries in the German raw milk market.

The remainder of the article is organized as follows. In the first part the raw milk market in Germany is presented to get an overview of the current situation on the German milk market and its developments. Then, measurements to assess oligopsony power are discussed and related literature is presented. The second part

of the paper contains the theoretical model description and the empirical analysis followed by the conclusion.

2 The German milk market

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 (European Dairy Association 2013). Germany is the highest processor of milk (about 30 Mrd. (Eurostat)). In the past years, structural changes on both producers' and processors' site, innovations in milk production and the decision of the EU Commission to liberalize the market have changed the milk market. The increasing concentration of dairy processing facilities raise concerns regarding buyer market power of dairy processors. Table 1 shows German dairies' concentration in the federal states measured as processing quantity of the top 1 to 3 biggest processors relative to total processing quantity in the corresponding federal state.

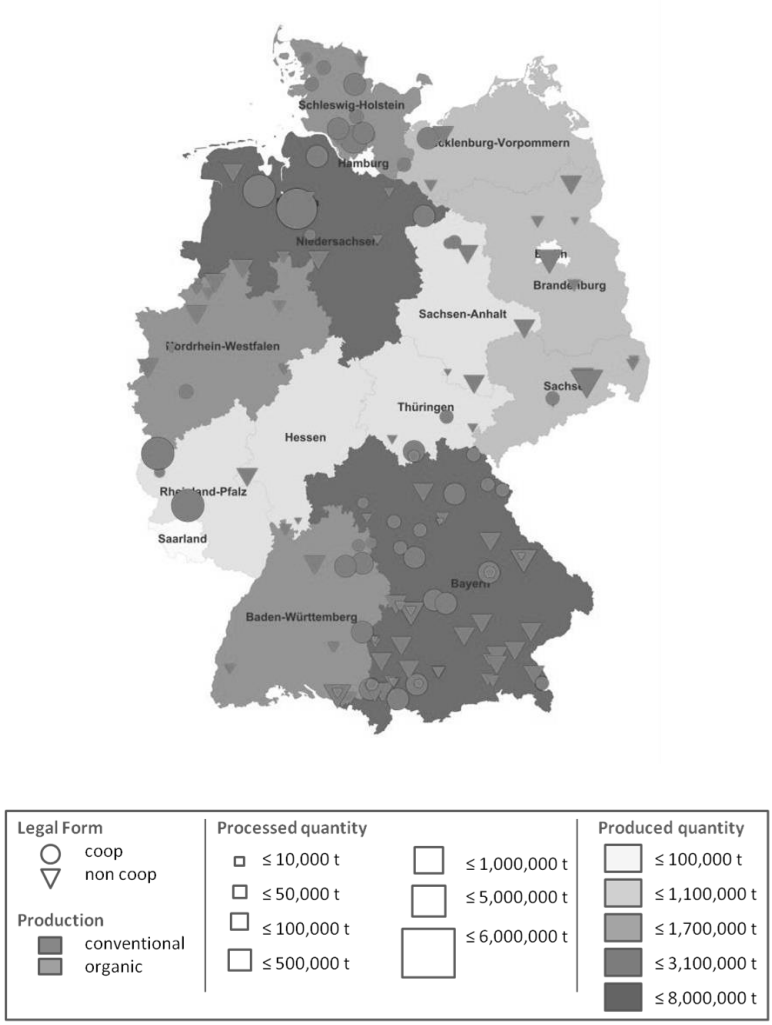
Table 1: Dairies' concentration according to processing quantities in 2012

	HE	SN	BB	NI	RP	TH	MV	SH	BW	ST	NW	BY
C1	0.83	0.72	0.70	0.69	0.57	0.49	0.44	0.41	0.40	0.32	0.29	0.08
C2	0.99	0.82	0.94	0.85	0.99	0.80	0.86	0.52	0.58	0.60	0.52	0.15
C3	1.00	0.89	1.00	0.89	1.00	1.00	0.94	0.63	0.75	0.81	0.64	0.20

Source: own calculation based on AMI data.

This table shows that there are quite some differences between the federal states. Hesse (HE), Rhinland-Palatinate (RP) and Berlin and Brandenburg (BB have only few dairies which lead to a C3 of 1. Apart from that it appears that federal states in the north of Germany have quite a higher concentration (Lower Saxony (NI) 0.69, Mecklenburg-Western Pomerania (MV) 0.44, Schleswig Holstein (SH) 0.41) whereas Bavaria (BY) has an extremely low concentration (0.08). This can also be pictured in the following figure, showing the regional distribution of dairy processors.

Figure 1: Regional distribution of milk production and dairy processing facilities in 2012



Source: Own calculation

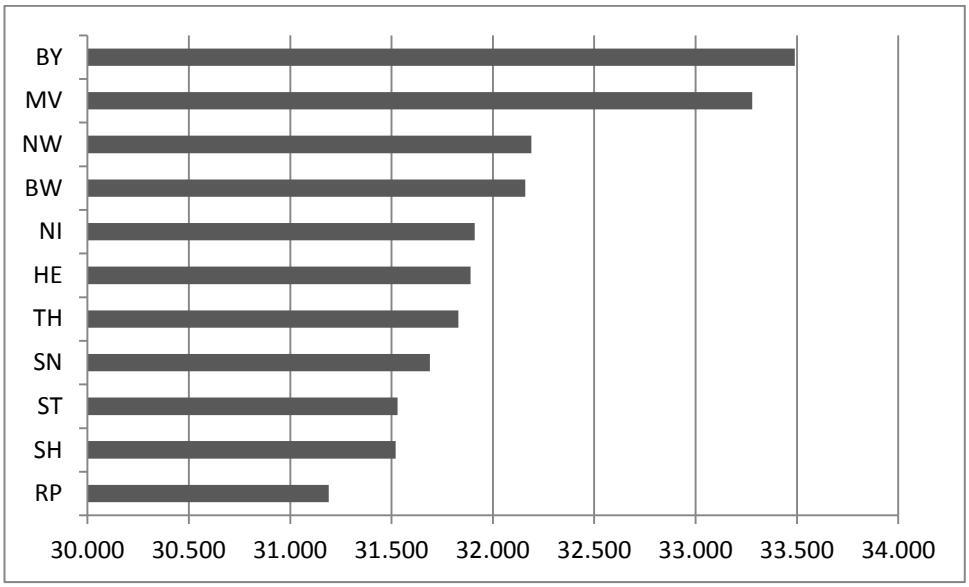
Figure 1 shows that there are areas in Mecklenburg-Western Pomerania (MV), Hesse (HE), Baden-Wuerttemberg (BW) and North Rhine-Westphalia (NW) where dairy farmers have only limited selling alternatives.

Examining structural change reveals that the number of dairy processors has strongly decreased over the observed time period form 197 in 2001 to 137 in 2012. 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 (from 26.3 Mio tons in 2001 to 27.4 Mio tons in 2012).

Taking a closer look at the raw milk prices shows differences between the federal states. It stands out that Bavaria, the federal state with the lowest concentration pays the highest raw milk price.

Table 2: Raw milk price in 2012



Source: own calculation.

3 Assessing and measuring market power

Generally, market power refers to the extent to which an entity is able to influence the price of a good. Under perfect competition, firms on the market are assumed to have no market power. In the case of the German milk market, the correlation between concentration and raw milk price leads to the hypothesis of market power. However, market power does not only depend on the concentration in the market in terms of the market share and the number of competitions but also on other indicators like the development of retailer prices, production efficiency, development of consumption, world market prices, technical progress etc.

Buyer market power refers to the ability to set the price below the competitive level. In the case of the dairy industry the price processors pay for raw milk is lower than the price which would arise in a market with perfect competition. Firms choose the quantities of their input factors so that the maximize profit. In a perfect competitive market, the costs for inputs are determined by supply and demand for inputs. As raw milk is a highly perishable good, the geographic market area of the product is limited. This leads to only limited selling alternatives for dairy farmers which may result in spatial buyer market power of dairy processors. Then the market can be represented in an oligopsony or even a monopsony market. In an oligopsony market only few large buyers are faced with a high number of suppliers.

In order to measure market power several approaches can be identified in the economic literature. The first approach that evolved in the 1950s and 1960s is the structure-conduct-performance that originates from the so called "traditional industrial organization". It assumes a causal relation of market structure, market conduct and market performance and tries to infer firm conduct from the relation between profitability and market concentration. (Tirole 1995).

The new empirical industrial organization (NEIO) emerged in the 1970s and criticizes the causal relation of the structure conduct performance approach as the market structure is an endogenous variable that is not independent of the market performance. Further, the methodologies of the structure-conduct-performance approach give no insight on the cause of market power. The conjectural variation approach provides estimates of the degree of imperfect competition that depends on the deviation from perfect competition. (Bresnahan 1989; Appelbaum 1982). Further, this approach gives insight on the strategic interaction between firms and uses economic theory to measure market power which is then econometrically estimated by structural. 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.

A lot of the NEIO studies in agricultural economics estimate the exercise of oligopoly power, for example of retailers (Gohin and Guymard 2000; Anders 2008; Soregaroli et al. 2011; Salhofer et al. 2012; Sckokai et al. 2013). Studies that jointly estimate oligopoly and oligopsony power are Schroeter and Azzam (1990), Wann and Sexton (1992), Gohin and Guyomard (2000) and Anders (2008). Notable studies that specifically analyze oligopsony power of dairy processors are Perehozhuk et al. (2009, 2011 and 2014). These papers study oligopsony power in the Ukrainian dairy industry on a regional level as well as in the Hungarian dairy industry on plant level. Evidence of oligopsony power could be found in both studies.

4 Theoretical framework to measure market power

Our theoretical model is based on the conjectural variation approach and is similar to Perekhozhuk et al. (2009, 2011 and 2014). The main difference is that we could not get data on labor and capital quantities used in the dairy industry. Instead we use prices for labor and capital. This leads to a different form of the estimation function. The degree of imperfect competition is estimated for the national and regional areas of the dairy industry in Germany.

The supply of raw milk a dairy is facing can be denoted by

$$w_{Mi} = f_W(X_M^a, Z^a) \tag{1}$$

where w_{Mi} represent the raw milk price, X_M^a is the demand of dairies in area *a* and Z^a are factors that influence the supply capacities of the farms in the respective area.

Each dairy produces a homogeneous output q_i. Assuming a Cobb Douglas production form that utilizes raw milk x_{Mi}, labor x_{Li} and capital x_{Ki} as inputs yields the following equation:

$$q_i = f_q(x_{Mi}, x_{Li}, x_{Ki}) = b x_{Li}^{\alpha_L} x_{Ki}^{\alpha_K} x_{Mi}^{\alpha_M} \tag{2}$$

Consequently, the profit function of dairy *i* is equal to

$$\pi_i = Pq_i - f_W(X^a, Z^a)x_{Mi} - w_{Li}x_{Li} - w_{Ki}x_{Ki} \tag{3}$$

We assume that dairy *i* may exercise market power on the raw milk market, but is a price taker on the markets for labor, capital and also on the output market for dairy products. Dairy plant *i* maximizes its profit with respect to its inputs which yields the following first order conditions:

$$\frac{\partial \pi_i}{\partial x_{Mi}} = P \cdot \frac{\partial f_q(x_{Mi}, x_{Li}, x_{Ki})}{\partial x_{Mi}} - f_W(X_a, Z_a) - \frac{\partial f_W(X_M^a, Z_a)}{\partial X_M^a}\frac{\partial X_M^a}{\partial x_{Mi}}x_{Mi} = 0 \tag{4}$$

$$\frac{\partial \pi_i}{\partial x_{Li}} = P \cdot \alpha_L x_{Li}^{\alpha_L - 1} x_{Ki}^{\alpha_K} x_{Mi}^{\alpha_M} - w_{Li} = 0 \tag{5}$$

$$\frac{\partial \pi_i}{\partial x_{Ki}} = P \cdot \alpha_K x_{Li}^{\alpha_L} x_{Ki}^{\alpha_K - 1} x_{Mi}^{\alpha_M} - w_{Ki} = 0 \tag{6}$$

Reformulating of (4) generates

$$w_{Mi} = P\frac{\partial f_q(x_{Mi}, x_{Li}, x_{Ki})}{\partial x_{Mi}} \Bigg/ \left(1 + \frac{\theta_{Mi}}{\varepsilon_a^{WX}}\right) \tag{7}$$

where $\varepsilon_M^a = \left(\partial X_M^a / \partial w_{Mi}\right)\left(w_{Mi} / X_M^a\right)$ represents the market price elasticity of raw milk supply and $\partial f_q\left(x_{Mi}, x_{Li}, x_{Ki}\right)/\partial x_{Mi}$ reflects the marginal product of raw milk input. $\theta_{Mi} = \left(\partial X_M^a / \partial x_{Mi}\right)\left(x_{Mi} / X_M^a\right)$ is the conduct parameter which measures the conjectural elasticity of dairy plant *i* on the input market. It consists of the market share of plant *i* $\left(x_{Mi} / X_M^a\right)$ and the change in total demand when the demand of firm i changes $\left(\partial X_M^a / \partial x_{Mi}\right)$. 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 (Bresnahan 1982; Hyde and Perloff 1998). Following Appelbaum (1982), $\theta_{Mi} = 0$ hints to a perfectly competitive

market whereas a $\theta_{Mi} = 1$ indicates a monopsony (or cartel behavior) on the factor market. $0 < \theta_{Mi} < 1$ suggests the existence of an oligopsonistic market structure

For simplicity, setting the factor productivity *b* in equation (2) equal to one and taking the derivative of the production function with respect to x_{Mi} gives the following form of equation (7)

$$w_{Mi} = P\alpha_M x_{Li}^{\alpha_L} x_{Ki}^{\alpha_K} x_{Mi}^{\alpha_M - 1} \Bigg/ \left(1 + \frac{\theta_{Mi}}{\varepsilon_M^a}\right) \tag{8}$$

Inserting the profit maximizing values for labor and capital into (8) yields

$$w_{Mi} = \frac{P^{\frac{1}{-\alpha_L - a_K + 1}} \alpha_M \alpha_L^{\frac{a_L}{-\alpha_L - a_K + 1}} \alpha_K^{\frac{a_K}{-\alpha_L - a_K + 1}} x_{Mi}^{\frac{\alpha_M + \alpha_L + a_K - 1}{-\alpha_L - a_K + 1}} w_{Li}^{\frac{-a_L}{-\alpha_L - a_K + 1}} w_{Ki}^{\frac{-a_K}{-\alpha_L - a_K + 1}}}{\left(1 + \frac{\theta_{Mi}}{\varepsilon_M^a}\right)} \tag{9}$$

5 Econometric specification and data description

In order to estimate the market power parameter in equation (9) we take the natural log of the function

$$\begin{aligned} \ln(w_{Mi}) = {} & \ln(\alpha_M) + \left(\frac{a_L}{-\alpha_L - a_K + 1}\right)\ln(\alpha_L) + \left(\frac{a_K}{-\alpha_L - a_K + 1}\right)\ln(\alpha_K) \\ & + \left(\frac{1}{-\alpha_L - a_K + 1}\right)\ln(P) + \left(\frac{\alpha_M + \alpha_L + a_K - 1}{-\alpha_L - a_K + 1}\right)\ln(x_{Mi}) \\ & + \left(\frac{-a_L}{-\alpha_L - a_K + 1}\right)\ln(w_{Li}) + \left(\frac{-a_K}{-\alpha_L - a_K + 1}\right)\ln(w_{Ki}) - \ln\left(1 + \frac{\theta_{Mi}}{\varepsilon_M^a}\right) \end{aligned} \tag{10}$$

The production function parameters α_M, α_L, a_K are defined to be positive. For now, we set the supply elasticity to $\varepsilon_M^a = 0.01$, representing an inelastic supply curve. For the milk market this is a realistic assumption as an enlargement of dairy production is accompanied by high investment costs and is only limitedly possible in the short term. This assumption will be dismissed in forthcoming versions of this paper where a structural model will be simultaneously estimated.

Function (10) is estimated using the minpack.lm package in the statistical software R. This package contains a nlsLM function that uses a Levenberg-Marquardt algorithm to solve this non-linear problem.

We use a panel data set containing yearly information for the time span 2001-2012. The panel is unbalanced as some dairies quit or no information was gained. The data on dairies' processing quantity and raw milk prices was gathered from the AMI (Agrarmarkt Informations-Gesellschaft mbH). Unfortunately, we could not get data on product portfolios and the wholesale prices received by dairy processors. P is a price index containing the national average selling price for butter, cheese, skim milk, whole milk and whey powder. Information on wages in the dairy industry was collected from the statistical offices of the federal states in Germany. Interest rates were gathered from the European Central Bank. The data that is used for the estimation is summarized in the following table.

Table 3: Description of model variables

Variable	Description
x_M	Yearly quantity of procured raw milk by dairy processors in Germany
w_M	Yearly average price for raw milk paid by dairy processors
w_L	Hourly wage for workers in the dairy industry on federal states basis
w_K	Yearly national interest rate for corporates, rate fixation up to 1 year
P	price index containing the national average selling price for butter, cheese, skim milk, whole milk and whey powder

6 Estimation and results

The estimation was carried out for several subsets to estimate oligopsony power on the national and regional level. On the regional level we differentiate between federal states and broader areas like south Germany versus north Germany.

To start with the parameter estimates for the national level and broader areas in Germany are represented. As the descriptive analysis of the data set showed that the concentration of dairy processors is high in the north, we did the estimation of the market power parameter for the subsets north (containing Berlin and Brandenburg (BB), Mecklenburg-Western Pomerania (MV), Schleswig-Holstein (SH), Lower Saxony (NI), Saxony-Anhalt (ST)) and south (containing). We also examined whether there are differences between north (Mecklenburg-Western Pomerania (MV), Schleswig-Holstein (SH), Lower Saxony (NI)), east (Berlin and Brandenburg (BB), Saxony (SN), Saxony-Anhalt (ST), Thuringia (TH)), west (North-Rhine Westfalia (NW), Hesse (HE), Rhineland Palatinate (RP)) and south (Baden-Wuerttemberg (BW) and Bavaria (BY)) (see table 4).

Table 4: Parameter estimates national level and broader areas

		North/South		North/East/West/South			
	GE	North	South	North	East	West	South
α_M	0.9691 ***	0.9838 ***	0.9650 ***	0.9858 ***	0.9616 ***	0.9720 ***	0.9734 ***
α_L	8.92e-09	4.97e-04	1.01e-07	4.92e-07	1.12e-07	1.45e-05	1.89e-03
α_K	2.45e-05	4.48e-08	1.65e06	1.25e-06	2.01e-06	9.22e-08	1.78e-08
θ	0.7483 ***	0.7649 ***	0.7346 ***	0.7408 ***	0.7353 *	0.7255	0.7543 ***
R^2	0.3528	0.8787	0.4875	0.9168	0.6813	0.9072	0.9466

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

The estimation results indicate market power in all regions. Considering the parameters of the production function, there are no specific differences between the analyzed regions. For the market power parameter θ we also found only slightly different results. As expected, the market power parameter is higher in the north of Germany compared to the south where concentration of dairy processors is not as

high as in the north (however, the difference is small). The R^2 for the estimations of the subsets are all satisfying. On the national level the R^2 is not optimal.

Table 5: Estimation parameters federal states

	BB	**MV**	**SN**	**ST**	**TH**	**BW**
α_M	0.546 ***	0.9517 ***	0.9985 ***	1.0000 ***	0.5913 ***	0.9618 ***
α_L	0.4236 ***	4.05e-08	2.82e-03	4.53e-03	0.3934	8.38e-08
α_K	6.17e-10	9.71e-06	3.26e-08	2.559e-08	1.96e-06	8.60e-07
θ	0.3756 ***	0.7567	0.7223 **	0.7324 ***	0.3778	0.7217
R^2	0.9592	0.9802	0.9920	0.9894	0.9883	0.9326
	BY	**SH**	**NI**	**NW**	**HE**	**RP**
α_M	0.9620 ***	0.9756 ***	09952	0.9607	0.9854 ***	0.9515 ***
α_L	9.51e-08	5.55e-03	3.32e-04	4.82e-06	4.66e-06	2.63e-03
α_K	9.83e-07	2.26e-08	3.24e-08	2.65e-07	5.54e-08	2.65e-05
θ	0.7379 *	0.7635 ***	0.7581 ***	0.7480	0.7101	0.6645
R^2	0.7508	0.9708	0.9767	0.9437	0.9800	0.9930

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

With respect to the federal states, it seems counter intuitive that the lowest market power parameter can be found in Berlin and Brandenburg (0.375), the federal state with the highest concentration of dairy processors. For Schleswig Holstein and Lower Saxony the parameter is slightly higher than in Bavaria which is what we expected.

7 Conclusion

Addressing the increasing concentration of dairy processors in Germany this paper investigated market power of dairy processors on a national and regional level. We developed a theoretical framework of the conjectural variation approach that incorporates a Cobb Douglas production function.

Our empirical results indicate oligopsony power on the national level as well as on regional level. However, the estimation can be further improved. Further, the supply elasticity of raw milk is given. For future work we plan to set up a structural market model that simultaneously estimates the supply elasticity of raw milk and the market power parameter of dairy processors.

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