RTG 2654 Sustainable Food Systems

University of Goettingen

SustainableFood Discussion Papers

No. 12

Investigating market power in the German dairy industry

Jasmin Wehner
Jan-Henning Feil
Xiaohua Yu

October 2024

Investigating market power in the German dairy industry

Jasmin Wehner[1]   Jan-Henning Feil[2]   Xiaohua Yu[1,3]

[1]University of Göttingen, Platz der Goettinger Sieben 5, 37073 Goettingen
[2]Martin-Luther-University Halle-Wittenberg, 06108 Halle (Saale)
[3] Corresponding Author: xyu@gwdg.de

Market power in economic theory is defined as deviations from marginal cost pricing, which results in unfair competition and welfare losses. In complex agri-food supply chains, the exercise of market power is a significant contributor to welfare losses, as multiple actors throughout the chain can exert such power. However, the potential dual role of dairy processors—as both buyers in the raw milk market and sellers in the output market—has received little attention so far. Using a panel data set with 323 observations from major German dairy processors between the years 2010 and 2021, we show that dairy processors exercise both, oligopsonistic as well as oligopolistic market power. Results suggest that dairy processors take advantage of their central position in the dairy supply chain, and buy milk from dairy farmers 9.2 percent below the value of the marginal product and sell processed milk to retailers 1.1 percent above the marginal costs. We demonstrate that it is important to incorporate the dual role of supply chain actors in market power analyses. In order to reduce welfare losses generated by market power, we recommend that the federal cartel authority should monitor market actors within the dairy supply chain continuously and consider the dual role of market actors in their reports and recommendations to the government.

1 Introduction

The growing number of farmer protests, including the 2024 European farmers' protests, is fueling the societal and political debate about who is putting price pressure on the farming sector (Mambro, 2024). Processors claim it stems from retailers and they would just pass on unreasonable price increases to farmers; retailers again claim the pressure would directly caused by the processors. In addition, antitrust investigations of public authorities in the agri-food sector recognize evidence for potential unfair competition and market power in the German retail food chain (Federal Cartel Authority, 2024). This is concerning since the abuse of market power by those in the middle of the supply chain results in welfare losses for the most vulnerable actors at both ends: the farmers and the end consumers. In case buyer market power exists, agricultural subsidies payed for farmers might be diverted to processors. However, the extent to which processors, compared to retailers, execute market power in the agri-food sector remains understudied.

The objective of this study is to separate the processors out of the agri-food value chain and, for the first time, simultaneously investigating their company-level potential buyer power over farmers and/or supply power over retailers. We conduct this by the example of the German dairy industry, which has been subject to discussions in recent years, whether or not it contributes to ongoing market pressure on the upstream dairy farming sector (Knuck et al., 2023; Federal Cartel Authority, 2024). Additionally, Germany is the largest milk producing country in Europe and sixth largest in the world (Jürgens, 2021). We apply the extended Solow residual-based (SRB) method by Hyde & Perloff (1994) and Raper et al. (2007) to simultaneously investigate potential oligopolistic and oligopsonistic market power at company-level. We rely on the common definitions of Lerner indexes for market power. Oligopsonistic market power is measured as company's availability to buy raw milk at a price below its marginal value in production. Similarly, oligopolistic market power is measured as company's availability to sell the processed milk above the marginal costs. Accordingly, we use a panel data set of major German dairy processors covering the years from 2010 to 2021.

Unlike prior efforts, we collect company specific data including input prices and processed milk quantities for major German dairy processing companies. Additionally, we test simultaneously for oligopolistic and oligopsonistic market power exercised from the same firm. Previous studies explored the dual market power of dairy processors for the case of whole milk powder in France by using a method where they first, estimate overall market distortions, and second, decompose it to oligopolistic, oligopsonistic and joint contributions. The authors find that processors indeed execute both, oligopsonistic as well as oligopolistic power as they buy raw milk at a price 16 percent below its marginal contribution to their profits and sell whole milk powder at a price 41 percent above marginal costs (Avignon & Guigue, 2023). Other studies looked at the German dairy supply chain already and found either no signs of oligopsonistic market power (Knuck et al., 2023) or minimal signs of oligopsonistic market power and substantial signs of oligopolistic market power (Grau & Hockmann, 2017).

Our paper combines several features from the above mentioned studies. First, we create a unique data set with 323 observations including scarce information about raw milk price and processed

milk quantities on company level based on their balance sheets and other data sources similar to Avignon & Guigue (2023). Due to the comparable dairy value chain structure between France and Germany, we expect relatively similar results. In contrast to Grau & Hockmann (2017), we apply the Solow residual-based (SRB) method for the first time to the agri-food sector. This method allows us to empirically test for two kinds of market power executed from dairy processors both in the raw and output market simultaneously. Further, our results suggest that dairy processors execute relatively higher rates of market power in the raw milk than in the output market.

We structured the paper as follows: we provide a short overview about the current literature on market power in the dairy value chain as well as the milk sector in Germany in Section 3. We explain the SRB method which allows us the simultaneous test of market power in both direction in Section 2. We explain the compilation of the company level dataset including milk input price and milk quantity information in Section 4. After presenting the results in Section 5, we discuss methodological and conceptual shortcomings in Section 6 and conclude in Section 7.

2 Theory and Method

We utilize the NEIO (New Empirical Industrial Organization) based concept of market power. More specifically, we use the Solow residual-based (SRB) tests developed by Hall (1988) and Domowitz et al. (1988) to measure market power originating from firms. Hyde & Perloff (1994) as well as Raper et al. (2007) extend the SRB method in order to test for both, oligopolistic and oligopsonistic market power exercised by the same company i. In general, the Lerner index for oligopolistic (downstream, or product market) market power is defined as the ability to set output price P_i above marginal costs MC_i and the Lerner index for oligopsonistic market power (upstream, or factor market) is characterized by company's ability to set an input price W_i below its marginal value in production VMP_i.

2.1 Prime method based on production function

We start assuming a constant returns to scale (CRS) production function for a milk-processing company:

$$Y = Ae^\rho K^{\alpha_1} M^\beta L^{1-\alpha-\beta_2} \tag{1}$$

, where K is the capital input, M is the raw milk input, L is the labor input, A denotes the productivity level and ρ the Hicks-neutral technology progress. Additionally, α and β denote input-output elasticities. According to Solow (1956), α can be seen as the revenue share of capital and β as the revenue share for raw milk:

$$\alpha = \frac{KW_K}{YP_Y} \qquad\qquad \beta = \frac{MW_M}{YP_Y}$$

. Further, W_K, W_M, and P_Y respectively denote interest rates, raw milk price, and processed milk price. Hence, we can obtain the Solow Residual SR for a perfectly competitive market:

$$SR = \Delta \ln y - (\alpha \Delta \ln k + \beta \Delta \ln m) = \Delta \ln A + \dot{\rho} \tag{2}$$

, where the inputs are normalised by labor $y = Y/L$, $k = K/L$, and $m = M/L$ and Δ represents the first-order difference.

2.1.1 Monopolistic market

Under imperfect competition, according to Hall (1988) and Domowitz et al. (1988), when the company has market power in the output market, we have the Solow residual SR_1:

$$SR_1 = \beta^{mp} \Delta \ln y + (1 - \beta^{mp})(\Delta \ln A + \dot{r}) \tag{3}$$

, where β^{mp} is the Lerner Index for the output market and defined as

$$\beta^{mp} = \frac{P_Y - MC}{P_Y}$$

. If $\beta^{mp} > 0$, there might be market power in the output market. If $\beta^{mp} = 0$, there seems to be no market power and Equation 3 collapses to the case of Equation 2 which is the perfect competition case.

2.1.2 Monopsonistic market

When the firm has market power in the input market (raw milk market), we can rewrite the Solow residual for the monopsonistic market where the marginal value of product VMP_i is greater than the price of the input W_i.

$$SR_2 = \left[\frac{\beta^{ms}}{1 + \beta^{ms}}\right][\Delta \ln y - \alpha \Delta \ln k] + \left[\frac{1}{1 + \beta^{ms}}\right][\Delta \ln A + \dot{\rho}] \tag{4}$$

, where β^{ms} is the monopsonistic Lerner index:

$$\beta^{ms} = \frac{VMP_i - W_i}{W_i}$$

For instance, a milk processing firm could reduce its purchase of raw milk to suppress the raw milk price. Equation 4 shows that in the special case of $\beta^{ms} = 0$, it degenerates to Equation 2 which is again a perfectly competitive input market.

2.1.3 Joint monopolistic and monopsonistic market

Hyde & Perloff (1994) and Raper et al. (2007) show an empirical test for the case that the market is jointly monopolistic and monopsonistic. Combining Equation 3 and 4 yields to:

$$SR_3 = b_0 + b_1 \Delta \ln y + b_2(\alpha \Delta \ln k) + e \tag{5}$$

, where

$$b_1 = \beta^{mp} + \frac{\beta^{ms}}{1 + \beta^{ms}} \qquad\qquad b_2 = -\frac{\beta^{ms}}{1 + \beta^{ms}}$$

and

$$e = (1 - \beta^{mp})(\Delta \ln A + \dot{r}) + \left[\frac{1}{1 + \beta^{ms}} \right] (\Delta \ln A + \dot{\rho})$$

, where b_1 and b_2 are parameters to be estimated while e is a function of Lerner indices and productivity shock. However, e could be correlated with $\Delta \ln y$ and $\Delta \ln k$, and appropriate instruments variables are necessary for consistent estimation. In the literature, per capita GDP and exogenous factor prices often serve the purpose (e.g. Domowitz et al., 1988; Raper et al., 2007). Equation 5 could yield four different cases for the market structure, which are listed in Table 1.

Case	Situation	Outcome
1	$b_1 = b_2 = 0$	Both seller and buyer markets are perfectly competitive
2	$b_1 > 0$ and $b_2 = 0$	There is seller market power, buyer market is perfectly competitive
3	$b_1 = -b_2 > 0$	There is buyer market power, seller market is perfectly competitive
4	$b_1 \neq -b_2, b_1 > 0$ and $b_2 < 0$	Market power exists in both, seller and buyer markets

Table 1: Overview of potential outcomes from Equations 5 and 10

2.2 Dual method based on cost function

Following Hall (1988) and Domowitz et al. (1988), Roeger (1995) developed a prime-dual measure of the Solow residual to detect the market power based on the difference between prime and dual Solow residuals. Compared with the prime measure based on the production function, the prime-dual measure is more robust (theoretically and empirically). Particularly, the prime-dual method is immune from the endogeneity issue.

2.2.1 Perfect competition market

When we assume a cost function $C(W, Y) = G(W)Y$ which also satisfies the condition of a constant return to scale production function, we can use the Shepard Lemma to derive the dual Solow residual for the perfectly competitive market:

$$SRP = (\alpha \Delta \ln w_k + \beta \Delta \ln w_m) - \Delta \ln p_Y = \Delta \ln A + \dot{\rho} \tag{6}$$

, where $w_k = \frac{W_k}{W_L}$; $W_m = \frac{W_M}{W_L}$; and $p_Y = \frac{P_Y}{W_L}$. Here, all input and output prices are normalized by wage.

2.2.2 Monopolistic market

Analogous to Equation 3, we can derive an equation to measure the dual Solow residual (price-based) for a monopolistic market:

$$SRP_1 = -\beta^{mp} \ln P_Y + (1 - \beta^{mp})(\Delta \ln A + \dot{\rho}) \tag{7}$$

Following Raper et al. (2007), if we now combine Equations 7 with 3, we yield a prime-dual test for the monopolistic market:

$$SR_1 - SRP_1 = \beta^{mp}(\Delta \ln y + \Delta \ln P_Y) \tag{8}$$

2.2.3 Monopsonistic market

Analogous to Equation 4, we can derive an Equation to measure the dual Solow residual for the monopsonistic raw milk market:

$$SRP_2 = -\left[\frac{\beta^{ms}}{1 + \beta^{ms}}\right][\Delta \ln P_Y - \alpha \Delta \ln w_k] + \left[\frac{1}{1 + \beta^{ms}}\right](\Delta \ln A + \dot{\rho}) \tag{9}$$

If we combine Equations 9 and 4, we yield a prime-dual test for the monopsonistic market.

$$SR_2 - SRP_2 = \left[\frac{\beta^{ms}}{1 + \beta^{ms}}\right][(\Delta \ln y + \Delta \ln P_Y) - \alpha(\Delta \ln w_k + \Delta \ln k)] \tag{10}$$

2.2.4 Joint monopolistic and monopsonistic market

Combining Equations 8 and 10, we obtain an equation which can jointly test monopolistic and monopsonistic market power:

$$SR_2 - SRP_2 = b_1(\Delta \ln y + \Delta \ln P_y) + b_2 [\alpha(\Delta \ln w_k + \Delta \ln k)] \tag{11}$$

, where

$$b_1 = \beta^{mp} + \frac{\beta^{ms}}{1 + \beta^{ms}} \qquad\qquad b_2 = -\frac{\beta^{ms}}{1 + \beta^{ms}}$$

. Similar to Equation 5, we can differentiate between four cases for the market structure, which are listed in Table 1. Compared to the prime method, Equation 11 can be estimated by a simple OLS without the intercept as the shock is cancelled out.

3 Evidence before the study

3.1 Market power in the dairy supply chain

There are many related studies to market power in the dairy sector across the world related to the US (Cakir & Balagtas, 2012; Yu & Gould, 2019) and China (Chen & Yu, 2019, 2021). The majority of the studies look into market power in specific European countries (Austria: Salhofer et al. (2011), France: (Gohin & Guyomard, 2000; Avignon & Guigue, 2023), Germany: (Grau & Hockmann, 2017), Hungary: (Perekhozhuk et al., 2013), Ukraine: (Perekhozhuk et al., 2014)) while we identified two comparison studies covering three EU countries (Spain, France, Italy): (Koppenberg & Hirsch, 2021; Koppenberg, 2023).

Cakir & Balagtas (2012) look into market power of dairy cooperatives in the US by using a model of vertical relationships between cooperatives and processor-retailers. Using data for the period from the year 2000 to 2017, they find that processors-retailers can increase the retail price by 0.4 percent above marginal costs and cooperatives can sell their milk to fluid milk plant by 9 percent above the minimum price (Cakir & Balagtas, 2012). Another paper investigates the relationship between market competitiveness and price asymmetry in the US fluid milk market using data from January 2001 to December 2011 for 18 US cities and confirm that retailers market power was associated with higher degrees of asymmetry (Yu & Gould, 2019).

Using Chinese data on dairy processors from January 2008 to December 2015 reveals that calculated Lerner indexes for three main dairy processors amount to up to 25 percent while importers do not seem to exhibit market power (Chen & Yu, 2019). Another study looked at the top eight Chinese dairy firms between the years 2003 and 2015 and the relationships between subsidies and market power. They find a negative association between subsidies and market power for privately owned dairy firms (Chen & Yu, 2021).

Some papers in the European context measure market power with the conjectural elasticity, which can be calculated for oligopsonistic power of dairy processing companies in the raw milk market only (Perekhozhuk et al., 2013, 2014) or extended for both, oligopsonistic power of dairy processing companies in the raw milk market as well as oligopsonistic power of retailers in the the output market (Grau & Hockmann, 2017).

Conjectural elasticity is a measurement for how competitive a market is, ranging from zero (perfect competition) to one (monopsony), and values between zero and one indicate some degree of oligopsonistic market structures. In case of the Ukrainian raw milk market using data from the years 1996 to 2015, Perekhozhuk et al. (2014) find hints for oligopsony market power on national of the degree of 0.15 as well as in six administrative regions, ranging from of degree sizes between 0.09 to 0.32. They further show that deviations to procurement prices from the value marginal product for raw milk amount up to 49.4 percent which corresponds to loss of revenue of about (USD 447) per month for a average dairy farm (Perekhozhuk et al., 2014). Using dairy plant level data for the Hungarian raw milk market from the years 1993 to 2006, they find conjectural elasticities of 0.22 to 0.30 (Perekhozhuk et al., 2013). Similarly, market power of retailing seems to exists towards consumers in higher magnitudes than towards input suppliers using Austrian data from January

1997 to December 2008 (Salhofer et al., 2011).

Another strand of literature investigated the oligopsonistic market power of dairy processors across multiple European countries by calculating markups for each sector between the years 2008 and 2017. They find that average Spanish (Italy, France) dairy processors charge prices exceeding marginal costs by 19.5 (12.5, 7.3) percent. More interestingly, they associate the markups to farm characteristics and find negative associations between markup and firm size as well as revenue growth (in France and Italy). They estimate positive associations between markups and profits which seems to be attributed increased rent seeking in the dairy processing industries (Koppenberg & Hirsch, 2021). Another paper by the same author looks into farm-level seller market power of dairy farmers across 18 European countries between the years 2014 to 2017. Koppenberg (2023) differentiates between conventional and organic farmers and finds that organic farmers have a markup of 411 percent while organic farmers sell their milk 595 percent above their marginal costs. The markups seem to be positively associated with market shares of large dairy processors while being negatively associated with large dairy processors and the presence of large retailers (Koppenberg, 2023).

We identified two papers that are closely related to our paper. One paper looks into the separate market power from retailers and dairy processors in the German dairy sector. The second paper is conceptually closer by looking also into the potential dual role of by dairy processing companies but focuses on the French whole milk powder. In general, one sided market power analyses do not adequately reflect rising strategic interactions between food manufacturer and food retailers anymore. Researchers highlight the importance of investigating the potential two sided source of market power from food manufacturers (Sexton & Xia, 2018).

In case of the German dairy sector, Grau & Hockmann (2017) use data from the years 2000 to 2011 and find that retailers execute oligopsonistic market power over processors with degrees of conjectural elasticities of 0.29 to 0.39, but processors execute only minor oligopsonistic market power over farmers with values between 0.04 to 0.07.

Avignon & Guigue (2023) collect firm level data over a period from the year 2003 to 2018 and focus into whole milk powder due to the substitutability with raw milk and the price determination on global level. They recover margins and accounting marginal costs at the firm level and find that French dairy firms buy milk 16 percent below the value of the marginal product and sell dairy products at a price exceeding their marginal costs by 41 percents (Avignon & Guigue, 2023).

3.2 Structure in the German milk sector

Germany is with 32 million tons of cow milk the largest producer in the EU and the sixth largest consumer in the world. We illustrate the German dairy value chain in Figure 1. They are countless feed and livestock suppliers for 54000 dairy farmers in Germany. These dairy farmers produce raw milk and sell it to 212 dairy processors. The dairy processors sell the processed dairy products to various retailers and wholesalers, from which the end consumer can obtain the product (Knuck et al., 2023).

The amount of dairy processing companies has shrunk by 53 percent from the year 2000 to the
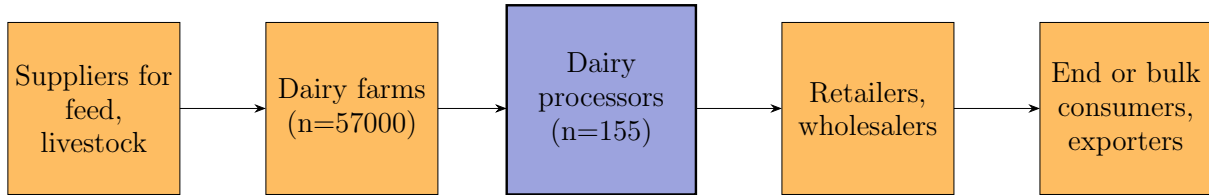
Figure 1: Schematic illustration of the German dairy supply chain with numbers for the year 2021

year 2010. Since then, the amount of dairy processing companies has remained fairly constant. This consolidation of dairy processors is often used as an indication for market power (Grau & Hockmann, 2017; MIV, 2020). However, the C4 ratio, which denotes the market share of the four largest dairy processors within the sector, amounts to 53 percent. This is moderate compared to most of the European countries (Denmark: 98 percent, Netherlands: 85 percent) but still higher than some European countries (Spain: 20 percent, Czechia: 39 percent) (Jongeneel, 2023).

Around two thirds of all milk is processed in cooperatively organised dairy processors. However, the implications for market power are ambiguous in the case of Germany. Farmers who are members of a cooperative might have more bargaining power and might be able to achieve a higher raw milk price for themselves. In practise, this is not always the case due to varies reasons explained in more detail in Section 6.3 as well as in Grau & Hockmann (2017); Sexton & Lavoie (2001).

We illustrate the German wide milk quantities across the study period in Figure A1 and display the 30 dairy processing companies in Figure 2, where the size of the bubbles correspond to the revenue generated in Germany and the color denotes whether the company is organized as cooperative or private entity. We observe substantial geographical differences as most of the dairy processing companies are located in Southern and North Western Germany. In Southern Germany, we observe larger variations in revenues (between 200 and 800 Million Euros) compared to the other regions in Germany.

The interactions between farmers, dairy processors, and retailers are often subject to investigations and interventions by the Federal Cartel Authority (FCA). The relationship between farmers and dairy processors is characterised by long periods of notice and duration as well as exclusive supply obligations in Germany (Federal Cartel Authority, 2017a). Almost all contracts between farmers and dairy processors have an *Evergreen Clause*, meaning that the contract gets automatically renewed unless one party gives notice. It is only possible to give notice once a year for 87.5 percent of all processed milk in Germany. Effectively, 52.8 percent of all processed milk is subject to a 24 month notice period. Consequently, the switching quotas between dairy processors were between 2 percent in the years from 2013 to 2015. Further, 97.8 percent of the total milk quantities are subject to exclusive supply obligations (Federal Cartel Authority, 2017b). More recently, the FCA has prohibited a measurement for post stabilisation of milk prices, which was proposed by farmers. The FCA feared price gouging without alternative options for end consumers (Lehmann, 2022). Further, the FCA concluded in another paper that they could not find substantial evidence for market power exercised by retailers over dairy processors (Federal Cartel Authority, 2012).
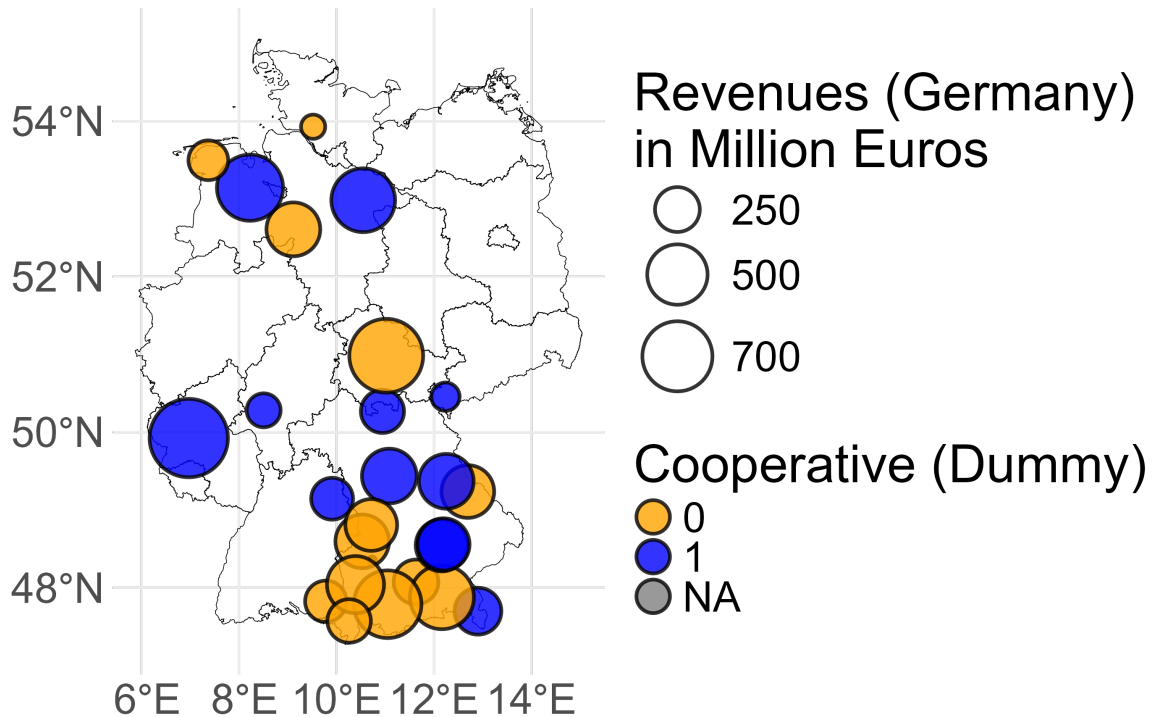
Figure 2: Geographical locations and revenues of most important dairy processors in Germany in the year 2020 (missing values due to zero revenues in Germany in the year 2020). Size of the bubbles is proportional to revenues generated in Germany in Million Euros. Source: own compilation

4 Data

We compile panel data[1] of the 30 biggest dairy processing companies in Germany from the years 2010 to 2021, which process between 57 percent in yr2010 and 79 percent in yr2019 of all processed milk within Germany (see Table A1).

We source milk prices from three different sources. Our main source for milk input or farm gate prices were the balance sheets. Whenever possible, we complemented this missing price information on dairy processing plant level from various agricultural newspapers[2] or with price information from the agricultural chambers[3] of the respective states. Whenever multiple prices where reported for the same year and company, we calculated average milk prices. In case price information was still missing, we filled missing values with average farm gate prices of the respective state. We source output or retail milk prices from the federal office for agriculture and food. This procedure allowed us to to end up with no missing values for input and output prices.

Similarly, we complement missing data about processed milk quantities for milk processing companies with data from the Bavarian State Institute for Agriculture as well as the statistical reports from the Federal Ministry of Food and Agriculture based on district level. This procedure allowed

---

[1]An earlier version of this data set with only 19 dairy processors for the years 2010 and 2017 has been published in another paper (Meyer et al., 2019).

[2]agrarheute, Top agrar

[3]Baden-Wuerttemberg, North Rhine-Westphalia, Schleswig-Holstein, and Rhineland Palatinate

us to to end up with at least four quantity data entries for each company. We match the data from the statistical institutes based on district and Zip-codes of the respective milk processing companies. Other missing quantity data was complemented by annual reports, newspaper articles, or by information that the companies provided directly.

Almost 50 percent of the companies are organized as cooperative. We display descriptive statistics in long and wide format in Tables A2 and A3. We list variable names, descriptions, and respective sources in the Table 2.

We illustrate milk prices for each milk processing company per state and year in Figure 3. This figure shows that we observe the highest farm gate milk prices in Southern Germany in the states Baden-Wuerttemberg and Bavaria, where also most of the biggest milk processing plants are located. We observe the lowest farm gate milk prices in states in Eastern Germany (Saxony and Thuringia) as well as in Northern Germany (Lower Saxony and Schleswig-Holstein). Across all states, farm gate milk prices stabilized at 37 EuroCents per kg milk after a drop in milk prices in the years 2015 and 2016 due to over supply of milk after the phase out of the milk quota system (BMEL, 2024).

We observe constant milk quantities over the time period between the year 2010 and 2021 across all states (see Figure 4) and districts (see Figure A1). Most of the milk is processed in the agricultural state Lower Saxony, and the lowest milk quantities are processed in Bavaria, Hesse, and Thuringia. The average processed milk quantity has increased from 625.75 million kg in the year 2010 to a peak in the year 2019 with 938.17 million kg. In the last two years of our analysis, the processed milk quantity has reduced to 835.02 million kg in the year 2021 (see Table A3).

5 Results

5.1 Results CRS production function

We display results for the simple CRS production function from Equation 1 in Table 3. Unsurprisingly, we find a positive association between milk input and milk output as well as between capital input and milk output. We normalize the milk output by dividing revenues generated in Germany by the milk retail price, which was only available on state level. With one percent more input milk, the milk processing company generates 44.5 percent more processed milk as output. With one percent more capital, the milk processing company creates 56.4 percent more processed milk. Interestingly, we observe over study period a negative time trend of -2.61 percent.

5.2 Results for the Prime Method

We demonstrate the results of the Prime method from Equation 5 in Table 4. We regress the Solow residual on b_1 and b_2, which are coefficients of milk input and capital. We calculated the dependent variable SR based on Equation 2. Hence, we assume that dairy processing companies exercise market power over farmers in the raw milk market. We estimate that dairy processors are able to buy the raw milk 231 percent below the value of the marginal product. The coefficients itself are highly statistically significant and the tests reject the case of perfect market competition as well

Variable	Unit	Years	Source
Milk price (farm gate)	Euro per kg	2010-2021	Balance sheets accessed via the Federal Gazette publishing house, German agricultural newspaper, various agricultural chambers
Milk retail price	Euro per kg	2010-2021	Federal Office for Agriculture and Food
Milk quantity, complemented with	Kg		Balance sheets accessed via the Federal Gazette publishing house
Federal Ministry of Food and Agriculture		2010-2021	Federal Ministry of Food and Agriculture
Bavarian milk processing quantity		2010-2018	Bavarian State Institute for Agriculture
Electricity price calculated with:	Euro per kg		
Total dairy production in Germany	Kg per year	2010-2021	Statista
Energy use of the dairy processing industry	Euro	2010-2018	Statistical yearbooks of the *Manufacturing industry cost structure*
Industry energy price	Euro-Cent per kilowatt hour	2010-2021	Statista
Average salary	Euro per employee	2010-2021	Balance sheets accessed via the Federal Gazette publishing house
Equity capital	Euro	2010-2021	Balance sheets accessed via the Federal Gazette publishing house
Interest rate	In percent	2010-2021	German Central Bank
GDP per capita	Euro	2010-2021	Statista

Table 2: Variables used in the analysis with respective unit, year, and sources with hyperlinks.
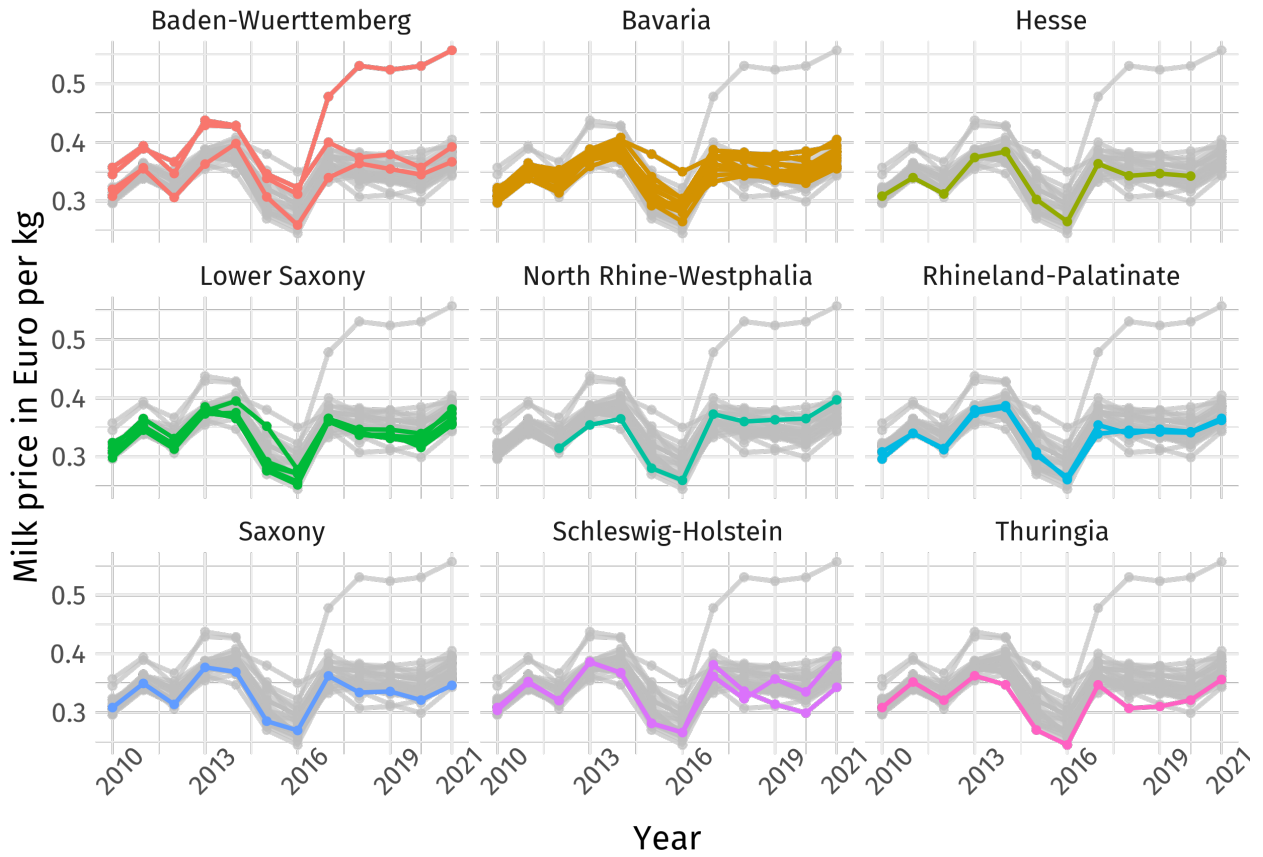
Figure 3: Milk price in Euro per kg per year per state in Germany. Each line represents one milk processing company. Missing values in Hesse and North Rhine-Westphalia due to missing balance sheet data for respective milk processing companies. Source: own compilation.

	Milk output (kg log)
Milk input (kg log)	0.445***
	(0.0354)
Equity capital (Euro log)	0.564***
	(0.0448)
Time trend (yr2009=1)	-0.0261***
	(0.00441)
Constant	1.931***
	(0.332)
Company FE	Yes
N	323
R^2	0.824
adj. R^2	0.805
AIC	-46.19
BIC	-31.08

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: Results of the CRS production function, Source: own calculations
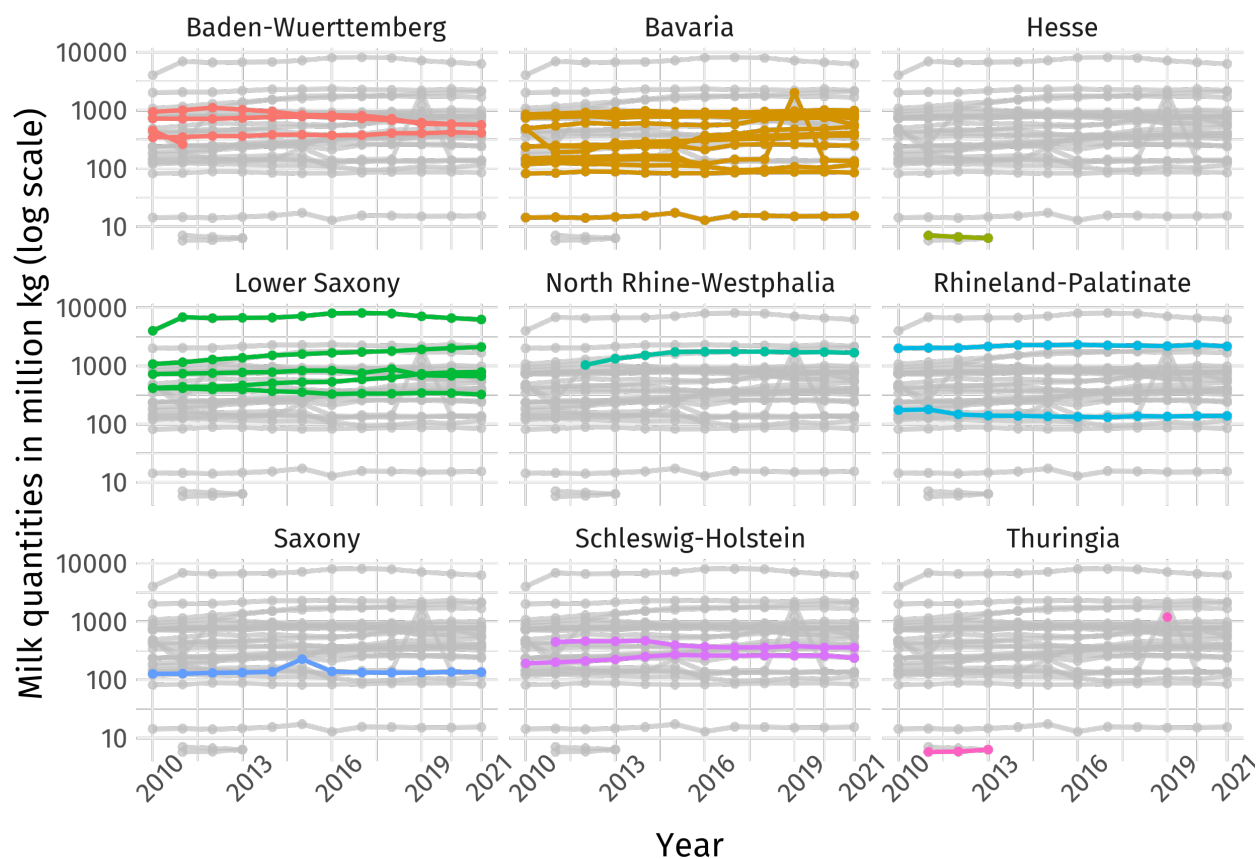
Figure 4: Milk quantities in million kg per year and per state in Germany. Each line represents one milk processing company. Missing values are due to missing data for respective milk processing companies and for respective districts where milk processing companies are located. Source: own compilation.

as the case of only oligopolistic market power. We cannot reject the test for exclusive oligopsonistic market power. However, as mentioned in Section 2.1.3, the prime method suffers from endogeneity so the coefficients should be interpreted with caution.

	Solow residual
b_0	0.00992**
	(0.00374)
b_1	0.705***
	(0.0170)
b_2	-0.698***
	(0.0181)
Company FE	Yes
N	291
R^2	0.872
adj. R^2	0.858
AIC	-820.8
BIC	-809.8
Test: $b_1=b_2=0$	$F(2,260)=889.51$***
Test: $b_2=0$	T-statistic = -38.52***
Test: $b_1=-b_2$	$F(1,260)=0.38$
β_{mp}	0.007***
β_{ms}	2.311***

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Results of the Prime method, Source: own calculations

5.3 Results for the Prime-Dual Method

We display the results of the Prime-Dual method in Table 5 based on Equation 11. Similar to the results from the Prime Method, we reject the tests for perfect competition, and that either oligopsony or oligopoly is the only source of market power. Hence, we conclude that dairy processing companies exercise upstream and downstream market power simultaneously (see Case 4 from Table 1). We show that dairy processing companies exercise downstream market power by selling processed milk about 1.1 percent above the marginal costs. Further, dairy processing companies exercise upstream market power by buying raw milk from dairy farmers at 9.2 percent below the value of the marginal product. The coefficient for the downstream market power is statistically significant at the 5 percent level, while the coefficient for the upstream market power is statistically significant at the 0.1 percent level.

5.4 Summary

Coefficients in the Prime as well as the Prime-Dual method were highly statistically significant. Both models rejected the hypothesis of perfect competition in the raw milk as well as in the output market. The hypothesis that oligopolistic market power was the only source of market power

	Only MP market dpsolow	Joint MP and MS market dpsolow
b_1	0.0964** (0.0348)	0.103** (0.0331)
b_2		-0.0113*** (0.00200)
Company FE	Yes	Yes
N	289	289
R^2	0.026	0.123
adj. R^2	0.023	0.117
AIC	-95.35	-123.7
BIC	-91.69	-116.4
Test: $b_1=b_2=0$	NA	$F(2,287)=20.15$***
Test: $b_2=0$	NA	T-statistic=-5.64***
Test: $b_1=-b_2$	NA	$F(1,287)=7.76$***
β_{mp}	0.0964**	0.011*
β_{ms}	NA	0.092***

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Results of the Prime-Dual method, Source: own calculations

was also rejected in both models. The hypothesis that oligopsony was the exclusive source of market power was only rejected by the Prime-Dual method. Thus, both models conclude that dairy processing companies execute statistically significant market power over farmers in the raw milk market. Moreover, the theoretically and empirically more robust Prime Dual method shows that dairy processor companies execute both, oligopsonistic as well as oligopolistic market power.

6 Discussion and Limitations

6.1 Comparison to other studies

Our findings show that dairy processors execute oligopsonistic and oligopolistic market power. This finding is align with other empirical papers about the German and European dairy value chain who also find strong evidence for market power at various stages within the supply chain (Grau & Hockmann, 2017; Koppenberg & Hirsch, 2021; Koppenberg, 2023).

Our findings are also align with a similar study about the French whole milk powder sector, who identified downstream and upstream market power of 41 and and 16 percent, respectively (Avignon & Guigue, 2023). This study is a good reference study for our paper as France is the second biggest dairy producer within the EU (after Germany) and has a similar dairy supply chain structure. In France, the top 5 dairy processing companies control 63 percent of raw milk purchases, while the top 4 dairy processing companies control 53 percent of raw milk purchases (Avignon & Guigue, 2023) and see Section 3. Compared to their main results, our finding are moderate and show higher

market power distortions in the upstream market (9.2 percent) than in the downstream market (1.1 percent). We hypothesize that this discrepancy for the downstream market stems from choice of product: while we focus on raw milk, they focus on whole milk powder which can be used for not only liquid milk but also other dairy product groups. This allows them to derive dairy product specific market power estimates. Hence, dairy processors have simply more options to exercise oligopsonistic market power via multiple dairy products (and not just raw milk). Additionally, their theoretical model differs and they use more comprehensive data sources, which allows them to work with 7996 observations[4] (Avignon & Guigue, 2023)

In contrast to our results, one qualitative paper states that the execution of oligopsonistic market power is unlikely as milk producers seem to have sufficient legal and institutional possibilities to push through their interests additional to flexible contract arrangements (Knuck et al., 2023). We argue that these possibilities may exist but dairy processors have still more leeway to set up contracts to their advantage, as stated by the Federal Cartel Authority (2024, 2017b).

6.2 Methodological issues

The method requires the two strong assumptions. First, we have to assume a constant returns to scale (CRS) production function, meaning that we assume a constant elasticity of substitution. Further, we acknowledge that constant returns to scale might not adequately reflect the production parameters within a dairy. Due to data unavailability, we consider only milk, labour and capital as inputs. Therefore, we neglect other, potentially relevant input factors related to transport, energy, marketing, or distribution. Second, we have to assume Hicks-neutral technical change, meaning that the marginal productivity of all production factors by the same proportion at the same capital-labor ratio (Raper et al., 2007).

We acknowledge that we established a non random data set and that our sample might suffer from selection bias (Heckelei et al., 2023). Nevertheless, we think that our estimation results can indicate certain economic practises of dairy firms. We oriented ourselves on the top-20 dairy lists from the *Association of the German Dairy Industry* which is based on the top processed milk quantity and revenues. We added ten more dairy processors based on the study from Jürgens (2021). Our sample covers 67 percent of all processed milk quantity in Germany in the year 2021 (see Table A1). However, we recognize that market power can be also executed by smaller dairy processors, as demonstrated by Koppenberg & Hirsch (2021), or driven by geographical specificity's which we did not consider.

6.3 Conceptual issues

We do not differentiate between dairy cooperatives and other dairy corporate forms and we argue that it is also not relevant for the objective of analyzing market power due to three reasons. First, output levels are implicitly determined by independent farmer members and the cooperative accepts and markets all of it. Hence, decentralized production decisions and no control over the supply limit the exercise of market power. Indeed, notice periods for milk delivery contracts are often longer for corporate dairy processors than for cooperatives (Federal Cartel Authority, 2017b). Second,

---

[4]We include only 289 observations in our study.

voluntary membership[5], and potential free rider behaviour of other corporate dairy processors undermine the execution of market power (Sexton & Lavoie, 2001). Third, Koppenberg (2023) find that in the European context, farm size seems to be associated with exercising market power rather than the organisational structure of a farm.

We were not able to estimate a statistically meaningful association between the cooperative dummy variable and the processed milk output. We attribute this to insufficient company-varying and time-varying data as the organizational structure for the same company does only change for one out of 30 companies within the study period. Thus, we argue that any company-varying aspects are captured by the company fixed effects in the model. Regarding our data set, dairy processors organized as cooperatives generate more revenue, process more milk, and pay one Eurocent more for the milk for the farmers on average. Other corporate firm structures have a higher equity capital and have more employees on average (see Table 6). Nevertheless, we encourage future research to find ways how to disentangle potential market power indicators for different organizational structures of dairy companies.

Variable	Average Other Corporate Firm	Average Cooperative	T_Value	P_Value
Revenues in Germany in Million Euro	347.51	574.02	3.76	0.00
Capital in Million Euro	191.37	102.19	-2.91	0.00
Labors	2122.24	1134.69	-2.63	0.01
Input price milk	0.34	0.35	2.62	0.01
Milk quantity in Million kg	462.09	1207.95	5.08	0.00

Table 6: Summary statistics for Cooperatives vs Other corporate forms, Source: own calculation.

Further, we only focus on the oligopsonistic and oligopolistic market power originating from dairy processors, and might overlook potential market power originating from other actors in the supply chain (see Figure 1). The German dairy supply chain is characterised by highly concentrated retailer part [6] which are often accused of exercising upstream market power (Grau & Hockmann, 2017). Since the concentration in food processing industries increases, it would be also very interesting to look into other food processing companies, such as the meat processing industry (Paul, 2001). In comparison to the studies who use conjectural elasticities, we can only estimate one static index for the whole time period their approach allows to develop a dynamic index of market power over a period (Grau & Hockmann, 2017; Perekhozhuk et al., 2013).

6.4   Data quality

We might over- or underestimate complemented input or output prices as well as milk quantities for some dairy companies. Despite efforts of minimizing missing data, we had to complement

---

[5]Exception: regional markets that are controlled by a few cooperatives.

[6]In the year 2015, four retailers (Edeka, Rewe, Aldi and the Schwarz-Group) have 85 percent market share (Federal Cartel Authority, 2016).

missing data with data on higher administrative levels which might not reflect the actual economic performance of a specific dairy company.

Whenever possible, we considered only the delivered milk quantity for a dairy company and excluded bought in addition milk. However, this distinction was not always possible and might be another source of misspecification.

We do not differentiate between different fat and protein contents of milk as the dairy processing plants report, if at all, only one price per year. We assume that different prices for different fat and protein contents, which exist among dairy processing plants, would not have a major impact on the results. If reported, the differences are minimal and vary between 4 to 4.41 percent fat or 3 to 3.47 percent protein content. We source the German revenue information from the balance sheets. However, we are not able to differentiate between revenues generated from sales of milk and sales of other dairy products, such as yoghurts and cheese due to data unavailability. It is also suitable to consider only milk for analysis as other byproducts that are added during the production process are, compared to other dairy products, neglectable. We acknowledge that sales of milk might be only a minor contribution to revenues and that most of the milk is used for cheese production in Germany (MIV, 2020).

7   Conclusions

We explored the potential exercise of market power of dairy processors within the dairy value chain in Germany. We simultaneously tested whether dairy processors exercise oligopolistic market power in the raw milk market and oligopsonistic market power in the output product market. Our main finding using the Prime-Dual Method suggests that, dairy processors exercise market power in both markets by buying raw milk at 9.2 percent below the value of the marginal product and selling processed milk by 1.1 percent above marginal costs. However, this result should be interpreted with caution as the applied method requires strong assumptions such as a constant returns to scale production function as well as Hicks-neutral technical change. Conceptually, we also did not differentiate between dairy processors that are organized cooperatives or other corporate forms. Further, we approximated the value of the milk output only with state level output prices due to data unavailability. Nevertheless, we believe that our results serve as first empirical basis for informing policy makers and governmental bodies that dairy processors execute market power in both, the raw milk and output product market. Thus, we highly recommend to attribute more investigation efforts to the role of dairy processors within the supply chain. In order to decrease market distortions, we argue for more flexible contract conditions as well as reliable milk price forecasting between dairy farmers and dairy processors. Additionally, future research should investigate measurements to reduce market power induced welfare losses between dairy processors and retailers. Ultimately, measurements in the agri-food sector should aim to reduce market power in order to increase welfare of the most vulnerable actors at both ends of the supply chain.

Upcoming research could extend the methodology to incorporate a more realistic production function as well as a distinction between cooperatives and alternative corporate forms of dairy processors. Moreover, this analysis could be extended to other food processing value chains, such as the

meat value chain. Overall, future efforts should focus on improving transparency regarding input and output prices, as well as the quantities of processed milk from dairy processors.

References

Avignon, R., & Guigue, E. (2023). Markups and Markdowns in the French Dairy Market. *Markups and Markdowns in the French Dairy Market (2023) Working Paper Link*, .

BMEL (2024). *Paradigmenwechsel am Milchmarkt – von der Milchquotenregelung zu mehr Verantwortung der Marktakteure Link*. Technical Report, Bundesministerium für Ernährung und Landwirtschaft.

Cakir, M., & Balagtas, J. V. (2012). Estimating market power of U.S. Dairy Cooperatives in the fluid milk market. *American Journal of Agricultural Economics*, *94*, 647–658. doi:10.1093/ajae/aar136.

Chen, Y., & Yu, X. (2019). Do subsidies cause a less competitive milk market in China? *Agricultural Economics*, *50*, 303–314. doi:10.1111/agec.12485.

Chen, Y., & Yu, X. (2021). Estimating market power for the Chinese fluid milk market with imported products. *Agribusiness*, *38*, 386–401. doi:10.1002/agr.21725.

Domowitz, I., Hubbard, R. G., & Petersen, B. C. (1988). Market structure and cyclical fluctuations in U.S. manufacturing. *The Review of Economics and Statistics*, *70*, 55. doi:10.2307/1928150.

Federal Cartel Authority (2012). *Sektoruntersuchung Milch Abschlussbericht gemäß Paragraf 32e GWB Januar 2012*. Technical Report, Federal Cartel Authority. URL: https://www.bundeskartellamt.de/SharedDocs/Publikation/DE/Sektoruntersuchungen/Sektoruntersuchung%20Milch%20-%20Abschlussbericht.pdf?__blob=publicationFile&v=4 accessed: 2024-09-05.

Federal Cartel Authority (2016). Die Big Four haben 85 prozent marktanteil. https://www.bundeskartellamt.de/SharedDocs/Interviews/DE/2016/Fuldarer_Zeitung__Die_Big_Four_haben_85_Prozent_Marktanteil.html. Accessed: 2024-09-04.

Federal Cartel Authority (2017a). Interim report on conditions for the supply of raw milk. https://www.bundeskartellamt.de/SharedDocs/Meldung/EN/Pressemitteilungen/2017/13_03_2017_Milch.html. Accessed: 2024-09-05.

Federal Cartel Authority (2017b). Sachstand im verfahren zu lieferbedingungen für rohmilch. https://www.bundeskartellamt.de/SharedDocs/Publikation/DE/Berichte/Sachstand_Milch.pdf?__blob=publicationFile&v=3. Accessed: 2024-09-05.

Federal Cartel Authority (2024). Monopolkommission zur Wettbewerbssituation in der Lebensmittellieferkette. Link.

Gohin, A., & Guyomard, H. (2000). Measuring market power for food retail activities: French Evidence. *Journal of Agricultural Economics*, *51*, 181–195. doi:10.1111/j.1477-9552.2000.tb01222.x.

Grau, A., & Hockmann, H. (2017). Market power in the German dairy value chain. *Agribusiness*, *34*, 93–111. doi:10.1002/agr.21529.

Hall, R. E. (1988). The relation between price and marginal cost in U.S. industry. *Journal of Political Economy*, *96*, 921–947. doi:10.1086/261570.

Heckelei, T., Hüttel, S., Odening, M., & Rommel, J. (2023). The p-value debate and statistical (mal)practice – implications for the agricultural and food economics community. *German Journal of Agricultural Economics*, *72*. doi:10.30430/gjae.2023.0231.

Hyde, C. E., & Perloff, J. M. (1994). Can monopsony power be estimated? *American Journal of Agricultural Economics*, *76*, 1151–1155. doi:10.2307/1243408.

Jongeneel, R. (2023). *Development of milk production in the EUafter the end of milk quotas*. Technical Report, European Parliament, Policy Department for Structural and Cohesion Policies Link.

Jürgens, K. (2021). *Wertschöpfungsstudie Deutsche Molkereien Aktualisierung 2021*. Technical Report, Milcherzeugergemeinschaft MEG Milch Board w. V. Link.

Knuck, J., Banse, M., Freund, F., Laquai, V., Margarian, A., & Thies, A. (2023). *Evaluierung der Lieferbeziehungen zwischenmilcherzeugenden Betrieben und Molkereien*. Technical Report, Johann Heinrich von Thünen-Institut Bundesforschungsinstitut für Ländliche Räume, Wald und Fischerei. Thünen Working Paper 215. URL: `https://literatur.thuenen.de/digbib_extern/dn066536.pdf`.

Koppenberg, M. (2023). Markups, organic agriculture and downstream concentration at the example of European dairy farmers. *Agricultural Economics*, *54*, 161–178. doi:10.1111/agec.12762.

Koppenberg, M., & Hirsch, S. (2021). Output market power and firm characteristics in dairy processing: Evidence from three EU countries. *Journal of Agricultural Economics*, *73*, 490–517. doi:10.1111/1477-9552.12460.

Lehmann, N. (2022). Kartellamt: Darum dürfen milchbauern die milchpreise nicht absprechen. `https://www.agrarheute.com/markt/milch/bundeskartellamt-untersagt-milchbauern-absprachen-ueber-milchpreise-589646`. Accessed: 2024-09-04.

Mambro, A. D. (2024). Map: farmers protests lead to concessions almost everywhere. *EURACTIV*, . doi:https://www.euractiv.com/section/agriculture-food/news/snapshot-of-farmers-protests-and-its-not-over/.

Meyer, J., Feil, J.-H., & Schaper, C. (2019). Internationalization strategies in the German dairy industry and their influence on the economic performance of firms. *International Journal on Food System Dynamics*, *Vol 10*, No 4 (2019). doi:10.18461/IJFSD.V10I4.22.

MIV (2020). *Milch und mehr – die deutsche Milchwirtschaft auf einen Blick*. Technical Report, Informationsbroschüre des Milchindustrie-Verbandes e.V.

Paul, C. J. M. (2001). Cost economies and market power: The case of the U.S. meat packing industry. *Review of Economics and Statistics*, *83*, 531–540. doi:10.1162/00346530152480171.

Perekhozhuk, O., Glauben, T., Teuber, R., & Grings, M. (2014). Regional-level analysis of oligopsony power in the Ukrainian Dairy industry. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, *63*, 43–76. doi:10.1111/cjag.12037.

Perekhozhuk, O., Hockmann, H., Fertő, I., & Bakucs, L. Z. (2013). Identification of market power in the Hungarian Dairy Industry: A plant-level analysis. *Journal of Agricultural & Food Industrial Organization*, *11*, 1–13. doi:10.1515/jafio-2012-0005.

Raper, K. C., Love, H. A., & Shumway, C. R. (2007). Distinguishing the source of market power. *American Journal of Agricultural Economics*, *89*, 78–90. doi:10.1111/j.1467-8276.2007.00964.x.

Roeger, W. (1995). Can imperfect competition explain the difference between primal and dual productivity measures? estimates for U.S. manufacturing. *Journal of Political Economy*, *103*, 316–330. doi:10.1086/261985.

Salhofer, K., Tribl, C., & Sinabell, F. (2011). Market power in Austrian food retailing: the case of milk products. *Empirica*, *39*, 109–122. doi:10.1007/s10663-011-9166-3.

Sexton, R. J., & Lavoie, N. (2001). Chapter 15 food processing and distribution: An industrial organization approach. In *Marketing, Distribution and Consumers* (pp. 863–932). Elsevier. doi:10.1016/s1574-0072(01)10023-x.

Sexton, R. J., & Xia, T. (2018). Increasing concentration in the agricultural supply chain: Implications for market power and sector performance. *Annual Review of Resource Economics*, *10*, 229–251. doi:10.1146/annurev-resource-100517-023312.

Solow, R. M. (1956). A contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, *70*, 65. doi:10.2307/1884513.

Yu, C., & Gould, B. W. (2019). Market power and farm-retail price transmission: The case of US fluid milk markets. *Agribusiness*, *35*, 537–555. doi:10.1002/agr.21606.

Appendix

Year	Milk quantity in million kg		Ratio
	in analysis	in Germany	
2010	16895.31	29629.00	0.57
2011	20190.14	30336.00	0.67
2012	21100.27	30685.00	0.69
2013	21748.87	31338.00	0.69
2014	22465.69	32395.00	0.69
2015	23107.56	32685.00	0.71
2016	23950.07	32672.00	0.73
2017	23941.57	32598.00	0.73
2018	24215.19	33087.00	0.73
2019	26268.83	33080.00	0.79
2020	23040.06	33155.00	0.69
2021	21710.54	32507.00	0.67

Table A1: Milk quantities per year of milk processing companies incorporated into the analysis vs milk quantities in whole Germany in million kg. Source: Statista and own compilation.

ID	Coop. dummy	Rev_ger M_Euro	Equity_capital M_Euro	P_input Euro_kg	P_output Euro_kg	Q_milk M_kg	Salary Hun_Euro	Employees Total
1	0	390.57	136.21	0.33	0.36	909.50	399.05	2376.67
2	1	481.74	107.00	0.34	0.34	1609.09	550.23	456.58
3	0	457.75	194.78	0.34	0.36	604.75	438.80	2391.58
4	0	563.06	541.60	0.35	0.36	327.69	397.12	4615.33
5	1	316.84	55.82	0.34	0.36	777.68	534.14	1027.75
6	1	439.56	66.63	0.34	0.36	802.62	563.43	979.75
7	0	416.09	245.98	0.35	0.36	345.73	480.80	1696.75
8	1	834.31	117.96	0.38	0.36	707.18	625.45	1373.42
9	1	962.45	116.99	0.36	0.35	1396.56	584.75	1387.92
10	0.91	2895.40	506.96	0.33	0.34	6859.49	545.84	6765.58
11	0	390.96	53.14	0.35	0.34	759.58	541.79	743.33
12	1	837.02	173.47	0.33	0.35	2192.88	559.52	1857.45
13	0	216.62	61.88	0.35	0.36	243.11	549.46	995.25
14	0	298.38	34.46	0.34	0.36	826.78	725.44	466.33
15	1	470.50	59.65	0.33	0.34	570.41	558.07	662.83
16	0	228.58	9.26	0.33	0.34	362.23	498.27	334.00
17	0	307.02	70.14	0.36	0.36	880.63	571.42	586.50
18	0	180.63	6.02	0.33	0.34	403.18	427.28	139.58
19	0	670.63	1493.26	0.33	0.36	294.65	479.15	17411.50
20	0	509.56	39.35	0.32	0.35	304.50	393.65	266.92
21	1	208.00	133.26	0.37	0.36	296.94	505.73	337.92
22	1	174.64	29.53	0.36	0.36	110.98	464.00	394.17
23	0	274.77	43.27	0.35	0.36	85.30	549.85	635.92
24	1	185.31	38.66	0.44	0.36	379.15	657.39	142.25
25	0	90.30	10.90	0.34	0.35	144.21	434.83	205.75
26	1	282.17	13.85	0.35	0.36	150.22	491.84	452.50
27	1	36.07	9.11	0.33	0.35	6.70	436.70	104.11
28	1	77.92	19.67	0.33	0.35	141.32	393.31	126.50
29	0	48.10	12.22	0.34	0.34	241.23	521.00	100.61
30	0	309.68	91.27	0.35	0.36	15.02	815.96	691.58

Table A2: Descriptive statistics per milk processing company, averaged over the period yr2020 to yr2021. Source: own compilation.

Year	Coop.	Rev_ger M_Euro	Equity_cap M_Euro	P_input Euro_kg	P_output Euro_kg	Q_milk M_kg	Salary Hun_Euro	Employees Total	Interest Percent
2010	0.47	329.34	81.61	0.31	0.33	625.75	454.23	925.98	3.43
2011	0.43	420.00	90.84	0.36	0.36	673.00	451.35	1051.23	3.28
2012	0.47	426.44	95.31	0.33	0.34	703.34	468.70	1061.22	2.25
2013	0.47	474.94	113.81	0.38	0.39	724.96	491.04	1327.21	2.37
2014	0.47	451.53	128.27	0.39	0.39	802.35	507.50	1364.05	2.01
2015	0.47	410.11	157.68	0.31	0.31	825.27	507.56	1802.50	1.07
2016	0.47	409.18	167.75	0.28	0.29	855.36	519.70	1986.30	0.65
2017	0.47	486.77	175.77	0.37	0.38	886.72	524.56	2058.11	0.97
2018	0.47	486.02	180.73	0.36	0.36	896.86	527.07	2091.38	0.95
2019	0.47	543.29	193.95	0.36	0.36	938.17	589.21	2001.52	0.21
2020	0.47	482.86	199.21	0.35	0.35	853.34	609.54	2065.11	-0.18
2021	0.45	499.92	218.98	0.38	0.38	835.02	618.73	2255.55	-0.01

Table A3: Descriptive statistics per year, averaged over all milk processing companies. Source: own compilation.

Milk quantity in million kg

< 1M	10M - 50M	100M - 500M	NA
1M - 10M	50M - 100M	> 500M	