MARKUP AND PRODUCT DIFFERENTIATION IN THE GERMAN BREWING SECTOR

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Abstract

In this paper we provide a method to separate the markup from product differentiation from other sources of market power, i.e. collusive behavior or market intransparency, based on the estimation of a single reduced form equation. We apply this method to a sample of 118 German breweries, since beer is a differentiated product and at the same time the sector has repeatedly been subject to collusive behavior. Our empirical results show that the "general" markup goes beyond the markup from product differentiation, but the latter accounts for most of the deviation of prices from marginal costs. Moreover, typically for a market with monopolistic competition, we observe average costs above marginal costs and, hence, a high markup does not necessarily translate into a high a profit margin.

Keywords: markup, product differentiation, monopolistic competition, Germany, beer
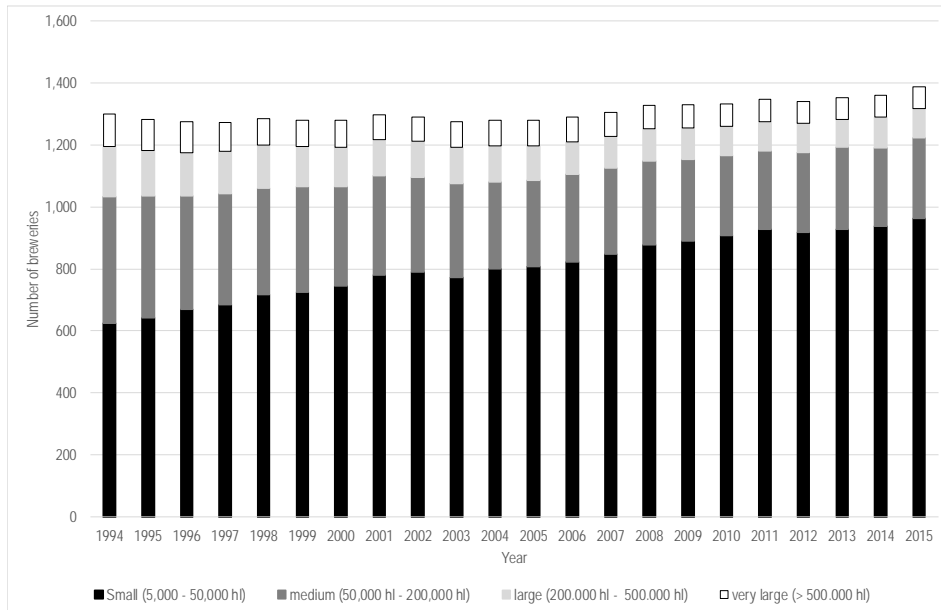
1   Introduction

The brewing industry worldwide is highly concentrated. In 2015 the four largest firms (AB-InBev, SAB Miller, Heineken, Carlsberg) accounted for almost 50% of the global beer production (Statista, 2017a). As a global exception, the brewing industry in Germany is still characterized by a comparably low concentration. Only two of the five worldwide market leaders (AB-InBev as number two and Carlsberg as number nine) are listed among Germany's top ten breweries, and these two firms accounted for approximately 15% of the German beer production in 2012 (NGG, 2013). In fact, as illustrated in Figure 1 the number of breweries even increased over the last two decades from 1,273 in 1997 to 1,388 in 2015 (Deutscher Brauerbund, 2017). However, this aggregated numbers give a very incomplete picture of the developments. Only in the group of very small breweries (producing up to 5,000 hl/year) new establishments entered the market. Their number increased from 615 in 1994 to 964 in 2015 (DeStatis, 2010, 2016). In all other groups we observe a steady decrease. Though exports increased over the last two decades, this could not completely compensate for the decrease in national beer consumption of about 1.3% per year, leading also to a decrease in national production by 18.2% within the last 21 years. Moreover, the beer market in Germany is still very much nationally oriented. Exports accounted on average for 12.5% of domestic production and imports accounted on average for 5.5% of consumption between 1995 and 2015.

Despite the low concentration in the sector, there is some evidence of collusive behavior. For example, in 2014 the German Federal Cartel Office (Bundeskartellamt) imposed fines amounting to €338 million on 11 breweries for two illegal price fixing agreements in 2006 and 2008 (Bundeskartellamt, 2014). In another proceeding, which started in 2010, the Bundeskartellamt imposed fines of about €94 million on different food retailers for vertical price fixing with AB-Inbev (Bundeskartellamt, 2016).

Moreover, beer is also a perfect example of a differentiated product market (Hausman et al., 1994; Slade, 2004; Rojas and Peterson, 2008) with different styles (Lager, Pils, Wheat) and many different brands available. In fact, we observe considerable price differences between different beers, even of the same style from different breweries. This may be due to consumers' attachment to specific brands, preferences for products from a specific place-of-origin or preferences for local products (van Ittersum et al., 2003; Profeta et al., 2008; Hasselbach and Roosen, 2015). Moreover, in the last decade the German brewing sector spent on average approximately €375 mill. or 4.7% of total revenues annually on marketing (Statista, 2017b). Therefore, after sweets and milk, beer has the third highest marketing expenditures and accounts for 12% of all marketing expenditures in the food and beverages industry (Zühlsdorf and Spiller, 2012).

Figure 1: Number of breweries in different size classes in Germany, 1994 - 2015

Quelle: Deutscher Brauerbund, 2017; DeStatis, 2010, 2016

Figure 2: Production, consumption, export, and import of beer in Germany, 2005 -2015
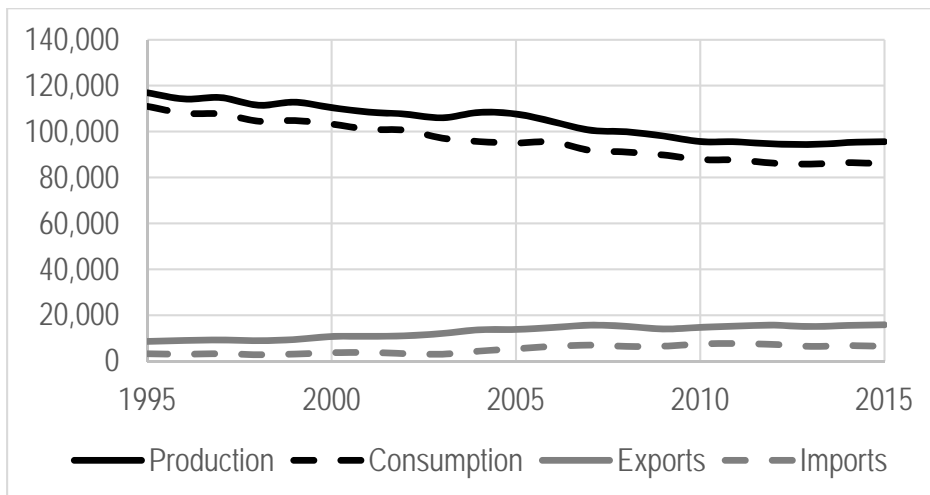
Quelle: STATISTA

The aim of this paper is to investigate whether German breweries price above marginal costs, and if so, if this is due to product differentiation or due to other sources of imperfect competition, e.g. collusive behavior. Based on a framework developed by Hall (1988, 1990) and De Loecker and Warzynski (2012) we estimate markups based on firm level data. This measure relies on the insight that the output elasticity of a variable factor of production is only equal to its expenditure share in total revenue when price equals marginal cost of production. This "general" markup serves as a general measure of imperfect competition, without placing any assumption on the price setting behavior of the firms. Hence, observed markup may be due to imperfect competition, product differentiation or other sources like market intransparency. We then identify the markup which is due to product differentiation based on an approach by Klette and Griliches (1996) and the assumption of monopolistic competition. We show how both measures can be derived by estimating one reduced form model of the production and demand side of the market. Comparing these two measures indicates to what extent the observed markup is due to product differentiation and to what extent it is due to other sources.

The rest of the paper is organized as follows: The next chapter discusses our theoretical framework. Section 3 describes our data and our empirical model while section 4 presents the results. We finish with drawing some conclusions and discussing the limitations of our analysis in section 5.

2 Theoretical Framework

Following Hall (1988, 1990) and De Loecker and Warzynski (2012) we model a firm producing a single output Q utilizing variable inputs which can be freely adjusted (X_V) and quasi-fixed inputs facing adjustment costs (X_F). Assuming that imperfect competition is restricted to the output market, i.e. firms are price takers on the input markets, and they minimize cost

$$C(\boldsymbol{W}, Q) = \min\{\boldsymbol{W}'\boldsymbol{X} : F(X_V, X_F) = Q\}, \tag{1}$$

then first order conditions for variable inputs are given as:

$$\frac{\partial \mathcal{L}}{\partial X_V} = W_V - \lambda \frac{\partial F(X_V, X_F)}{\partial X_V} = 0, \tag{2}$$

where W_V is the price of variable inputs. The Lagrangian multiplier $\lambda = \frac{\partial \mathcal{L}}{\partial Q} = \frac{\partial C(\boldsymbol{W}, Q)}{\partial Q}$ can be interpreted as marginal costs (MC). By multiplying both sides of equation (2) with $\frac{X_V}{Y}$, where $Y = QP$ is firm's revenue with P being the output price, and rearranging slightly we derive:

$$\frac{P}{MC} \frac{W_V X_V}{Y} = \frac{\partial F(X_V, X_F)}{\partial X_V} \frac{X_V}{Q}. \tag{3}$$

In equation (3) $\frac{W_V X_V}{Y} = s_V^Y$ is the revenue share of the variable input X_V and $\frac{P}{MC} = \mu$ is the markup parameter. The output elasticity of a variable input is defined as $\varepsilon_V = \frac{\partial F(X_V, X_F)}{\partial X_V} \frac{X_V}{Q}$. Hence, we can rewrite (3) as

$$\mu s_V^Y = \varepsilon_V. \tag{4}$$

From equation (4) we can see that under perfect competition – when firms price at their marginal cost, $\frac{P}{MC} = 1$ and the revenue share of a variable input equals its output elasticity. Using (4) we can derive a measure of the "general" markup μ. This requires data on revenue shares of the variable input, which can usually be calculated from the available firm-level data, and the estimation of a production function to derive the output elasticity of the variable input. Based on firm-level panel data we can write a firm's the production function as

$$q_{it} = f(x, t) + \sigma_i + e_{it} \tag{5}$$

where q_{it} is the logarithm of physical output quantity Q_{it}, $f(x, t)$ is a function of the log inputs x and time t as a dummy for technology, and i denotes different firms. Time-invariant and unobserved firm-specific differences, including time-persistent productivity differences are captured by σ_i while e_{it} denotes an i.i.d. error capturing idiosyncratic productivity shocks and measurement errors.

Following Klette and Griliches (1996) and assuming imperfect substitutability between the firms' products, i.e. horizontal product differentiation, the demand facing the individual firm can be modelled by a CES demand function:

$$Q_{it} = \left(\frac{P_{it}}{P_t^L}\right)^\eta Q_t^L \exp(w_{it}) \tag{6}$$

The demand for product Q_{it} is determined by the firm price P_{it} relative to the industry price P_t^L and the aggregated industry demand Q_t^L.[1] Any other unobserved demand shocks, such as changes in consumer tastes or advertising effects are captured in the residual term w_{it}. Assuming a CES demand function η is constant across firms and can be interpreted as the own price elasticity of demand for each firm's product. In a perfectly competitive environment with perfectly elastic demand only one price can exist. Hence, η shows to which extent firms face a downward sloping demand curve for their products that allows for some flexibility in their pricing decision. Assuming monopolistic competition between firms our constant markup measure from product differentiation is

$$\mu_\eta = \frac{\eta}{\eta+1} \, . \qquad (7)$$

It is important to stress at this point, that this approach does not assume any strategic interaction between firms. This is different to for example Nevo (2001) and Rojas (2008) who test for different models of pricing conduct. However, this would need rather disaggregated, brand-level, demand data necessary to estimate a complete demand system, while our approach is based on firm level data.

Taking logs and rearranging terms in equation (6) we can express a firm's deviation from the industry price level as a function of the firms' individual market shares and the demand shocks in the error term w_{it}.

$$p_{it} - p_t^L = \eta^{-1}(q_{it} - q_t^L - w_{it}) \qquad (8)$$

Substituting this expression into the production function (5) results in

$$y_{it}^L = \left(\frac{\eta+1}{\eta}\right) f(x,t) + \left(\frac{\eta+1}{\eta}\right)\sigma_i - \eta^{-1}q_t^L + \left(\frac{\eta+1}{\eta}\right)e_{it} - \eta^{-1}w_{it} \qquad (9)$$

where y_{it}^L are a firm's revenues deflated by an industry-level price index, i.e. $y_{it}^L = q_{it} + p_{it} - p_t^L$. Hence, equation (9) allows us to recover the output elasticity ε_V from the parameters of $f(x,t)$ and derive the general mark-up μ and a mark-up from product differentiation μ_η. Without product differentiation, the demand elasticity η goes to infinity and consequently the demand specific markup μ_η goes to one. However, this case does not rule out other forms of imperfect competition as for example collusive behavior or market intransparency, captured in the general markup μ.

3   Data and Empirical Model

We employ an unbalanced panel of German breweries which participated in a voluntary benchmarking program conducted on behalf of the German Brewers Association over a period of 13 years from 1996 to 2008.[2] We exclude microbreweries that produce less than 5,000 hl/year and large breweries that produce more than 300,000 hl/year from the sample, since we only have a very few observations in this size classes and it can be expected that these breweries use different production technologies. This provides us a rather homogenous sample of 118 small and midsized businesses with an average of 48 employees and revenues of 7.8 million € Nevertheless, these firms represent the core of the German brewing sector. On average, each

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[1]   De Loecker (2011a) uses a very similar approach and derives segment specific demand elasticities while allowing for multiproduct firms.

[2]   As firms participate voluntarily in the program, we neither have information about firms' motivation to participate, nor why they enter or exit the sample. Hence, we have to assume that participation in the program is random and uncorrelated with firms' levels of inputs and outputs. If this is not the case, estimated production elasticities are biased. Olley and Pakes (1996) for example raise concerns of a possible correlation between firm's decision to enter and exit a sector and the size of their capital stock.

brewery was observed for about 7 years resulting in 826 observations. Most of the observed breweries are located in Bavaria (57%) and Baden-Württemberg (19%) in southern Germany.

Firm output is given as firm revenues deflated by a price index for the whole brewing industry as provided by the Federal Statistical Office of Germany. Descriptive statistics are given in Table 1. We aggregate inputs into three variables: material, labor, and capital. Material and labor are deduced form the firms' profit and loss statements. The variable material is constructed as an aggregate of all expenses for raw materials and intermediate products including malt, barley, hops, energy as well as purchased goods and services.[3] Before aggregating, all single components were deflated using specific price indices provided by the Federal Statistical Office of Germany to proxy physical inputs. Labor is measured by the sum of all wages paid to employees, including management and deflated by the labor cost index of trade and industry as provided by the Federal Statistical Office of Germany. We use the wage bill instead of the mere number of employees, because we are missing information on the actual work hours, the educational status and tenure of employees in the firms. Hence, we follow Fox and Smeets (2011), who show that the wage bill is a good approximation of quality adjusted labor input among others in the Danish food and beverages industry. Capital is measured as the end of year value of all machinery, equipment and buildings as stated in the firms' balance of accounts and deflated by the price index of machinery for food, beverages and tobacco manufacturing (Federal Statistical Office of Germany). Following De Loecker (2011b) aggregated industry demand Q_t^L includes imports and is derived from DeStatis (2002, 2006, 2008).

Table 1: Summary statistics of input and output variables

(1,000 €)	Mean	Max.	Min.	Std. Dev.
Output	7,833.9	30,110.2	669.9	6,089.4
Material	2,216.7	10,296.2	197.8	1,752.0
Labor	1,829.0	6,530.6	99.8	1,370.6
Capital	3,574.3	26,523.3	210.4	3,524.8

Quelle: own calculations, based on data from Brauerbund

To derive the general markup and the markup from product differentiation we need an estimate of equation (9). Representing the production function $f(x, t)$ in equation (7) in a translog form (Jorgenson, Christensen and Lau, 1973) and including non-neutral technical change, we have

$$y_{it}^L = \tilde{\beta}_0 + \sum_{j=M,L,C} \tilde{\beta}_j x_{jit} + \frac{1}{2} \sum_{\substack{j= \\ M,L,C}} \sum_{\substack{k= \\ M,L,C}} \tilde{\beta}_{jk} x_{jit} x_{kit} + \sum_{j=M,L,C} \tilde{\beta}_{jt} t x_{jit} + \tilde{\beta}_t t \tag{10}$$
$$+ \tilde{\beta}_{tt} t^2 + \tilde{\sigma}_i - \eta^{-1} q_t^L + \omega_{it}$$

where M, L, C indicate material, labor and capital, respectively. $\widetilde{\boldsymbol{\beta}} = \left(\frac{\eta+1}{\eta}\right) \boldsymbol{\beta}$ is a vector of reduced form parameters that combine production and demand parameters and $\boldsymbol{\beta}$ is a vector including all parameters of the production function $f(x, t)$. The remaining error term ω_{it} contains unobserved production and demand shocks, so $\omega_{it} = \left(\frac{\eta+1}{\eta}\right) e_{it} - \eta^{-1} w_{it}$. Since (10) is a reduced form equation of production and demand, t and t^2 may also include demand shifts, e.g. the general trend of decreasing beer consumption.

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[3] According to a brewing industry expert the set of components included in the variable material, is a good representation of a breweries variable costs.

From the parameters estimated in equation (10) we can directly derive η and the markup from product differentiation in equation (7). To derive the best estimate of general markup we need the production elasticity and the revenue share of a variable input free of adjustment costs. Capital is naturally considered as an input with costly adjustment. Whether we have to expect adjustment costs for labor depends on the presence of hiring and firing costs. However, for the material input we don't expect substantial adjustment costs. Klette (1999) and Crépon et al. (2005) identify labor as variable input whereas De Loecker and Warzinski (2012) note the possibility of labor adjustment costs. We follow De Loecker and Warzinski (2012) and use material to derive the general markup. The production elasticity of material ε_{it}^M is given by

$$\varepsilon_{it}^M = \tilde{\beta}_M + \tilde{\beta}_{MM}x_{Mit} + \tilde{\beta}_{ML}x_{Lit} + \tilde{\beta}_{MC}x_{Cit} + \tilde{\beta}_{Mt}t \qquad (11)$$

Based on equation (11) we derive firm and time specific output elasticities.

In calculating material revenue shares s_M^Y we follow De Loecker and Warzynski (2012) and correct observed output $\tilde{Q}_{it}$ by the predicted error $\hat{\omega}_{it}$ as the latter may be correlated with factors that are not among the inputs. Revenue shares are then given as

$$s_V^Y = \frac{W_M X_M}{P_{it}\tilde{Q}_{it}\exp(-\hat{\omega}_{it})} \qquad (12)$$

4 Results

We estimate equation (10) using a Fixed Effects Model. To test the appropriateness of the fixed effects estimator we employ the Hausman test and clearly reject the Null-Hypothesis of a consistent random effects estimator with $\chi_{15}^2 = 85.06$. By regressing time-demeaned values of the variables we eliminate time invariant productivity differences $\tilde{\sigma}_i$ and avoid possible endogeneity bias caused by the latter. We report an overall R^2 of 0.966 and values for between R^2 of 0.969 and within R^2 of 0.828. These values indicate that our model additionally explains a large fraction of the variance in output between the breweries and within individual firms across time periods. We are using a log likelihood ratio test for model specifications (Table 2) and reject the Null-Hypothesis of no second order effects (Cobb-Douglas form), no technical change and Hicks-neutral technical change.

Table 2: Log-likelihood ratio tests of model specifications

Null-Hypothesis	Chi²-value	p-value	Critical value (a=0.05)
No second order effects:			
$H_0: \tilde{\beta}_{ML} = \tilde{\beta}_{MC} = \tilde{\beta}_{LC} = \tilde{\beta}_{MM} = \tilde{\beta}_{LL} = \tilde{\beta}_{CC} = 0$	24.785	0.000	$\chi_6^2 = 12.59$
No technical change:			
$H_0: \tilde{\beta}_t = \tilde{\beta}_{tt} = \tilde{\beta}_{tM} = \tilde{\beta}_{tL} = \tilde{\beta}_{tC} = 0$	59.115	0.000	$\chi_5^2 = 11.07$
Hicks neutral technical change:			
$H_0: \tilde{\beta}_{tM} = \tilde{\beta}_{tL} = \tilde{\beta}_{tC} = 0$	51.738	0.000	$\chi_3^2 = 7.81$

We report the regression results obtained in Table 3. All first-order effects have the expected sign and are significant at the 1% level. The negative inverse demand elasticitiy $-\eta^{-1}$ is close to being significant at the 5% level and has a value of 0.435. This corresponds to a demand elasticity of -2.3. Using the latter enables us to calculate the demand specific markup parameters $\mu_\eta = \frac{\eta}{\eta+1}$ of 1.77 in the German market for beer.

Mean output elasticities are 0.637 for material, 0.863 for labor and 0.018 for capital. Hence, on average we observe increasing returns to scale ($\delta = \varepsilon_{it}^M + \varepsilon_{it}^L + \varepsilon_{it}^C$) of 1.519. Based on the

estimated output elasticity of the input material ε_{it}^{M} and the calculated firm specific revenue shares, we derive a mean general markup of 1.928. Price differentiation accounts for 0.83% of the markup (0.769/0.928) while the rest is due to some other factors. Using these estimates we can also calculate the ratio between prices and average costs, which is given by $\frac{P}{AC} = \frac{\mu}{\delta}$ (Crépon et al., 2005), as 1.27. This measures gives some indication of the firms' profit margins.

Table 3: Fixed effects estimates of reduced form equation

	Deflated Revenues		SE
Material	0.261	***	(0.025)
Labor	0.569	***	(0.031)
Capital	0.058	***	(0.013)
Material*Labor	-0.163	***	(0.041)
Material*Capital	0.007		(0.021)
Labor*Capital	-0.030		(0.019)
Material^2	0.071	***	(0.020)
Labor^2	0.092	***	(0.028)
Capital^2	0.010		(0.007)
Trend	0.003		(0.004)
Trend^2	0.001		(0.000)
Trend*Material	0.016	***	(0.002)
Trend*Labor	-0.015	***	(0.003)
Trend*Capital	-0.001		(0.001)
Demand Germany	0.435	*	(0.234)
Constant	0.123	***	(0.026)
R^2 overall	0.966		
R^2 within	0.828		
R^2 between	0.969		
Observations	826		
Hausman χ_{15}^2	85.06		

Standard errors in brackets
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5   Conclusions

Market concentration, market power and imperfect competition along different supply chains for food products and beverages are issues of increasing concern (OECD, 2014). According to OECD (2013) more than 180 antitrust cases in this regard were investigated by the European competition authorities over the period 2004 – 2011. To observe prices to be above marginal costs does not necessarily proof an abuse of market power or illegal collusion and price setting. In a market with differentiated products it may also reflect consumer preferences for certain tastes, regional products or brand loyalty. In this paper, we derive two distinct markup measures. Following De Loecker and Warzynki (2012) we derive a general markup as the ratio between prices and marginal costs. This measure is not conditional on any assumption about the price setting behavior of the firms. By following Klette and Griliches (1996) and assuming monopolistic competition with imperfect substitutability between the firms' products, we derive a markup measure which basically reflects horizontal product differentiation. We show how both measures can be derived by estimating one reduced form model of the production and demand side of the market.

Our results clearly point towards firms operating under increasing returns to scale in a market with imperfect competition. Increasing returns in the brewing industry are in line with findings by for example Nelson (2005), Tremblay et al. (2005) and Madsen and Wu (2014). Moreover,

most of the measured markup is due to product differentiation, reflecting consumers' preferences for specific brands or beer from specific breweries, e.g. the local brewery. However, the relatively high markup does not necessarily translate into high profits since the firms are not scale efficient. This is a standard result for a monopolistic competitive market with average costs above marginal costs. It also reflects the structure and situation in the German brewing industry. Most breweries are too small to be competitive on the international market. German breweries do not play a significant role on a global level. The largest German brewery (Radeberger Gruppe KG) is only at 23rd position and the three largest German breweries (Radeberger, Oettinger und Bitburger) account for 1.6 % of the world market worldwide (NGG, 2013). Though, most of the measured markup is due to product differentiation, the measured general markup is significantly higher than the estimated demand driven markup. This indicates that product differentiation is not the only source of markup.

Though our research gives some insights into the markups and pricing behavior of the German brewing sector, it also suffers from some shortcomings. First, given the aggregated nature of our data we are not able to explicitly model the demand for specific brands and beers. Rather, we have to assume a CES demand function with constant own demand elasticities across firms and time periods. These are strong assumptions concerning the residual demand functions of the firms. By utilizing data at the product level and estimating a demand system as in Nevo (2001) or Rojas (2008), one can test for different strategic interactions between firms. Second, some authors have questioned common procedures of estimating a production function because of endogeneity issues of input factors and have suggested alternative estimation techniques (Olley and Pakes, 1996; Levinsohn and Petrin, 2003).

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