EFFICIENCY AND CONCENTRATION IN THE UKRAINIAN BREWING INDUSTRY

by

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Abstract

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The present paper tests hypothesis that motivation to concentration in the Ukrainian brewing industry observed during the transition period was rooted in the potential gains from economies of scale and that the growing producers were more costs effective than the other industry participants. Non-parametric non-stochastic method of scale efficiency estimation is employed as the main tool while regression analysis is also used as a complementary device in the estimation. Based on the obtained results the stated above hypothesis was rejected. The results were shown being robust to changes in samples of breweries, specifications of inputs and outputs, and methods of estimation

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Chapter 1

INTRODUCTION

At times of the Soviet Union *the central planner* was determining the number of breweries, their capacities as well as the output and the prices. The total number of breweries amounted by the late 1980s to 180 all producing the mainstream 'mass market' brand "Zhygulivske". The brewing capacities were distributed approximately uniformly among the breweries. However, over the transition period of the 1990s the industry structure has change dramatically. Four brewing groups owning ten largest breweries comprised about 95% of the market in 2003. These largest breweries were rapidly growing in preceding six years expanding their Soviet times' capacitates through adding new brewing equipment to the existing production sites. Meanwhile many other breweries were loosing the customers and leaving the industry. By the beginning of 2004 the number of operating breweries in the industry has decreased to 65 or about 36% of the operating breweries under the central planning system in the 1980s.

The potential reasons for concentration may be rooted in possible efficiency gains from economies of scale or in possible market power gains. From point of view of the society concentration in an industry would be beneficial if it brings higher cost efficiency but leaves the pricing at least as it was before the concentration or as most possible closer to the competitive market pricing. In the present work I question *whether the observed concentration in the brewing industry of Ukraine during the transition period has brought higher cost efficiency originated by economies of scale and whether the group of larger producers are more cost effective comparative to the smaller industry participants.*

The brewing industry was analysed based on the Structure-Conduct-Performance Paradigm. To test the stated above hypothesis I employed Data Envelopment Analysis as the main tool and additionally performed purely regression analysis in part of check for robustness to datasets of operating characteristics of 55 breweries in 2001 and 2002. DEA specification of input orientated radial Ferrell measure with operating costs as aggregated input and revenue from sales as aggregated output was chosen as the base.

My results of estimated scale efficiencies suggested that scale economies do exist and some breweries, indeed, can benefit from increasing their scale of operations. However, the estimation has shown that the ten largest breweries were constantly operating above the scale efficient level. Therefore, these breweries were growing during the recent years above the efficient scale and efficiency gains from economies of scale cannot be an explanation of the motivation to grow for these breweries. These results from DEA estimation are also supported by the pure regression analysis of cost efficiency of the breweries in the same period. The largest breweries appeared even to be less profitable than some smaller breweries in terms of operating profit margins.

So, the industry leaders may have other objectives than cost minimisation. One of most possible candidates for the explanation is that these brewing groups might have the primary objective of market share maximisation. This might be especially true in the current conditions of the market when consumption per capita is increasing, consumers' choices are changeable and loyalties to particular brands of beer are not yet developed. This strategy is likely to be optimising over a longer period rather than over a few years as it is considered in the present study.

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LITERATURE REVIEW

Analysis of incentives to and effects of concentration in many studies has led to two major groups of arguments. On the one hand, arguments state for the growing concentration due to increasing efficiencies primarily related to economies of scale. On the other hand, arguments state that concentration is mainly motivated by the possibility to effective marketing and advertising, building barriers to entry and, in doing so, excising market power, which are so called demand-side incentives (McGree, 1974). Results of empirical studies vary in supporting or not these arguments depending upon the industry, time period under consideration and techniques of estimation. However, to some extent a consensus had been attained that there are more likely to be present in many industries mixed effects of increasing costs efficiency and market power associated with concentration, and the dominating effect is difficult to define so that all parties would accept (Edwards, 1974).

Despite the difficulties in estimation and the mixture of the effects one can conclude that, in general, an increase in concentration is in benefits for the society only if the effects of rising efficiency are present and if these effects offset potential dead weight losses of the society due to gained market power by the producers[1].

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[1] Additionally, in a particular case of alcoholic beverages other effects on the society should be taken into consideration, e.g. a drop in prices on alcoholic beverages might lead to a higher consumption of alcohol and, consequently, to a greater number of accidents caused by drunken people. However, beer is widely recognised as a substitute drink to hard liquors (e.g. vodka), especially it is relevant in particular case of Ukraine and Russia. Having thought that consumption of beer is less harmful than consumption of hard liquors then cheaper beer would stimulate people to the substitution and, therefore, would be desirable to some extent in a view of the whole society.

The best research of concentration dynamics and its effects in brewing industry specific analysis has been done for USA industry partly owing to very interesting empirical evidence of fast rising concentration starting from 1950s (in fact, number of breweries operating in the industry had fallen from 369 in 1950 to 26 in 1998). Some studies indicated at economies of scale as the driving force of the concentration (Elzinga, 1986; Scherer, 1974). While the others have found demand-side incentives for concentration more profound (Horowitz, 1967; Horowitz and Horowitz, 1965), in particular due to product differentiation (Greer, 1971), superior marketing position (Tremblay, 1985; Tremblay and Tremblay, 1988). Particularly interesting conclusions have obtained Mueller (1978)[2] arguing that economies of scale incentives prevailed up to 1970s after what marketing strategies became more influential in determining the industry concentration.

Also Sutton (1991)[3] discovered role of endogenous sunk costs (e.g. advertising, research and development) as a determinant of industry concentration, in particular, in food and beverages industries. He concluded that in industries where endogenous sunk costs, which determine 'competitive capability' of industry participants, are relatively high concentration is expected to be high. Applying this theory to brewing industry it might be a case that breweries are playing strategic dynamic games incurring excessive advertising costs in order to develop popularity of their brands of beer, crowd out other producers of non-branded beer and finally construct barriers to entry to preserve their market positions.

One of the most recent works addressing the analysis of concentration and cost efficiency is the study of US brewing industry by Zelenyuk (2002). The study

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[2] Cited from Zelenyuk (2002)

[3] Cited from Bresnahan (1992)

focuses at scale efficiencies measurement by applying the non-parametric non-stochastic efficiency estimation known as Data Envelopment Analysis or DEA (Farrell, 1957; Fare and al. 1994). The applied measure of scale efficiency is "a relative measure of how far a firm is from the 'best-practice' industry frontier associated with the minimum efficient scale, after one accounts for possible technical inefficiency of this firm" (Zelenyuk, 2002, p.96-97). The estimation is performed jointly for two groups of the industry participants: national and regional producers and, then they are analysed separately in a comparative assessment of the groups efficiencies taking into account important differences in their activity. The study concluded that national producers were operating constantly at significant diseconomies of scale while the regional producers, on the contrary, were operating close to the minimum efficient scale level. Thus, the estimation procedure applying DEA led to a rejection of the hypothesis that economies of scale as a supply-side factor were the rationale for the rising concentration.

Traditionally, in the research of concentration in manufacturing industries were used three techniques: engineering, survivor and regression analysis (Lipczynski and Wilson, 2001). DEA measurement of efficiencies is a relatively new technique and yet has little application in the research of scale economies and concentration. Each of these techniques has own benefits and drawbacks. The engineering (e.g. Pratten, 1971; Emerson and al. 1988)[4] turns to be too expensive, time and resources consuming, relying on expertise and subjective statements. The survivor technique (e.g. Scherer, 1974)[4] had been found difficult to apply because in many cases it appeared that most efficient firms came from both the group of largest and group of smallest firms (Shepherd, 1967)[4], and because it assumes market conditions where no imperfection exists. Regression analysis (e.g. Amess and Gourlay, 2000), remains most widely used but it is as well open to

[4] Cited from Lipczynski and Wilson, 2001

jeopardy and disputing about its correctness due to risks of misspecification, unsolved endogeneity problems, biasness arising from unavailability of full set of required data and measurement errors.

The used by Zelenyuk, 2002 DEA estimation has a number of assumptions that could be considered dubious with regard to some industries. This estimation requires careful assessment before applying it to empirics. Following McFadden (1978) DEA assumptions of monotone and convex production possibility set is an analytical convenience rather than economic realism, which may or may not be justified for some industries. Also, DEA is highly sensitive to measurement errors in the data sets. DEA advantage is the fact that the estimation is based on data sets of inputs and outputs, which are often available; moreover, making an assumption of equal prices of inputs allows an aggregation of all inputs into the total costs (Simar and Zelenyuk, 2003), which is too easily available from the financial statements. Another advantage concerns the possibility to remove the bias arising from the linear approximation in the estimation procedure and establish statistical properties of the obtained estimates (confidence intervals) by means of Bootstrap technique.

In the recent years two studies of the Ukrainian brewing industry related to concentration issues were prepared. The first (Maryanchyk, 2000) examined the interrelationship between performance and concentration and concluded that the relationship was positive for the firms which market share had been increasing and the causal relationship was bilateral during the period under consideration from 1Q1991 to 1Q2000. The second study (Demyanyk, 2001) investigated whether advertising in the brewing industry of Ukraine had been justified from an economic perspective. The study has shown that based on the empirical evidence for period from January 1998 to December 2000 advertising had not led to an increase in market shares in an amount sufficient to influence prices of beer but supported to the expansion of the market, so the competitiveness had been preserved.

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METHODOLOGY

In the present work I performed an estimation of the cost scale efficiencies by applying Two-stage DEA approach, which involves simultaneously Data envelopment analysis (DEA) and statistical regression estimation. This approach is advantageous because it clearly formulates the scale efficiency and its calculus, estimation of efficiency scores does not require any assumptions about functional form of the production relationship, "it focuses on the individual observations rather than population averages, as in the case of purely regression analysis" (Zheka, 2003 p.31), it allows taking into account many factors affecting the individual efficiencies so that the purified estimated efficiencies are net of environmental influences. At the first stage, cost scale efficiencies are estimated by use of two alternative approaches: *the original input orientated Farrell measure of technical efficiency* and *the transformed input orientated Farrell measure of technical efficiency*, which differs from the former in aggregation of all inputs in monetary units (Simar and Zelenyuk, 2003).

DEA methodology is widely used in measuring firms' efficiencies; in particular, technical efficiency[5], which estimates how well firms use resources given a particular input structure, and allocative efficiency, which estimates how effectively firms choose structure of inputs to produce outputs. In this paper I estimate the cost scale efficiency formulated as input oriented technical efficiency (Farrell, 1957; Fare and Zelenyuk, 2003). To illustrate how the DEA methodology works let consider a simple case of two inputs and one output (x_1, x_2, y_1) and assuming a constant return to scale (CRS) production technology. The

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[5] In some sources it is also called as productive efficiency

DEA methodology estimates an efficient frontier (FF') given a set of observations and individual efficiencies corresponding to each observation relative to the efficient frontier (FF') (see Figure 1).

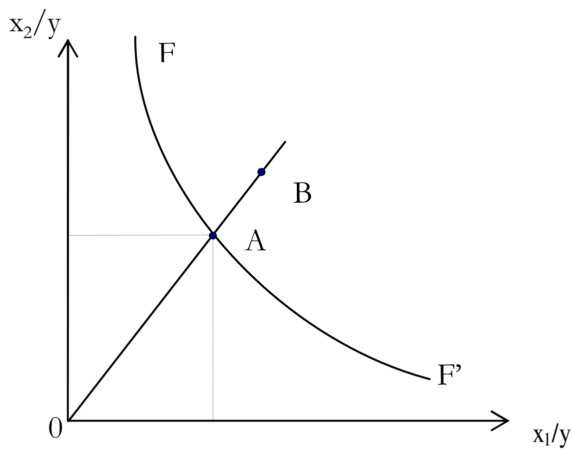

Figure 1. Technical efficiency definition

In this framework, a firm that produces one unit of output at costs of quantities of inputs at point B is considered technically inefficient with a relative measure of inefficiency measured by the distance AB, while a firm that produces the same unit of output by inputs at point A is considered as fully technically efficient and being on the efficiency frontier FF'. In general, the technical efficiency of a firm is measured by a ratio of OA distance to OB distance, i.e. TEi=OA/OB. Point A indicates the most efficient quantities of inputs x1 and x2 given their constant proportion along the ray OB from the origin.

In case of many inputs (vector $x \in R^{N}_{+}$.) and many outputs (vector $y \in R^{M}_{+}$.) technology, input oriented Ferrell technical efficiency is defined as (Zelenuyk, 2002)

$$F^{k}(y^{k}, x^{k} \mid r) = \min\{\lambda^{k} : (x^{k})\lambda^{k} \in L^{k}(y^{k} \mid r)\} \quad (1)$$

where input set is $L^k(y^k \mid r) = \{x^k : x^k \; can \quad produce \quad y^k \; with \quad r\}$ (2)

k=1,...K is an index for each individual firm in the sample,

λ is constant and,

r corresponds to return to scale specification, e.g. C is constant return to scale, V is variable return to scale.

DEA estimation requires a set of assumptions about the technology:

- doing nothing is feasible, i.e. for any amount of inputs output can be zero, i.e. $\forall x \; \exists y=0 \in P(x)$, $P(x)$ is a set of outputs given the technology;

- no free lunch or output set determined by zero input set is zero, i.e. $P(x)|_{x=0}=0;$

- weak disposability of inputs, i.e. for $\forall x \in L(y) \wedge \lambda \geq 1 \Rightarrow \lambda x \in L(y),$ where λ is a constant and $L(y)$ is a set of inputs that produce y given the technology;

- strong disposability of outputs, i.e. $\forall y \in P(x) \wedge \breve{y} \leq y \Rightarrow \breve{y} \in P(x);$

- P(x) is bounded, this reflects scare inputs used in the production, at least some of the inputs;

- assumption of equal access to the same technology.

Note that DEA estimation also requires assumptions of strong disposability and convexity of inputs set. In case of brewing industry these assumptions can be accepted only with limited extent because for some of the inputs a relatively fixed proportion is demanded, e.g. quantities of malt and hops follow a recipe, however, the others might be used as substitutes, e.g. labour and capital.

Therefore, it is hoped that in the present work these assumptions do not affect the estimates significantly while simplify the estimation procedure.

Also the choice of input orientation of the Ferrell measure assumes that the firms are rather cost minimising than revenue maximising. This assumption is likely to be reasonable in case of brewing industry so that the breweries set the capacities and then optimise over costs depending on market conditions. Expansion of brewing capacities is rather being a long-term planning decision, which restricts possibilities to revenue maximisation in short-term.

Due to the fact that in DEA estimation the frontier is constructed by linear connections of the points from the observed data, this leads to a bias equal to OA'/OB – OA/OB (see Figure 2). Also another source of bias in the DEA estimation arises due to assumption of convexity of the technology set. As the set is convex and the inputs/outputs are assumed to be continuous, there is a zero probability to observe the completely efficient enterprises but in DEA estimation there is always at least one efficient observation and the probability is always positive.

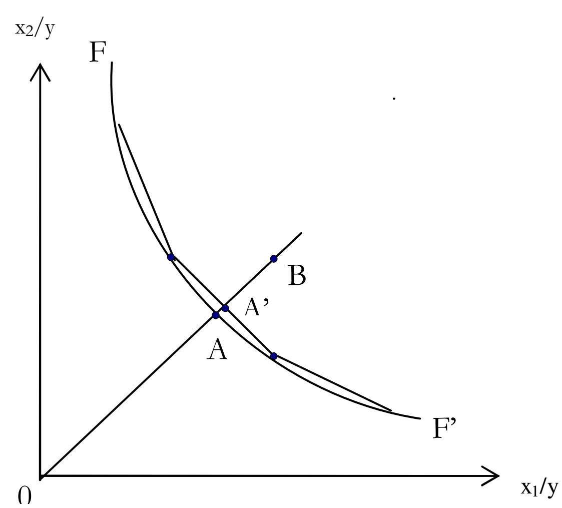

Figure 2. Bias definition in TE

In order to eliminate the bias, Bootstrap technique can be applied (Simar and Zelenyuk, 2003). Its essence is in resampling many times from the observed data set, i.e. pseudo population, and estimating the frontier each time from the taken sub-samples. As a result of many performed estimations, the bias can be defined at high level of statistical significance as a difference between the estimated frontier based on the pseudo population and the estimated frontier based on many sub-samples. At the end, the efficiency scores are corrected by the values of the bias.

Practically, there are two possible bootstrap applications to efficiency estimates: sub-sampling bootstrap and smooth homogeneous bootstrap. The first works well only for large samples at least more than 100 observations. The second option of bootstrap was developed by Simar and Zelenyuk (2003) particularly for technical efficiencies scores. This technique is based on adding noise to originally estimated technical efficiency scores and translating the noise to inputs or outputs (depending on efficiency orientation), and then constructing multiple sub-samples from the original data and the noise of the same sample size as the original sample. The rest of the procedure is the same as in other bootstrap applications.

However, the developed bootstrap techniques for technical efficiency need to be modified for application to scale efficiency, especially the smooth homogeneous bootstrap requires careful analysis. Appendix 1 summarises arguments for and against possible modification. As a result of the analysis, modification with adding noise separately and simultaneously to TE|VRS and TE|CRS in the bootstrap procedure was chosen[6].

[6] The proposed modification has not been proved being consistent and efficient and it is left for further investigation.

For an intuitive illustration of the definition of the cost scale efficiency formulated in terms of the technical efficiency let consider a typical for microeconomics diagram analysis (cited from Zelenyuk, 2002).

Under the general assumption of equal access to the technology, characterised by the long-run average cost function *AC(y,p|V)* with variable returns to scale (defined as |V) and y and p corresponding to output and price vectors, the only cost scale efficient point is at the level of production $y=y^{MES}$. In order to separate the effects of pure cost inefficiency and cost scale inefficiency an average cost function characterised by constant return to scale at minimum efficient scale (MES) y^{MES} is introduced as *AC(y,p|C)*.

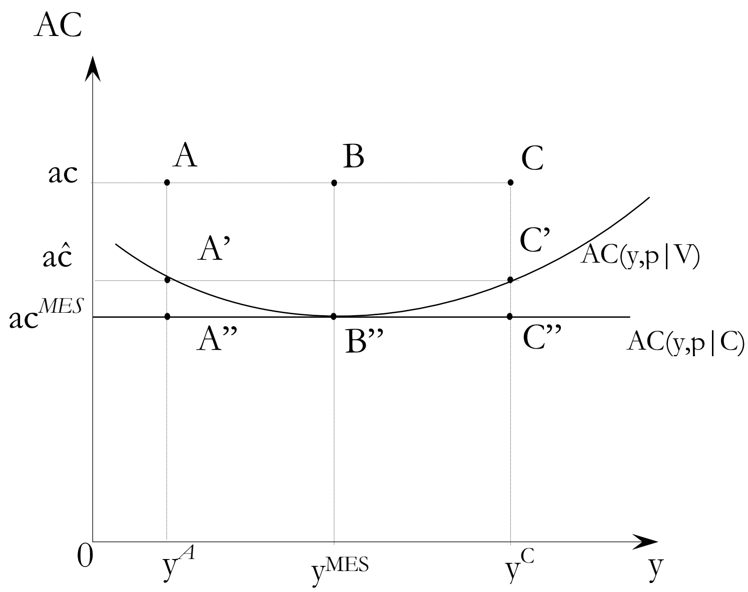

Figure 3. Cost scale efficiency definition

So, for an individual observation, let consider A with index *k*, the overall average cost inefficiency is being apart from B" is broken down so that being apart from *AC(y,p|V)* is due to the pure average cost inefficiency and being apart from efficient scale level y^{MES} and average costs ac^{MES} is due to the cost scale inefficiency. In formal formulation it is as following (Zelenyuk, 2002)

$$\text{Overall average cost efficinecy} = \underbrace{\frac{AC(y^k, p|V)}{ac^k}}_{\text{Pure average cost efficiency}} \times \underbrace{\frac{AC(y^k, p|C)}{AC(y^k, p|V)}}_{\text{Average cost scale efficiency}} \quad (3)$$

where ac^k is observed average cost of firm k

In terms of original input orientated Farrell radial distance measure of technical efficiency the separation of the efficiencies is defined as (Farrell, 1957)

$$F^k(y^k, x^k \mid C) = \underbrace{F^k(y^k, x^k \mid V)}_{\text{Pure cost efficiency}} \times \underbrace{SE^k(y^k, x^k)}_{\text{Cost scale efficiency}} \quad (4)$$

where $SE^k(y^k, x^k) = F^k(y^k, x^k \mid C) / F^k(y^k, x^k \mid V)$ (5)

As a result of the first stage of estimation, individual cost scale efficiencies $SE^k(y,x,)$ are obtained for each firm in the sample in two alternative formulations of the Farrell technical efficiency.

At the second stage, regression analysis based on dataset organised as balanced panel as for 2001, 2002 years is applied in order to estimate the relationship between the cost scale efficiency scores from the first stage and scale proxy controlling for other factors that describe differences in the environment among the firms.

The regression equation is

$Efficiency\ measure_k = a_0 + a_1 * scale_k + \sum b_j * control\ variable_{j,k} + u_k$ (6)

where j=1,….J are indices for control variables.

The control variables can be regional dummies, dummy of location in regional centres. Scale proxy can be defined as a dummy variable (it is one if a brewery is one of top ten largest breweries, which distribute the produced beer interregionally or at nation-wide level, and zero if a brewery has low level of sales with a distribution within its local market) or, alternatively, scale proxy can be introduced as a continuous variable, e.g. volumes of sales.

The estimated scale efficiency measure SE(y,c) in the first stage belongs to the interval (0;1] and the efficiency scores are not supposed to be distributed normally. Because of these constraints in the dependent variable standard OLS estimation theoretically is considered being inappropriate. Therefore, many researches applied Tobit or truncated regression models. However, Simar and Wilson (2003) have shown that Tobit and truncated regression estimations require unrealistic assumption of independence between the regressors at the second stage and the input variables at the first stage of DEA[7]. The authors have proved that the truncated regression with double bootstrap is statistically correct approach and superior to Tobit and simple truncated regression (Zelenyuk and Zheka, 2003). Another way to overcome the constraints in the dependent variable is to transform it so that to increase its range from minus infinity to plus infinity. For example, with a loss of one period estimates of dependent variable transformed as $\log(SE_t/SE_{t-1})$ can take any value from the set of the real numbers (Brown and Earle, 1999). Applying this transformation allows to use the standard methods of linear regression.

The hypothesis about significance of scale economies as a driving incentive to concentration is tested based on the scale efficiency scores at the first stage of estimation and the sign of the scale explanatory variable and its statistical significance at the second stage.

[7] However, Simar and Wilson (2003) suggested that truncated regression is superior to Tobit in applications to efficiency scores.

C h a p t e r   4

INDUSTRY DESCRIPTION[8]

Similarly to definitions of brewing industry in other countries the State Committee of Statistics of Ukraine defines it as comprising establishments primarily engaged in brewing beer, ale, malt liquors and non-alcoholic beer and we will follow this definition. Technology of brewing includes milling and mashing malt, adding brewing water, filtration, adding hops, wort boiling, wort cooling, yeast fermentation, lagering, and filtration, overall production process takes about 8 weeks.

The brewing industry of the Soviet era was primarily focused on the production of just one 'mass market' brand – 'Zhygulivske' – and a handful of other local brands. The quality of the beer varied considerably depending on the producer. Following a long period of decline in production that lasted from 1990 to 1996, the Ukrainian brewing industry started to recover only in 1997. Gradual growth in 1997 and 1998 was followed by a dynamic surge in 1999, 2000 and 2001 (with cumulative annual growth rate being about 25% between 1999 and 2002) (see Appendix 2). In contrast to the Soviet times with supply of only 'Zhygulivske' brand at present Ukrainian producers offer a variety of brands and improve quality of beer.

Export sales according to official statistics varied from year to year about 6-7% of total production. Major exporters were Obolon, which accounted over 90% of total exports, and BBH-owned Slavutich, which accounted for about 6%. Official together with estimated 'grey' import, meanwhile, comprise a small share of beer consumption in Ukraine about 1-2% in the recent years.

Per capita consumption in Ukraine considerably increased from 11.2 litres in 1996 to 36 litres in 2003 so that the cumulative annual growth rate amounted to 16.5%. Indeed, even the fall in GDP and disposable income that followed the 1998 crisis failed to decelerate the growth of consumption. As Ukrpivo experts expect consumption per capita will stabilise at about 55-60 litres by 2007 (see Appendix 2).

Industry structure: there are 65 breweries in the industry that fall into three categories.

1.) Large, renovated breweries with capacity in excess of 1 million hector litres. This group consists of the seven largest breweries in Ukraine that compete on a nation-wide level: Obolon, Desna, Rogan, Slavutich, Lvivska Pivovarnya, Yantar, and Sarmat (also see profile of the leading brewing groups in Ukraine in Appendix 3).

2.) Medium-sized breweries with capacity of 0.3–1.0 million hector litres. These breweries are mostly operating on the interregional level. Quality and the efficiency of production differ to a large extent among the members of this group.

3.) Small breweries, which have difficulties to compete with the market leaders. Each of them has only a small market share in their respective regions. Most of these breweries are undersized in terms of capacity and inferior in terms of product quality. The number of these breweries has been decreasing rapidly over the transition period.

Prior to 1997, the Ukrainian brewing market was characterised by low competition and absence of nation-wide brand with the exception of

[8] This chapter is prepared based on Internet search and confidential industry reports

Zhygulivske. Among the largest breweries only Obolon managed to create a wide distribution network and started marketing its products throughout the country. The situation changed dramatically when, in 1997, foreign strategic investors began to acquire Ukrainian breweries and applied their superior experience in marketing and branding to the Ukrainian market. Since then, industry concentration has increased and brewing groups Sun Interbrew, Obolon, BBH and Sarmat have gained control over a substantial share of the market. Combined market share of these groups reached about 80%, 90% and finally 95% in 2000, 2001 and 2003, respectively. Sun Interbrew and BBH are the major foreign brewing groups while Obolon and Sarmat are the major national groups in Ukraine.

The average price of beer in Ukraine is significantly lower in comparison to Western European benchmarks and even prices in CEE countries. This might present an opportunity for the breweries to improve their financial position with expected further growth in disposable incomes and corresponding rising consumption of beer. The tax base on beer is relatively low to compare with Russia and especially with CEE and European countries.

Table 1. Average retail prices for alcoholic beverages (including taxes), 2002

	UAH per litre	USD per litre
Beer	3.6	0.7
Wine	18	3.4
Hard liqueurs	20	3.8
Also-pops	8	1.5

Source: the SCSU

Since the late 1990s, the trends in Ukrainian beer consumption have moved to favour premium and super-premium brands of beer. The super-premium segment includes imported beer and well-known international brands (such as

Stella Artois and *Tuborg*) produced locally by Sun Interbrew and BBH (see Appendix 4).

The main raw materials purchased for the production of beer include brewing barley, lager malt, caramel malt, dark malt and hops. Additionally, the following materials are used in beer production: glass bottles, crown corks, labels, PET pre-forms, kizelgurgh (filtering diatomaceous earth) and enzymes.

In the table Appendix 5 a breakdown of total direct operating costs for an average brewing plant in Europe with annual capacity of 0.4 million hectolitres is provided. In Ukraine labour costs are expected to be about 6 times less than the European standard and malt prices are expected to be lower by about 150%.

The brewing industry is one of profitable sectors of the Ukrainian economy (see Appendix 6). Average gross profit margin (after deducting from revenue only all production costs) of 55 breweries sample is about 44% and 46% in 2001 and 2002, respectively. At the same time operating profit margin (after deducting from the gross margin all company overheads such as administrative and selling costs) is about 38% and 36% in 2001 and 2002, respectively. The factors that supported the industry to achieve high profit margins are:

- Mostly cash-based transactions;
- Breweries mostly control distribution channels;
- Breweries normally do not have to finance large social infrastructure like other industrial sectors do in the country.

All major Ukrainian breweries had improved their profit margins in 2001 and in 2002 compared to 1999-2000. And as it is highlighted in industry reports, this trend continues at present with an expectation of further gains in 2003 and 2004.

4.1. DATA DESCRIPTION

I have collected datasets from multiple sources: Fenix database provided financial data on an unbalanced sample of 55-63 breweries as for 2001-2002 periods and as for 1998-1999, the State Committee of Statistics of Ukraine provided aggregated data about the industry development, the Beer Association made available information on its member breweries and some financial data is derived from the Istock on-line database. As the main dataset for testing the stated hypothesis was chosen the dataset from Fenix database as for 2001-2002 due to the highest degree of data completeness and its quality. This dataset includes all the largest breweries and almost all interregional and microbreweries. In total the balanced panel dataset comprises 55 breweries that produce and sell about 95% of beer in Ukraine. Other datasets are used for robustness check of the results.

Table 2. Descriptive statistics of the main dataset, 55 observations

		Revenue	**Depreciated capital**	**Selling costs**	**Admin. expenses**
2001	Average	49 455	17 089	4 957	2 317
	Median	7 402	1 915	338	453
	St.dev.	146 696	44 007	16 425	5 219
2002	Average	62 542	20 933	8 723	2 776
	Median	6 866	2 388	354	463
	St.dev.	174 380	47 602	22 923	6 667

		Material costs	**Labour expenses**	**Costs of goods sold**	**Operating costs**
2001	Average	19 070	2 761	23 144	31 699
	Median	3 027	677	4 127	5 178
	St.dev.	52 451	6 988	60 628	86 482
2001	Average	23 149	3 196	26 524	40 729
	Median	3 011	759	3 745	4 620
	St.dev.	60 749	8 064	68 942	105 602

4.2. ESTIMATION RESULTS

Taking into account often criticised weakness of DEA in high sensitivity to specification of inputs and outputs let consider and analyse simultaneously three specifications estimated based on the main dataset. All three specifications have output being revenue from sales and differ in inputs identification:

1) three inputs: capital stock, material costs and selling costs;

2) one input: costs of production aggregated into the costs of goods sold (Cogs);

3) one input: costs of production and operating overheads aggregated into the operating costs[9].

In practice, all three specifications has shown very similar pattern of the relationship between sales and scale efficiency in both years (see Figures 4, 5).

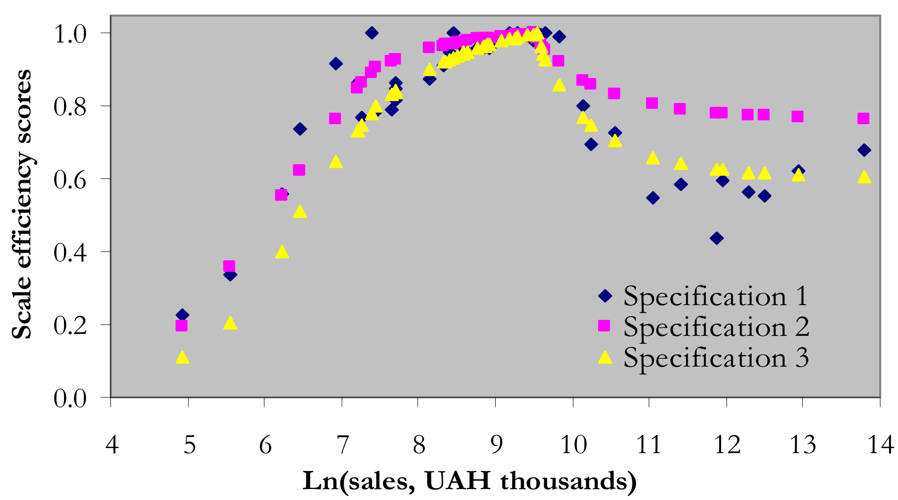

Figure 4. Scale efficiency scores as for 2001

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[9] Operating overheads are administrative costs, selling costs; the latter includes costs of advertising, finished goods transportation, storage and some other costs

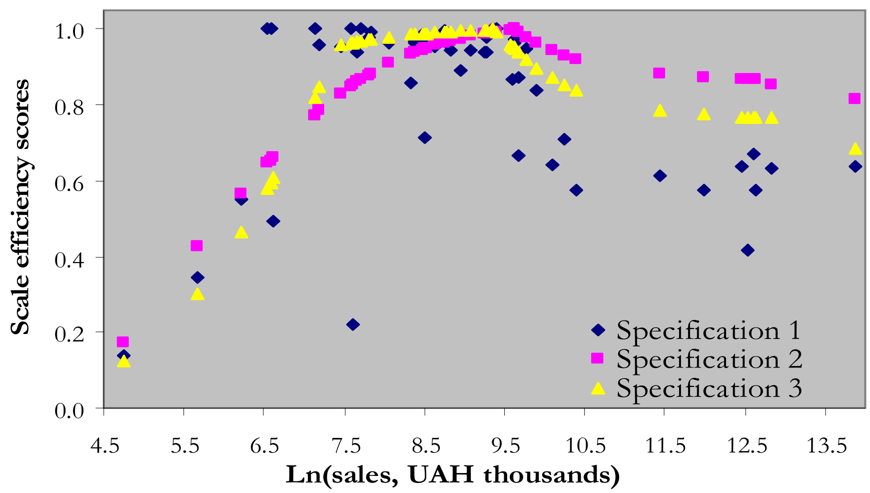

Figure 5. Scale efficiency scores as for 2002

Starting from the smallest breweries the scale efficiency increases with sales, it reaches maximum at about 35th-40th largest breweries in the sample of 55 breweries and then falls with further increase in sales. The efficiency maximum, the scale efficient level, is characterised by sales being about UAH 10-15 million or about 0.08-0.13 million hectolitres of beer. In contrast to 2001, breweries with sales about UAH 4-10 million in 2002 appeared to have very high scale efficiency scores indicating that scale efficient level may widen to about 0.03-0.13 million hectolitres.

While the overall trend is similar in all three specifications for both years the first specification that employs three inputs and one output deviates from the general trend, which is well defined in other specifications. It might be due to the fact that in multidirectional DEA optimisation being relatively very efficient in one of several equally treated specified inputs can lead to a high overall efficiency estimate. Therefore the first specification is considered as inferior to the others.

Although the second specification well defines the relationship between scale efficiency and scale of activity it does not take into account information about other important inputs: administrative costs, selling costs, other operating costs. Consideration of all operating costs is especially important because we have specified output in nominal terms. Some breweries might price beer at higher than the average level because they extensively advertise their branded beer as well as they might incur high transportation costs because of selling beer throughout Ukraine; not taking into account operating overheads for these breweries would lead to overestimation their efficiencies. Therefore, given the similar overall trend in scale efficiency variation with the scale of activity of the breweries, the third specification is preferable and it is chosen for further analysis as the base.

The estimated so far scale efficiencies are biased due to the reasons outlined in the methodology chapter. Suggested in Appendix 1 modified smooth homogeneous bootstrap for scale efficiency with 2000 interactions is applied to correct for the bias. The supplied sample to Bootstrap was reduced by three observations with the smallest sales in both 2001 and 2002 years. The sample was reduced with an objective to make it more homogeneous by eliminating very inefficient, loss making breweries that are likely to be close to bankruptcy, and for those operating conditions are likely to differ much from the rest of the sample. Elimination of very inefficient observations should not change scale efficiency estimates because they do not define the frontier but this is likely to narrower confidence intervals (see Figures 6, 7)[10].

The estimated bias corrected scale efficiencies, in general, repeated the relationship between the original scale efficiency scores and the sales. It only

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10 Existence in the sample very outlying observations leads to greater variation of the bias correction and, therefore, wider confidence intervals.

deviated from the previous trend in 2002 showing a possibility of another scale efficient level about the sixth smallest observation. However, another reason for the higher values of estimated bias corrected scale efficiency might be due to the fact that there are very few observations at small levels of sales so that missing any of them or adding a noise changes scale efficiencies of these observations downward in the bootstrap procedure; therefore, the estimated bias and the respective upward correction are high. The latter argument is also true with respect to the largest observations; their bias corrected efficiency estimates are higher than the original estimates and wider confidence intervals constructed at 5% level of significance indicate higher variation of the estimated bias.

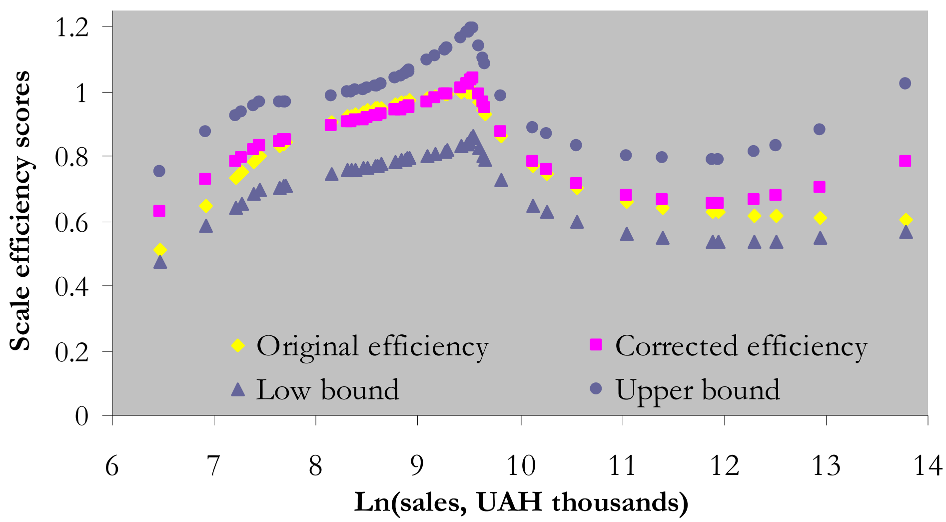


Figure 6. Corrected Scale efficiency scores as for 2001

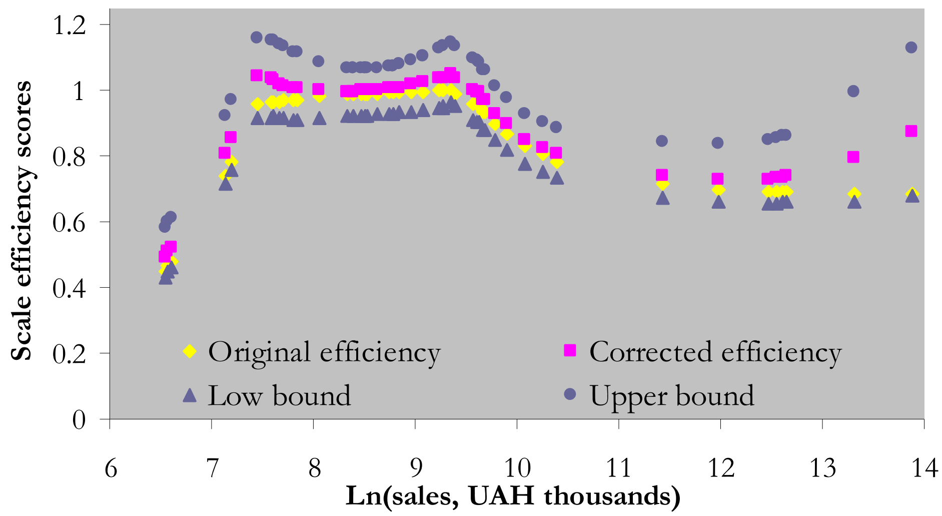


Figure 7. Corrected Scale efficiency scores as for 2002

So, both the originally estimated efficiency scores and the bias corrected efficiency scores provide evidence that the largest breweries are likely to be oversized operating above the scale efficient level.

Since the properties of consistency and efficiency of the used modification of Smooth Homogeneous Bootstrap has not been discovered the original scale efficiencies are chosen for further regression analysis.

At the second stage regression analysis is used in order to estimate statistically the relationship between the scale efficiency scores from the first stage and scale proxy (sales) controlling for other factors (location in big cities).

Scale efficiency scores belong to the range of (0; 1] with a distribution estimated by kernel density function (Appendix 7). Because of this restriction in efficiency scores it is still dubious which regression method is more appropriate to use in testing variables that may explain variation of the scale efficiency scores at levels[11]. Therefore, I decided to employ simultaneously several methods: simple OLS, robust OLS[12] and truncated regression.

Tables 3. Regressions output: Determinants of scale efficiency

	2001		
Scale efficiency	**OLS**	**Robust OLS**	**Truncated**
Ln(sales)	0.710***	1.031***	0.838***
Ln(sales)^2	-0.037***	-0.055***	-0.043***
Dummy city	-0.037	0.000	-0.062
Constant	-2.460***	-3.839***	-2.987***
R-squared	0.814		

	2002		
Scale efficiency	**OLS**	**Robust OLS**	**Truncated**
Ln(sales)	0.606***	0.709***	0.883***
Ln(sales)^2	-0.031***	-0.037***	-0.045***
Dummy city	-0.044	-0.024	-0.117*
Constant	-1.942***	-2.364***	-3.051***
R-squared	0.782		

All three models for both years has shown evidence of existence a concave u-shaped relationship between scale efficiency and sales while the scale efficiency attain its maximum of about Ln(sales)=(-0.606/(2*(-0.031))=9.8 (in case of OLS), which is very close to the scale efficient level of sales estimated by DEA (see graphs 5, 6). Insignificance of dummy representing location of breweries in big cities indicates that location is not likely to explain variation in scale efficiencies.

[11] Discussion of regression methods in applications to Ferrell type efficiencies is presented in methodology chapter

[12] Robust regression routine identifies outliers using Cook's D and some other methods and then puts a low weight on the outliers.

These regressions confirm that the largest breweries are likely to operate above the scale efficient level and experience diseconomies of scale.

Alternately, ad hoc method of transforming the scores so that to increase its range from minus infinity to plus infinity through $\log(SE_t/SE_{t-1})$ meaning scale efficiency percentage change over the period could be applied. Scatter plot of scale efficiency scores in 2001, 2002 is presented in Figure 8.

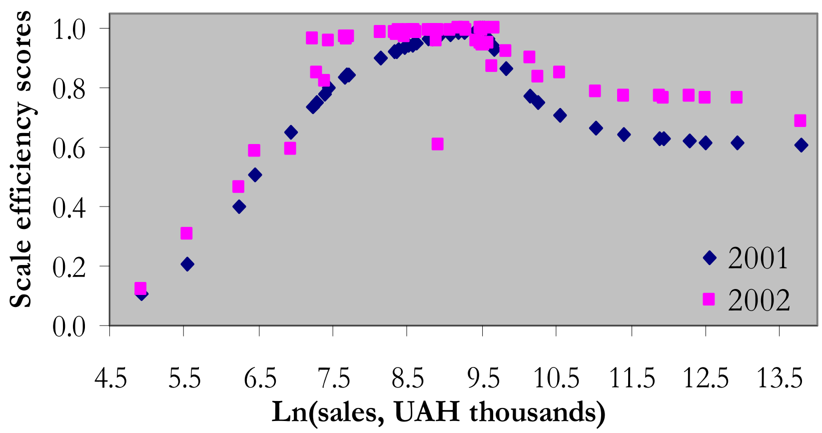


Figure 8. Scale efficiency scores for balanced panel dataset 2001-2002

Both OLS and Robust OLS regressions suggest that sales percentage change and dummy for big cities are unlikely to explain variation of scale efficiency percentage change over the respective period. Dummy introduced for top ten largest breweries all affiliated with the four leading brewing groups in Ukraine is positive and significant in OLS estimation meaning an increase, on average, in efficiency scores over 2001-2002 among these breweries. However, this coefficient is not significant in the Robust OLS. Sales in 2001 variable, on opposite, is negative but insignificant in OLS and negative and statistically significant at 5% level in Robust OLS meaning that, on average, higher levels of sales are associated, with lower percentage change in scale efficiency over the two years. Dummy 29 is constructed particular for the very outlying observation (see the Figure 8).

Table 4. Regressions output: Determinants of scale efficiency change

Scale efficiency % chang	OLS	Robust OLS
Sales % change	0.020	-0.016
Sales 2001	-0.006	-0.010**
Scale efficiency 2001	-0.293***	-0.597***
Dummy big	0.079**	0.012
Dummy cities	-0.010	-0.018
dummy for outlier	-0.443***	-
Constant	0.316***	0.606***
R-squared	0.727	

Scale efficiency 2001 is the only explanatory variable significant in both regression models. It has negative coefficient which is generally expected because, firstly, for breweries being very scale inefficient there are more possibilities to improve their efficiency than for the breweries already close to the scale efficient level (the scale efficiency score is bound to 1); secondly, there may be a non-persistent measurement error in the efficiency estimate which diminishes in the next year and results in the negative relationship.

Overall, regressions with dependent variable being percentage change in scale efficiencies have not revealed any certain and robust pattern of a relationship between scale efficiency change and scale of activity.

So, the results of estimation individual scale efficiencies using two-stage DEA approach lead to a rejection of the stated hypothesis that efficiency gains from economies of scale were the motivation of the largest breweries to grow during the transition period.

4.3 ROBUSTNESS OF THE RESULTS

I have performed several other estimations to test the sensitivity of the obtained above results to models specification and chosen methods of estimation:

- DEA estimation, in which output is specified in beer sales measured in thousands of decalitres and inputs are aggregated into operating costs, based on unbalanced panel dataset of 32 breweries obtained from UkrPivo Association

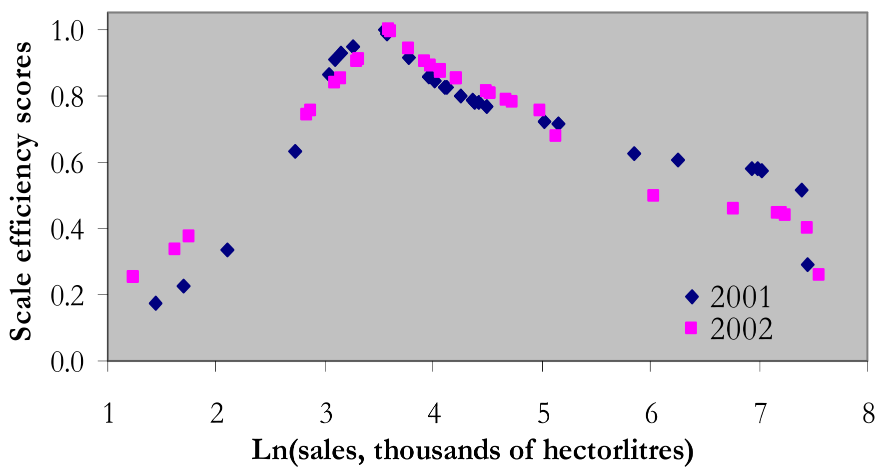


Figure 9. Scale efficiency scores as for 2001, 2002 for UkrPivo dataset

The estimation results strongly support the previously obtained results and indicate the efficient scale level about 0.03-0.04 million hectolitres.

- DEA estimation, in which output is specified as revenue from sales and inputs are aggregated into operating costs, based on unbalanced panel dataset of 16-21 observations collected from *Istock* database.

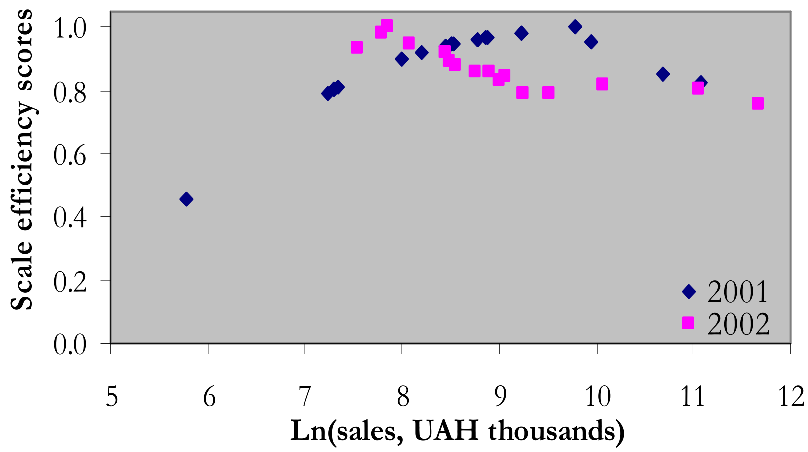


Figure 10. Scale efficiency scores as for 2001, 2002 for Istock dataset

This estimation results weakly support the previously obtained results.

- Regression analysis (OLS, robust OLS, and stochastic frontier[13]) based on dataset of 55 observations from Fenix database organised as balanced panel as for 2001, 2002. Here, the dependent variable is average costs ob brewing production which is the object of primal interest of my research.

Referring to table 5, in both the simple OLS and the robust OLS and in both years *dummy big* representing the ten largest breweries affiliated with the leading brewing groups is insignificant meaning that, on average, average costs of these large breweries are unlikely to differ significantly from average costs of other breweries. Also in all three models the variation of average costs of the ten largest breweries cannot be explained by variation of sales, as Wald test suggests.

Table 5. Regressions output: Determinants of average costs

	2001		
Average costs	OLS	Robust OLS	Stochastic frontier
Sales	-1.023***	-1.109***	-0.686***
Dummy big*sales	1.007***	1.092***	0.683***
Dummy big	0.049	0.039	0.148***
Dummies for outliers	7 dummies	-	-
Constant	0.681***	0.693***	0.427***
R-squared	0.958		
P-values of Wald test, H0: Sales+Dummy big*sales=0	0.260	0.333	0.000

	2002		
Average costs	OLS	Robust OLS	Stochastic frontier
Sales	-1.930**	-1.161***	-0.169***
Dummy big*sales	1.920**	1.151***	0.166***
Dummy big	-0.118	-0.019	0.193***
Dummies for outliers	7 dummies	-	-
Constant	0.824***	0.724***	0.399***
R-squared	0.782		
P-values of Wald test, H0: Sales+Dummy big*sales=0	0.755	0.585	0.739

However, estimated *dummy big* by the stochastic frontier model is highly significant indicating that smallest average costs of the group of largest breweries are higher than average costs of the smaller breweries on the 'best practice' frontier. The difference in the significance of the dummy for the group of largest breweries is due to the fact that OLS estimation focuses on sample averages while the stochastic frontier focuses on 'best practice' observations estimating the frontier. In case of testing scale cost efficiency the latter approach is considered

[13] Stochastic frontier estimates $AC_i=a_i+\Sigma(b_i*x_i)+\varepsilon_i$, where $\varepsilon_i = v_i + u_i$, $v_i\sim N(0;\sigma_v)$, and $u_i\sim|N(0;\sigma_u)|$; u_i represents deviation from the frontier due to pure costs inefficiency and v_i is error of the regression. So, stochastic frontier allows estimating separately pure costs inefficiency and scaling inefficiency.

being preferable. Thus, regression analysis also confirms the previously obtained results of the main estimation.

Having performed several estimations with different datasets and specifications, also having used several very different estimation methods we obtained similar results that the largest breweries operate above the scale efficient level, and they are likely to be less cost effective. Therefore, we can conclude that the obtained results are robust to changes in datasets used in estimation, models specification and methods of estimation.

Chapter 4

CONCLUSIONS AND EXTENSIONS

The present paper analysed addressed questions of motivation to concentration observed in the Ukrainian brewing industry during the transition period. It stated a hypothesis that *the observed concentration in the industry was motivated by potential efficiency gains originated by economies of scale* and *the group of larger producers were more cost effective comparative to the smaller industry participants.* This hypothesis was tested based on results of application of the main tool of estimation – DEA estimation – to the main dataset of operational characteristics of 55 breweries as for 2001 and 2002. Additionally, in the robustness of the results analysis two other DEA estimations of different datasets and regression analysis on the main dataset were performed.

Results of the main estimation as well as the other additional estimations have led to a rejection of the stated above hypothesis. In particular, the largest ten breweries all affiliated with the leading brewing groups, which were constantly growing in the previous years and currently comprising about 95% of the market, appeared experiencing significant diseconomies of scale and operating well above the efficient scale level, about 0.3-5.0 million hectolitres compared to the estimated MES being about 0.03-0.13 million hectolitres. Stochastic frontier regression analysis revealed that the group of ten largest breweries is also cost inefficient relative to the 'best practice' smaller breweries. The estimation results were shown being robust to changes in datasets, inputs and outputs specifications, and chosen methods of estimation.

There could be several possible explanations for the obtained results. Firstly, it could be a case that the largest breweries being on the increasing part of the estimated average cost function envisage another unobserved by others long-term average costs function that is flatter and below the estimated cost function, relative to which the largest breweries could be on the decreasing part and closer than other smaller breweries to the minimum efficient scale. Therefore, the largest breweries might be more scale efficient relative to the long-term average cost curve and relative to the short-term average cost curve of future periods experiencing temporal scale diseconomies relative to the current estimated average costs curve.

Secondly, there is a strong support to existence of endogenous sunk costs in the brewing industry. Following arguments of Sutton (1991)[14] breweries are likely to play a strategic game incurring excessively high endogenous sunk costs – aggressive advertising and marketing campaigns – which determine their 'competitive capability' and strategic market position. By popularising branded products the breweries might strive to establish individual demand on their own production with a flatter slope than the slop of demand on the rest of beer production, and shift this individual demand to the right so that to crowd out from the industry other breweries with a weak consumer loyalty. Suppose that the largest breweries selling beer on interregional and nation-wide levels extensively employ aggressive marketing strategies. Consequently, they may face flatter marked demand D_L and the breweries selling beer only at regional levels and not incurring high advertising costs face steeper demand D_R (see Figure 11). Under these conditions according to the microeconomics optimisation theory profit maximising output for the group of largest breweries is Y_L above the scale efficient level while for the smaller regional producers it may appear at or near the scale efficient level Y_R. The breweries that do not advertise or do not succeed in

[14] Cited from Bresnahan (1992)

advertising their brands may face D_B specifying conditions when these companies are better to leave the industry. Therefore, strategic actions by the largest breweries in incurring excessive endogenous costs could be an explanation of the increased concentration.

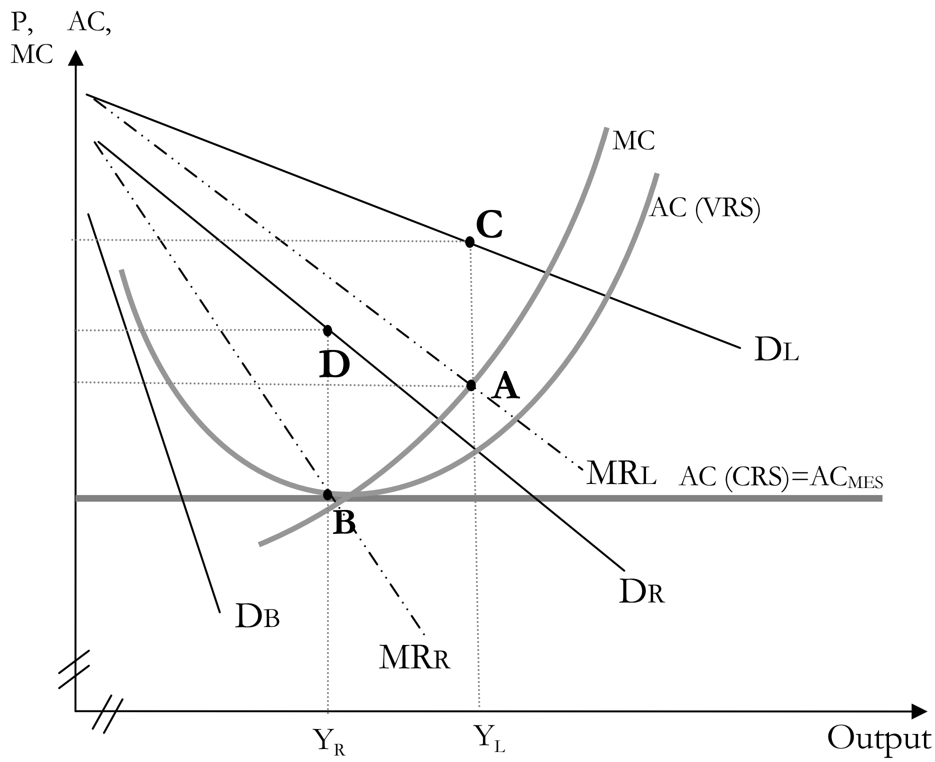


Figure 11. Demand and cost functions of the largest and regional breweries (cited from Zelenyuk, 2002)

And finally, very striking could be a hypothesis that the largest industry participant target market share maximisation rather than cost minimisation or profit maximisation. This might be especially true in the current conditions of the market when consumption per capita is increasing, consumers' choices are changeable and loyalties to particular brands of beer are not well developed. This strategy is likely to be optimising over a long period leading to further costs minimisation after the market matures.

BIBLIOGRAPHY

Amess, K. and Gourlay, A. *The Dymanics of UK Industrial concentration, 1993-1997.* Department of Economics, Loughborough University, URL: http://www.lboro.ac.uk/departments/ec

Bresnahan, T. (1992) *Sutton's Sunk Costs and Market Structure: Price Competition, Advertising, and the Evolution of Concentration*, The RAND Journal of Economics, V23, #1

Brown, D. and J. Earle (1999) *The Impact of Financial-Industrial Group Membership on Enterprise Restructuring in Russia,* CEPR working paper

Cherchye L. and Puyenbroeck T.V. *Profit Efficiency Analysis under Limited Information with an Application to German Farm Types*

Demyanyk, Y. (2001) *Advertising as a strategic action. Case of brewing industry inn Ukraine.* EERC thesis paper

Edwards, F.R. (1974) *Concentration, Monopoly, and Industrial Performance: One Man's* in Goldschmid, H.J., Mann, H.M., Weston, J.F. (Eds.): *Assessment.* Industrial Concentration: the new Learning. Columbia University Center for Law and Economic Studies.

Elyasiani, E. and S. Mehdian (1993) *Measuring technical and scale inefficiencies in the beer industry: Nonparametric and parametric evidence*

Elzinga, K. G. (2000), "*The Beer Industry*" in Adams, Walter, ed. *The structure of American industry*, -38, Seventh edition, New York: Macmillan; London: Collier Macmillan.

Fare R., Grosskopf, S., Norris, M. and Zhang, Z. (1994) *Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries.* The American Economic Review, V.84, I1

Farrell, M.J. (1957), *The Measurement of Productive Efficiency* Journal of Royal Statistical Society, Series A, General 120:3, 253-281.

Greer, D. F. (1971), *Production Differentiation and Concentration in the Brewing Industry* Journal of Industrial Economics 19:3, pp. 201-19.

Horowitz, I and A. R. Horowitz (1965), *Firms in a Declining Market: The Brewing Case* Journal of Industrial Economics 13, pp. 129-53.

Lipczynski, J., Wilson J. (2001) *Industrial Organisation: An Analysis of Competitive Markets.* Financial Times: Pearson publishing.

Maryanchyk, I. (2000) *Performance and concentration in a transition economy (the case of brewing industry*, EERC thesis paper

McFadden, D. (1978) Cost, Revenue, and Profit Functions, in M.Fuss and D. McFadden, (Eds.):

Production Economics: A Dual Approach to Theory and Applications, North-Holland, Amsterdam.

McGree , J.S. *Efficeincy and economies of scale in Goldschmid*, H.J., Mann, H.M., Weston, J.F. (Eds.): *Assessment. Industrial Concentration: the new Learning*. Columbia University Center for Law and Economic Studies.

Muller, J. and Schwalbach, J. (1980) *Structural Change in West Germany's Brewing Industry: Some Efficiency Considerations* The Journal of industrial Economics, V.28, #4

Paul C.J.M. (2001) *Cost Economies: a Driving Force for Consolidation and Concentration?* Working paper #01-012, University of California Davis

Scherer, F.M. (1974) *Economics of Scale and Industrial Concentration,* in Goldschmid, H.J., Mann, H.M., Weston, J.F., (Eds.): *Industrial Concentration: the new learning*, Columbia University Center for Law and Economic Studies.

Simar L. and P. Wilson (2003) *Estimation and inference in two-stage, semi-parametric models of production process*, Discussion paper (0307) of Institute of Statistics, University Catholique de Louvain.

Simar, L. and Zelenyuk, V. (2003) *Statistical Inference for Aggregates of Farrell-type Efficiencies* Discussion Paper #0324

Sutton, J (1991) *Sunk Costs and Market Structure: Price Competition, Advertising, and the Evolution of Concentration*, Cambridge, Mass.: The MIT Press

Tremblay, C. H., V. J. Tremblay (1988), *The Determinants of Horizontal Acquisitions: Evidence from the U.S. Brewing Industry* The Journal of Industrial Economics 37:1, pp. 21-45.

Tremblay, V.J. (1985), *A Reappraisal of Interpreting Rising Concentration: The Case of Beer* The Journal of Business 58: 4, pp. 419-31.]

Zelenyuk, V. (2002) *Causes of Concentration in the U.S. Brewing Industry: Reconciling the Debate with the Data Envelopment Analysis* PhD research paper. Oregon State University

Zelenyuk, V. and V. Zheka (2003) *Corporate Governance and Firm's Efficiency: The Case of a Transition Country, Ukraine*, MA research paper, EERC

Zheka, V. (2003) *Corporate Governance and Firm's Efficiency: The Case of a Transition Country, Ukraine*, MA thesis paper, EER

APPENDIX 1

The choice of an appropriate modification of the original smooth homogeneous bootstrap (SHB) for technical efficiency developed by Simar and Zelenyuk (2003) depends on a decision how the noise added to efficiency estimate could be translated to inputs (since we previously specified input orientated the Ferrell measure). Adding the noise to the scale efficiency (SE), and then through it adding the noise to inputs (pure analogue to what was done developing SHB for technical efficiency) is not appropriate because scale efficiency does not have own frontier but it is derived from frontiers under assumptions constant return to scale and variable return to scale.

Then we are left with options

1. adding noise through TE|CRS only
2. adding noise through TE|VRS only
3. adding noise separately and simultaneously to TE|CRS and TE|VRS in the Bootstrap procedure and then estimation the scale efficiencies B times (number of iterations) based on the each time bias correction.

Let analyse the first option: <u>smooth homogeneous bootstrap for SE with adding noise only through TE|CRS</u>. Reflection is done corresponding to CRS frontier. Observations in the groups of small and large enterprises after adding noise are allowed to be above the original VRS frontier (see Figure A1), therefore, their TE|VRS are likely to be overestimated and the corresponding scale efficiencies are likely to be underestimated after Bootstrap correction, which is very inappropriate, especially in cases when scale efficiencies of the group of large enterprises are tested.

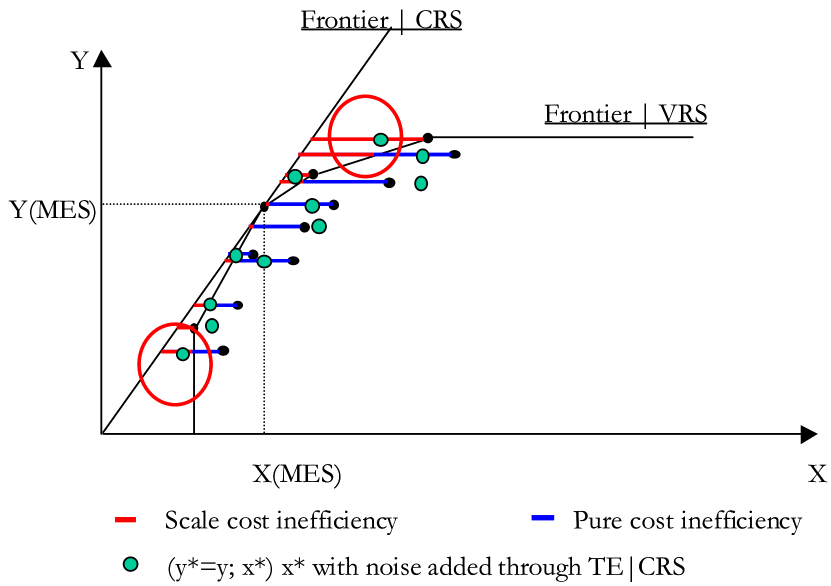


Figure A1. Smooth homogeneous bootstrap for SE with adding noise only through TE|CRS

Let analyse the second option: smooth homogeneous bootstrap for SE with adding noise only through TE|VRS. Reflection is performed corresponding to VRS frontier. Observations are not allowed to be above VRS frontier, but some of them would be above if we would assume CRS. The corresponding TE|CRS are likely to be underestimated and the corresponding scale efficiencies are likely to be underestimated after bootstrap correction (see Figure A2), this is again very undesirable property, especially in cases when scale efficiencies of the group of large enterprises are tested.

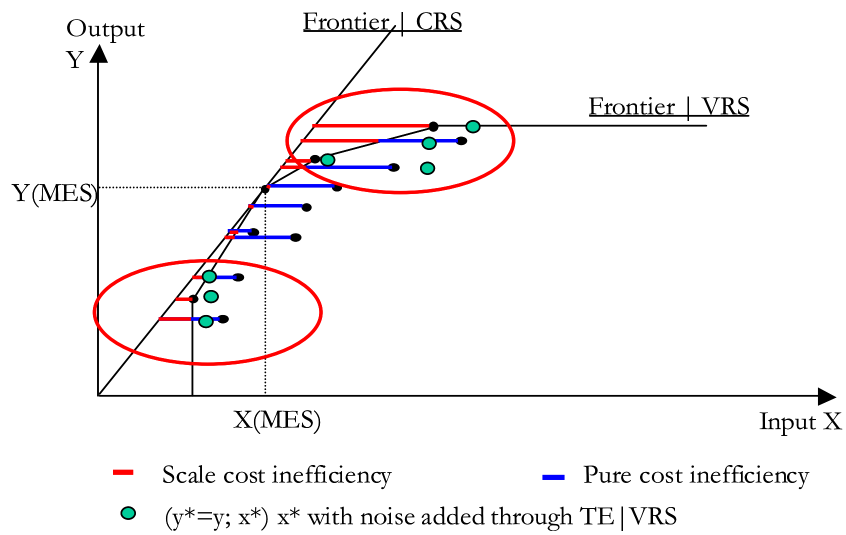
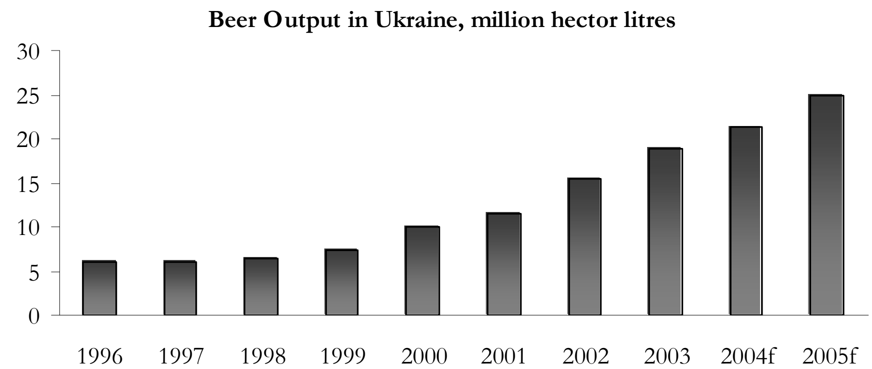


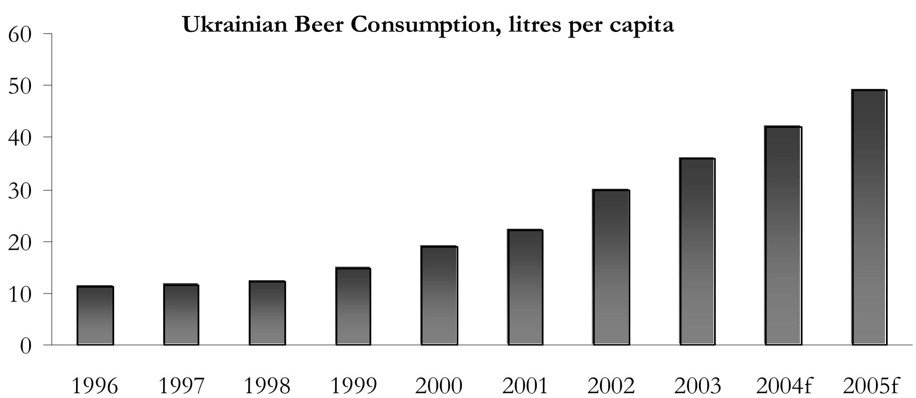
Figure A2. Smooth homogeneous bootstrap for SE with adding noise only through TE|VRS.

Let analyse the third option: Smooth Homogeneous Bootstrap for SE with adding noise separately and simultaneously through TE|CRS and TE|VRS. Reflection is performed twice: corresponding to VRS frontier and corresponding to CRS frontier. TE|CRS and TE|VRS are re-estimated in each iteration in the bootstrap procedure similarly to the estimation in the original SHB for TE, then corresponding SE are estimated in each iteration. The problem of the third option is that depending on the noise and characteristics of the CRS and VRS frontiers (their variances) the bias corrected frontiers may overlap and the corresponding scale efficiency scores can be greater than one.

APPENDIX 2



Source: Ukrpivo Association, the SCSU



Source: Ukrpivo Association, the SCSU

APPENDIX 3

PROFILE OF MAJOR BREWING GROUPS[15]

Sun Interbrew

In 1999 Interbrew S.A. (the Belgian brewer) and SUN Trade Limited (the Indian-owned trading company with extensive commercial interests in Russia and Ukraine) combined their interests in establishing a brewing group aimed to develop brewing business in the Commonwealth of Independent States (CIS), the Luxemburg-listed Sun Interbrew Limited. Sun Interbrew, the largest brewing group in Ukraine, commanded a 33.9% market share in terms of 2003 beer consumption.

Sun Interbrew operates three of the seven largest brewing plants in Ukraine. As of the end of 2003, their combined production amounted to 5.54 million hectolitres. Sun Interbrew's brewing capacities include:

- the Desna Brewery (in the Chernigiv region).
- the Yantar Brewery (in Mykolayv); and
- the Rogan Brewery (in Kharkiv).

All of the breweries are reequipped Soviet times' breweries and their current technological level corresponds to international standards. Sun Interbrew has invested heavily in brands development and the marketing of the produced beer. These breweries control significant market shares in their respective regions. Additionally, a comprehensive distribution network had been developed, allowing for channelling of production to different regions of the country. Each brewery in this group has an umbrella brand. Recently, Sun Interbrew entered into a long-term contract with French leading malting group Malteroup about supply of malt to its breweries from nearly finished new malt house near Kharkiv.

Obolon

Obolon, a brewing group owned by Ukrainian shareholders, is comprised of five brewing plants and an alco-pops plant, with four of the beer-producing facilities being rather small:

- the Obolon Brewery (located in Kyiv, it is the main production site of the concern and accounts for over 90% of the company's combined output);

[15] based on Internet search and industry reports ACNielsen Ukraine

- the Fastiv Brewery (in the Kyiv region);
- the Sevastopol Brewery (in the Crimea);
- the Akhtyrka Brewery (in the Sumy region);
- the Kolomiya Brewery (in the IvanoFrankivsk region); and
- the Krasyliv Alcopops Plant (in the Khmelnitska region).

In 2001, Obolon recorded a 25% year-on-year growth in its output - more than any other brewery in Ukraine. However, in 2002 and in 2003 it slowed its growth even lower than the industry grew. In 2003 Obolon market share was about 20.3%. The core market for Obolon is Kyiv, where it also controls a substantial market share.

BBH

BBH is a joint venture of Carlsberg Breweries and Scottish & Newcastle, which owns two breweries, nearly finished construction of the first green-field brewery in Ukraine. BBH's market share was about 20.2% in 2003 and it recently became the second-largest brewer in the country.

BBH owns the Slavutych Brewery (in the Zaporizhya region) and Kolos Brewery (in Lviv). In 1999, BBH acquired the Slavuta Malt Plant, the largest malt-house in Ukraine. Slavuta's capacity is about 80 thousand tonnes of light barley malt annually. But recently BBH sold Slavuta Malt Plant to the world leading malting group Soufflé with a long-term obligation to supply malt to BBH's breweries.

Sarmat Group

Sarmat Group is the fourth-largest brewer in Ukraine. Currently, Sarmat (controlled by Ukrainian shareholders), is comprised of five brewing plants located in the eastern and central urbanised regions of Ukraine and one brewery in the Crimea:

- the Donetsk Brewery (the largest and main production site of the Group, produced 2.5 million hectolitres of beer in 2003 and secured a 16.1% share of the Ukrainian market);
- the Dnepr Brewery (in Dnepropetrovsk);
- the Poltava Brewery (in Poltava);
- the Lugansk Brewery (in Lugansk);
- the Krym Brewery (including production sites in Simferopol, Kerch and Evpatoriya); and
- the Kyiv No.1 Brewery (located in Kyiv).

An acquisitive strategy, in addition to the development of a distribution infrastructure, makes the Sarmat Group a serious regional force in eastern, southern and central regions of Ukraine.

APPENDIX 4

CONSUMPTION BY SEGMENT, 2002

Segment	Share in total beer consumption	Trend
Super-premium	1-3%	Increasing
Premium (high quality premium and mainstream beers)	20-25%	Increasing
Mainstream (high quality discount beer)	50-55%	Increasing
Economy (low quality, short shelflife)	25-30%	Decreasing

Source: Renaissance Industry Research

APPENDIX 5

EUROPEAN STANDARD PLANT OPERATING COSTS

Assumptions: capacity 0.4 m hl, 6.2 th h per year operation

Item	Ratio per hl beer produced	Cost USD/hl beer produced
malt	18 kg	5
hops (cones)	0.15 kg	0.5
yeast (thick)	0.6 l	0
fuel	150 MJ	0.7
electricity	12 kWh	1.2
water	0.7m3	0.3
waste water treatment	0.55m3	1.1
spare part	lumpsum	1.2
Miscellaneous	lumpsum	1.3
labour (120)	(USD 20 000/year)	6
Total		17.3

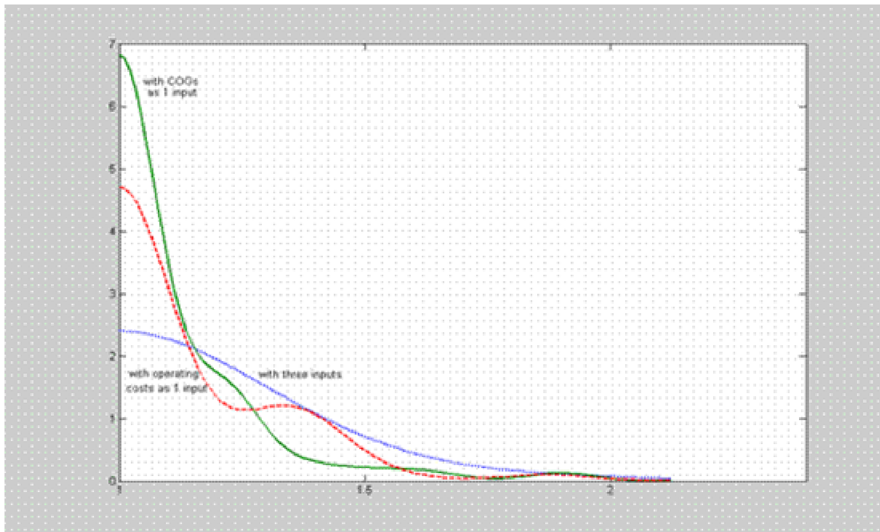
APPENDIX 6

PROFITABILITY MARGINS OF BREWERIES IN 2001 AND 2002

	Gross margin		**Operating margin**	
	2001	**2002**	**2001**	**2002**
Margins				
<30%	10	10	11	13
30-40%	6	9	16	14
40-50%	18	9	9	10
50-60%	11	14	9	7
>60%	8	11	3	3
# of breweries with positive profit margin	53	53	48	47
Total sample	55	55	55	55
Average margin	44%	46%	38%	36%
Margins of breweries ranked in sales				
1st qualtile	27%	21%	-17%	-18%
2nd qualtile	42%	41%	31%	28%
3rd qualtile	51%	51%	45%	40%
4th qualtile	44%	50%	29%	30%

APPENDIX 7

DENSITY FUNCTIONS OF SCALE EFFICIENCY SCORES FOR THREE SPECIFICATIONS, 2001



DENSITY FUNCTIONS OF SCALE EFFICIENCY SCORES FOR THREE SPECIFICATIONS, 2002