PRICE-CAP REGULATION AND QUALITY: CASE OF UKRAINIAN GASOLINE MARKET

by

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Abstract

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In this research we consider retail gasoline market in Ukraine focusing our attention on the quality efficiency performance of the industry in 2003 and 2004 periods. The following split is made due to the price-cap regulation – government regulation of the ceiling prices on gasoline at retail – that was established with Memorandum at the beginning of 2004. Specifically, we examine the gasoline quality change in 2004 (comparing to 2003) after price-cap regulation applying advance efficiency analysis methods including non-parametric Data Envelopment Analysis and Smooth Bootstrap. Based on data with gasoline quality factor it was found that we can not discard the possibility of a degradation in quality efficiency performance of retail gasoline industry under price-cap regulation after 2004. We also investigate efficiencies of the sub-group 2003 and sub-group 2004 of the period 2003-2004, and it turns out that conclusions do not change: we detect higher aggregate quality efficiency for 2003 than for 2004. So, I argue that the price-cap regulation in the beginning of 2004 was the political step that led to quality degradation of gasoline in Ukraine. Nowadays, the new government of Victor Yuschenko understands possible negative effects of the non-market regulation on the economy, and tries to avoid price-cap regulation dealing with unfavorable current situation on the retail gasoline market in Ukraine.

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Chapter 1

INTRODUCTION

The situation on the Ukrainian gasoline market in 2004 became one of the main subjects of discussions and disputes among Ukrainian economists, due to unnatural stability of prices of almost all sorts of gasoline, compared to the 70% oil price increase in the rest of the world.

As it was noted in the Ukrainian magazine "Correspondent" in August 2004, the prices of gasoline would have risen by 10% on average during the current year. But the real increase in prices on gasoline market is about 4% per litre, which is not substantial compared to, for instance, such transition countries as Belarus and Moldavia where the increase in prices on gasoline market is about 10% and 15% correspondingly.

The main instrument that held back prices of gasoline was creation, at the beginning of summer 2004 by The Cabinet of Ministers, of informational – analytic group, consisting of members from the government and such Ukrainian oil companies as "TNK-Ukraïna", "Lukoil-Ukraïna", and "Ukrtatnafta". The main aim of the group, as claimed by Kristina Kovalenko, an oil expert, was to force the oil suppliers not to increase prices until the Presidential Elections of 2004 (*Expert*, 2004). The following government intervention disturbs usual market patterns on the oil, and correspondingly, gasoline market in Ukraine, which provoked sudden increase of gasoline price at retail at the beginning of year 2005, which we can observe in the gasoline market nowadays.

In the economic literature government regulations which fix the upper bound of the price at which firms can sell their product or service on the domestic market are referred as price–cap regulation. Price-cap regulation on the gasoline market in Ukraine leads to ambiguous results. On one hand, by words of Petro

Miroshnikov, the president of "Alliance- Ukraïna" Oil Company: "steadiness of the markets depends by 90% on the stability of oil prices [since Ukraine imports oil for its leading production industries – steel, chemical and machinery] and only by 10% on the stability of Ukrainian currency – Hryvnya[1] ". That is one of the reasons why the government does everything possible to prevent destabilization of economic situation in Ukraine regardless on the negative effect of such stabilization. On the other hand, big oil companies (suppliers of gasoline to gasoline stations) as well as gasoline stations, experiencing pressure of government's regulation, keep prices of gasoline relatively (to the cost of production) low, which influences their performance and main economic characteristics, such as total cost, product and service quality, profit, and the most important issue which is efficiency of work on the gasoline market in Ukraine.

The purpose of my thesis is to analyze the current performance of gasoline stations by identifying quality efficiency frontiers for the firms under two different regulatory regimes: before price-cap regulation and after its establishment in May 2004. The major concern is the assessment of the price-cap regulation for the regulated gasoline stations due to suspected degradation of its product quality after the introduction of the regulation.

To highlight the importance of investigation in quality monitoring it is necessary to take into account the asymmetric information (when the government cares only about its initial aim of price regulation, but it is not possible to predict other changes under this regulation) as a main constraint in the setting of price-cap in government regulation. Regulating the economy government takes care of macroeconomic activities and stable economic situation in the country; unfortunately it has insufficient knowledge of the quality of products and services that are bought and sold on markets. I claim that price-cap regulation does not

[1] Because of gradual appreciation of hryvnya (UAH), inflation expectations rise.

provide any incentive for the gasoline stations to keep high level of gasoline quality. As an additional motivational fact, Resende and Façanha (2004) emphasized that quality indicator determination is a complex multidimensional problem which was studied empirically in this paper, while, before this problem has only intuitive and theoretic basis with little empirics. In this research we extend the methodology used in Resende and Façanha (2004) paper by adding several steps and improved techniques of the analysis while describing Ukrainian gasoline market.

Finally, as Ukraine transitions toward the market economy, the government should not carry out any regulation that makes industry unprofitable, and then subsidize it (method of price regulation in planned economy). Moreover, considering the size of the budget of Ukraine it is not possible. As was suggested by Nikolai Pesotskyy, the chief of the State Reserve of Ukraine, to keep stable economic situation in the country in the fall of 2004, reserves of oil products should guarantee constant supply of oil by dumping prices for at least three months in order refiners further can provide retail gasoline market with the product. This decision can not be enacted because the State Reserve needs 6,75 billion hryvnias for these three months, which is twice its annual budget.

The structure of my thesis is the following: Chapter 2 is devoted to review of the relevant theoretical and empirical literature; Chapter 3 contains the method of estimating quality efficiency frontiers; Chapter 4 describes data and variables; Chapter 5 describes the situation on the Ukrainian gasoline market; Chapter 6 contains empirical results; Chapter 7 made conclusions, gives practical policy advices and directions for further research.

Chapter 2

LITERATURE REVIEW

There is a large number of papers devoted to different aspects of government intervention in the economy. Extensive literature debating the economic propriety of price regulation in different industries was concerned of firms economic behavior on markets (e.g. see Nyborg and Telle, 2004). Other research papers discuss the effect of price regulation on different markets. Monopoly and monophony regimes were analyzed on domestic and foreign input markets (Mussa, 1984); oligopoly was studied by analyzing the nature of interactions between input suppliers on a production line (Krishna, 1986). Also, researches pay attention to the performance of the transition, developed and developing countries with regulated industries in the world (Hellman and Schankerman, 2000). The main point that is highlighted in all papers is that any regulation (through restrictions, building of constraints and protection) creates a production distortion for the regulated industry and the firms in it.

As one of transition countries Ukraine recently attracted meticulous attention to its political and economic decision making processes (Hellman and Schankerman, 2000). A report by European Bank for Reconstruction and Development (EBRD) argues that Ukraine as less advanced country (as Belarus, Moldova and Slovak Republic) puts into practice extremely high level of reported government intervention in prices and sales as a tool of macroeconomic management (Palianytsia, 2002). The fact itself does not mean provision of negative effect on the country's economy because, by words of Hellman and Schankerman (2000), highly advanced countries also intervene in economy but in more constructive form of supporting its labor force. So, high level of intervention and regulation by the government makes a room for high control over decision making of firms and, correspondingly, high level of corruption in the country. On the basis of transition countries' data analysis by Johnson et al. (1997) showed that one percent increase in regulation index[2] increases informal economy by 8,1%. Moreover, Friedman et al. (2002) found a 10% increase of informal economy with one percent increase in regulation index, after investigating 76 transition, developed and developing countries. This result shows substantial negative effect on Ukraine, in particular, considering that 52,2% of economy is informal (setting the third place between transition countries, after Georgia and Azerbaijan) with $161 billion in it (Schneider, 2002).

Considering all information stated above, it is important to analyze the situation on Ukrainian markets with respect to regulation (e.g. price regulation) that hinders business activity and is considered as one of the obstacles to businesses (Palianytsia, 2002). The author claims that 27,6% of firms in Ukraine experienced regulation of prices; the output of 8,7% of firms is subject to fixed prices or "price-ceiling" (price-cap). And the number of different kinds of regulations in Ukraine due to the report for EBRD equals to ten, such as registration procedures; premises with permits for their construction, reconstruction and use; licensing; technical regulations; regulations of import operations; regulations of export operations; inspections; administration of taxation; regulation of prices; regulations of contracts. Palianytsia (2002) also added that the main problem in this context is that Ukrainian business faces the implementation and enforcement of specific regulative laws, which cause upraise of corruption and enhance incentives for firms to cheat on their consumers (in our case gasoline stations can cheat on consumers by selling lower quality gasoline). This fact motivates us to look on the details of the regulation, its main characteristics and cause-and-effect relation with product quality on gasoline market in Ukraine.

[2] Regulation index is ranging from 1 to 5, with 1- the least regulation in a country.

Kutsak (2002) splits all regulations into Direct Regulation and Indirect Regulation. Direct regulation directly influences price decision process of the regulated firm in the way of subsidies, two-part tariff, price discrimination and other. I will not precisely stop on this, because what is really the subject of interest is "indirect regulation". Indirect regulation consists of five main elements that are chosen by the government due to policy and the aims that regulation should reach (Train, 1991), such as:

- Regulation of rate-of-return (ROR),
- Regulation of output (ROO),
- Regulation of sales (ROS),
- Regulation of cost (ROC),
- Price-cap regulation (PC).

All these regulations influence price indirectly by creating constraints for regulated firms. Main characteristics of these regulations are summarized in the following table[3] (based on Kutsak, 2002):

Regulation	Task of the Government	Intervene	Do not intervene	Result
ROR	Determine the cost, not affect price directly	max price on capital	Max price level, output level, input mix	The regulator could not attain socially desirable outcome; inefficient mix of input usage
ROO	Determine the share of regulation	Profit from the unit of output	Amount of inputs, outputs, prices	The regulator stimulates the demand in order to increase profitability of firms
ROS	Quantify the sales	Revenue	Output level, input mix until the constraint	The regulator provoke too little output; inefficient mix of input usage
ROC	Determine costs	The share of firm's cost	Price and output level	The regulator provoke too little output; inefficient mix of input usage
PC	Consider cost, demand for the product and profit conditions	Price (incentive to minimize costs)	Output, input mix	The regulator pushes firms to minimize costs (maximize profit and productivity)

[3] Table 1: "Regulations and its characteristics".

Analyzing the table above, we can consider price-cap regulation as one of the most “appropriate” for both government targets and regulated firms on the particular market due to its minimum cost on control and incentive to minimize costs of firm’s product/service respectively. Evidence to claim this was presented by Train (1991). The author views price-cap regulation from different sides (single- and multi-output firms; static and dynamic world) to conclude about decision making process of the regulated firms. As price-cap regulation is the regulation when government sets the maximum price for the regulated industry by which regulated firms can sell their products, it creates an incentive for regulated firms to minimize their costs in order to reach high profit, to be highly productive and efficient. Also, the firm will produce with cost minimizing input mix, adjust optimally changes in cost and invest in cost minimizing and cost effective innovations. In the case of multi-output firms government will use an aggregation over the price-cap measure in the form of price indices or weighted average of the prices. Regulated firms will react to this kind of regulation by adjusting output and prices in the way that increases their profit. Moreover, in the process of implementation and further control of different regulations and restrictions regulator bears monetary and non-monetary costs, which forces government to use price-cap regulation as the cheapest one among other kinds of regulation (Mills and Rockoff, 1987).

Considering specificity of gasoline station market (selling of one product – gasoline with certain product quality), some more information about price-cap regulation of one-output firm should be added. Determining “price-cap” for the market, government could know the optimal price and to mandate it, or it could not know the optimal price, and, as a result, set too low or too high cap. If the cap is low then regulated firms lose money, and finally go out of business. If the cap is high, regulated firms will price below the cap which is equal to “no regulation”. Also disadvantages of the price-cap regulation should be described, as a leading motivation to concern in my research. The main disadvantage described in the research is the issue of product quality that is affected by regulation, and price-cap regulation specifically.

So, the next block of the economic literature, that is needed to be taken into consideration, concerns incentives of regulated firms to invest in quality of their products and services. Weisman (2003) made a theoretical proof of the fact that different levels of "price-cap" provide regulated firms with different incentives to invest in quality, ceteris paribus. The author showed this result in the following proposition No.1:

$$\text{sgn} \left\{ \frac{dk^*}{d\bar{p}} \right\} > 0$$

where ' k* ' is profit maximizing level of investment in quality, ' $\bar{p}$ ' is exogenous "price – cap". The formula is obtained by using profit maximization of a firm $P = Q(\bar{p}, q)^* \bar{p} - C(Q, k)$ with respect to 'k' , where demand is given by $Q(\bullet)$, q is quality with density function $f(q, k)$ and distribution $F(q, k)$, 'k' is investment in quality. From this formula it was concluded that low "price-cap" provides regulated firms with an incentive to reduce investment in quality, and vice versa, high "price-cap" provides regulated firms with an incentive to increase investment in quality.

However, in practice we face ambiguous results about relations between price-cap regulation and investments in quality. Price regulation may force regulated firms to reduce the quality of their product (or service). This result was explained by Kahn (1988): minimizing the cost of the good under price regulation and, thus, attaining maximum profit the company can decrease the quality of the good as well as accompanying services. Also, Booz and Hamilton (1999) showed that the decrease in quality of Railtrack, a monopolistic holder of railway network in UK, was mainly because of implementation of price-cap regulation. And, Sappington

(2002) and Oftel (2000) provided empirical evidence that price-cap regulation had no effect on quality of telecommunication in UK and USA.

Kidokoro (2002) tried to deal with this ambiguity in his theoretical research. The author concluded that the result of increase or decrease in incentive of regulated firms to invest in quality mainly depends on the source of improvement. He split all firms into "investment related" category, when the quality of products/services is improved through investment, and "effort related" category, when the quality of products/services is upgraded through a firm's own effort (without direct investment into labor, infrastructure). Theory shows that investigation of these two categories really leads to the opposite results form the point of incentive to invest in quality under price-cap regulation. For the "investment related" category decrease in price under price-cap regulation will decrease quality, and consumer surplus can be increased only with mix of the regulations (when elements of two or more regulation regimes are used together during one period). For the "effort related" category decrease in price under price-cap regulation will increase quality, and consumer surplus can be increased only with price-cap regulation. To consider gasoline industry, gasoline market belong to the "investment related" category because the quality of the product can be improved only by investments in this industry; and, the quality of the service can be mainly increased by additional costs for labor (trainings for raising the level of one's skill) and/or costs which appear while investing in such indicators of service quality as gasoline' infrastructure (bars, restaurants, hotels, play grounds). This fact shows that the expectations of decreasing incentive to invest in quality with respect to price-cap regulation in Ukraine from the beginning of this year are consisted with theory.

The investigation of relations between an incentive of Ukrainian gasoline stations to invest in quality with respect to price-cap regulation can be made by analyzing quality efficiency frontiers. Resende and Façanha (2004) identified quality efficiency frontiers (quality across different regimes) for the firms under the different regulatory regimes, which has important policy implications. The authors analyzed two period of time – the period without price-cap regulation and the period after it was established with Data Envelopment Analysis method (the method is described in Chapter 3 'Methodology'; also, for examples of DEA application see Kumar and Russell (2002) who estimated the densities of the distributions of income per worker across countries, 1965-1990 and Scales (1997) who measured the efficiency of government service delivery in the five case studies – acute care services in Victorian hospitals, Queensland oral health services for school students, NSW correctional centers, NSW police patrols, and NSW Roads and Traffic Authority motor registries). The following conclusions were made (Resende and Façanha, 2004): "The efficiency-measurement technique considered in the present paper could assist yardstick schemes of adjustment of the productivity offset, and yet provide a multidimensional assessment of quality". In the paper authors argue that there are a lot of papers that deal with quality (e.g. telecommunications), but there is little empirical investigations on this issue. The same result goes into gasoline market. This is the reason why issue that is investigated in my thesis is new and interesting from the economic point of view.

To conclude, I need to say that many authorities currently adopt price-cap regulation method (Sappington, 2002). The use of "price-cap" can force regulated firms to decrease quality of their goods, but can not influence the incentives to improve quality, or at least to keep the quality at certain level. Research papers that consider quality estimation have important policy implications, but only recently the empirical research was done on this topic. The issue that my thesis deals with concerns empirical estimations of an incentive to invest in product quality on Ukrainian gasoline market under price-cap regulation.

Chapter3

METHODOLOGY

Methodological framework of this research can be split into several steps. First of all, we will estimate quality[4] efficiency of the gasoline market in Ukraine using Data Envelopment Analysis (DEA). Quality efficiency scores will be obtained by this method. Then, the estimated quality efficiency scores will be corrected for bias with Bootstrap procedure, and then will be used to construct kernel densities. Estimated kernel densities from the bias-corrected quality efficiency scores will be compared with the help of Li test to see if they change from 2003 to 2004, in order to make the main conclusions of the research. Also these procedure will be made for aggregation measurement. Steps in more details are described below.

First, we use Data Envelopment Analysis (DEA) as the most applicable methodology for quality efficiency measurement (Resende and Façanha (2004)). DEA is the linear programming technique that identifies the efficiency frontier (the best potential frontier) within a sample and measure efficiency scores as the difference between actual observation and its potential measure on the efficiency frontier. Decision making units (DMU), which can be entrepreneurs, firms, countries, are said to be efficient if their observations locates on the efficient frontier (best practice).

Before we begin estimating quality efficiency scores with DEA, we need to characterize the DEA analysis by terminology, definitions, assumptions, advantages and disadvantages.

[4] In the research we will use terminology of "quality efficiency" frontier (score) instead of usually seen in papers "efficiency" frontier (score) in order to include quality parameter in our estimations. More detailed explanation can be found in the Chapter 6, "Empirical Results".

Let's us consider the market of gasoline. There are *k* Decision Making Units, where *k*=1, 2, ….., n. We also determine the vector of N inputs (x) for *k*'s DMU: $x^k=(x^k_1, x^k_2,...,x^k_n)'$, and the vector of M outputs (y) for *k*'s DMU: $y^k = (y^k_1, y^k_2,\ldots,y^k_m)'$. Vectors of output and inputs (characteristics of input-output variables are in the Chapter 4, "Data Description") are assumed to consist of non-negative real values.

First of all, DEA is a nonparametric approach that allows us to estimate efficiency (in our case, quality efficiency) without the knowledge of the special functional form of production on the market/ in the industry. Technology (T) is determined in general case, as (Charnes et al, 1978):

$$T^k \equiv \{(x^k, y^k) \in R_+^N R_+^M : y^k \in R_+^M \text{ is producible from } x^k \in R_+^N\}$$

In other words, technology is the tool in production process of receiving certain outputs by using certain inputs. For simplicity in obtaining appropriate results, we assume that the technology is identical for all MDU (in our case, gasoline stations).

Moreover, as was proven by Simar and Zelenyuk (2003), the DEA estimators of efficiency are consistent maximum likelihood estimators of true real efficiencies of decision making units.

An alternative characterization of technology is Output Requirement set P(x), which can be written in the following way:

$$P^k(x^k) \equiv \{y^k \in R_+^M : y^k \in R_+^M \text{ is producible from } x^k \in R_+^N\}, \quad x \in R_+^N$$

the set of all possible combinations of outputs that are producible from particular level of inputs.

and the Input Requirement set L(y):

$$L^k(y^k) \equiv \{x^k \in R_+^N : y^k \in R_+^M \text{ is producible from } x^k \in R_+^N\}, \qquad y^k \in R_+^M$$

which is the set of all possible combinations of inputs for each particular level of output.

The main assumptions that allow us to construct efficiency estimators are Main Regularity Axioms (Simar and Zelenyuk, 2004):

1.“No free lunch” : We can not produce something from nothing.

$$y \notin P(0_N), \forall y \geq P(0_M)$$

2. “Producing Nothing is Possible” : Using our inputs we can produce no output.

$$O_M \in P(x), \forall x \in \Re_+^N$$

3. “Boundedness of the Output Set”: We can produce only finite amount of output from our finite amount of input.

$$P(x) \text{ is a bounded set, } \forall x \in \Re_+^N$$

4. “Closedness of the Technology Set”: We are taking into consideration all point on the boundary of technology.

$$\text{T is a closed set for all } x^k \in R^N{}_+ .$$

5. “Strong disposability of Outputs”: If we can produce certain amount of output with certain input combination, than we can produce the same amount of output with any input combination that is not less.

$$y^0 \in P(x) \Rightarrow y \in P(x), \forall y \leq y^0, x \in \Re_+^N$$

Considering all these assumptions, we will define Farrell output oriented technical efficiency measure, as the most appropriate estimator (Simar and Zelenyuk,2004):

$$\text{TE}(x,y) = \max \{ \theta : \theta y \in P(x) \},\ y \in P(x)$$

Output set in this case (or the frontier of the output set) is described as follows:

$$\partial P(x) = \{y: y \in P(x), \theta y \notin P(x), \forall \theta \in (1,\infty) \},\ y \in R^{M}{}_{+}$$

So as can be concluded, *k*'s DMU is efficient only if $y^k \in \partial P(x^k)$, in other words if efficient score equals to 1. If efficient score belongs to the range (1,+ ∞), we determine this DMU as technically inefficient. The technical inefficient score is calculated as (1 – 1/TE)%.

Further steps will allow us to construct unobserved technology set under two assumptions such that the technology is available to all DMU and all observable input-output combinations are feasible under technology (belong to the technology set):

$$\text{Pr}ob\ \{\ (x^k, y^k) \in T\ \} = 1, \quad \text{k} = 1, ..., \text{n}$$

To proceed with DEA, we need some more properties, such as:

1. Additivity Property, saying that if two activities are feasible then their sum is also feasible:

$$\text{if } (x^k, y^k) \in T \text{ and } (x^j, y^j) \in T \Rightarrow (x^{k+j}, y^{k+j}) \in T$$

2. Free (strong) disposability of all inputs and outputs tells us that if one activity is feasible then the other is also feasible when its inputs are at least as large and outputs and at least as small:

$$\text{if } (x^k, y^k) \in T \text{ then } (x^j, y^j) \in T \text{ when } x^k \leq x^j, y^k \geq y^j$$

3. Constant Returns to Scale (CRS):

$$\text{if } (x^k, y^k) \in T \text{ then } z^k (x^k, y^k) \in T \text{ when } z^k \geq 0$$

4. Variable Returns to Scale (VRS):

if (x^k, y^k) є T then z^k (x^k, y^k) є T when $z^k \geq 0$ and $\sum_{k=1}^{n} z^k = 1$

Now, we can write DEA-estimator of Farrell output oriented technical efficiency score of observation *k* (*k*=1, 2, …,n) :

$$T\widehat{E}(x^k, y^k) = \max_{\theta, z_1, \ldots, z_n} \theta$$

subject to

$$\sum_{j=1}^{n} z^j y_m^j - \theta y_m^k \geq 0, \qquad m=1, \ldots, M$$

$$\sum_{j=1}^{n} z^j x_i^j - x_i^k \leq 0, \qquad i=1,\ldots, N$$

$$\theta \geq 0, \quad z^j \geq 0, \quad \sum_{j=1}^{n} z^j = 1, \qquad j=1,\ldots, n.$$

gives us the optimal θ $(\hat{\theta})$ by using standard linear programming problem.

Another issue that needs to be considered is the choice of input orientation or output orientation for the DEA procedure. It is not essential for conclusion weather DMU is efficient or not (the result will be the same under both orientations), but it is essential for the efficiency scores, which will be different under different orientations. According to the economic theory for our analysis we will choose the output orientation of the model and will look at the change of output keeping the level of input constant. So, the further DEA analysis will be made in output-oriented framework.

Further, we need to consider of returns to scale choice for our technology. We can argue that the size of gasoline stations will influence their ability to perform quality-efficiency, the assumption of constant return to scale is inappropriate. To allow the variation of outputs and inputs in the sample along with the station size, we will use the less restrictive variable returns to scale frontier.

So, as we can see, DEA approach has its strengths as well as weaknesses. The summary of the former are as follows (Steering Committee, 1997):

- We can compute technical efficiency only with help of observed inputs and outputs;
- We can deal with multiple inputs and outputs;
- We can estimate not only efficiency/ inefficiency, but also determine the source of it;
- We can look at the efficient DMU and its characteristics, and try to 'peer' this result of inefficient ones.

The summary of weaknesses are as follows:

- We can compare only the DMUs that operate in the similar operating environment;
- DEA results can be applicable only for the particular sample (can not compare the results between countries if the research was made for each country separately);
- DEA scores are sensitive to the specification of the input and output and the size of the sample;
- DEA scores are sensitive to measurement error.

The next step after DEA analysis is Bootstrap analysis. Bootstrap is a non-parametric technique that deals with weaknesses of the DEA, in particular, Bootstrap estimates efficiency scores from DEA with minimum bias (bias-corrected efficiency scores). The step is necessary because DEA efficiency scores (with bias) are the estimates of 'true' efficiency scores (without bias) that are unknown. Bootstrap corrects the estimated efficiency scores for bias, and hence approximates them to the 'true' ones. We will use one of the algorithm of bootstrapping (Simar and Zelenyuk, 2004) that suggests 'using the sample of DEA-estimates where those equal to unity are smoothed away from the bound by adding a small noise within 5%-quantile of the distribution of estimated technical efficiencies, or, in other words:

$$\widehat{TE}(x^k, \mathrm{y}^k) = \begin{cases} \widehat{TE}(x^k, \mathrm{y}^k) + \varepsilon^k, & \text{if } TE(x^k, \mathrm{y}^k) = 1 \\ \widehat{TE}(x^k, \mathrm{y}^k), & \text{otherwise} \end{cases}$$

where ε^k =Uniform(0, min $\{n^{-2/(M+N+1)}$, a$\}$), a is the empirical distribution of estimated technical efficiencies ignoring those equal unity.

For our purpose we will use Smooth Bootstrap. The arguments for the choice can be found in Simar and Zelenyuk paper (2004): "smooth" because it is an approximation of the consistent sub-sampling bootstrap. Also, we will use described above algorithm of smoothing (in Simar and Zelenyuk (2004) paper it is "Algorithm II") as good in size and more robust (than "Algorithm I") to the increase in dimension. After estimating bias corrected efficiency scores we can go to the net step.

The next step is the constructing of Li test statistics (Simar and Zelenyuk, 2004). Li test is adapted to DEA nonparametric procedures designed to determine weather the two independent samples are generated from the same probability distribution. The authors concluded that this test is a reliable tool for testing equality or non-equality of distributions estimated technical efficiency scores. For our purpose, we will consider two independent samples as the sample in the period without price-cap regulation (year 2003) and the period with price-cap regulation (year 2004).

Li test use following hypotheses: the null hypothesis is $f_{2003}(x_{2003}) = f_{2004}(x_{2004})$, and alternative one is $f_{2003}(x_{2003}) \neq f_{2004}(x_{2004})$ on a set of positive measure. Conclusion about the equality or non-equality of two quality efficiency densities is made by the p-value:

$$p-value = \frac{1}{B}\sum_{b}^{B} I \ \left\{ J^{nc,b}_{n2003,n2004} > J^{nc}_{2003A,n2004} \right\}$$

where ' I ' is the indicator function, $J^{nc,b}_{n2003,n2004}$ and $J^{nc}_{n2003,n2004}$ are non-parametric kernel density estimators (for more details see Simar and Zelenyuk, 2004). If p-value is less then 0,024 (or 2,4%), then we reject the null hypothesis of densities equality at 5% confidence level, and the opposite result if p-value is more than 2,4%.

The Li test helps us to determine whether there was quality change in the product in the gasoline market due to changes in exogenous factors that influence decisions making units, such as price-cap regulation implementation. To determine the direction of this change (whether it was quality fall-off or improving) we will compare means of quality efficiency scores of our two densities. In the above described framework, improving can be seen from lower mean of the density for 2004, and deterioration otherwise[5].

For precise concentration on the quality question we assume that any change in the quality efficiency frontiers (change in the quality of gasoline) was mainly due to the price-cap regulation, and other factors such as market changes during years 2003-2004 had little effect on the conclusions, that might have influenced the performance of firms on the gasoline market[6].

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[5] The quality efficiency scores are determined from one to infinity (TE Є [1, ∞)), where DMUs which scores equal to one are considered 100% efficient due to output orientation.

[6] Scientific Centre "Psyheya", www.oilreview.kiev.ua.

The next step is devoted to examination of the industry performance during 2003-2004, thus we need aggregation of the data. As, in practice, researches often have aggregated data and are interested in measurement of the group (industry, region, country) efficiency measures, we have aggregate efficiency measurement tools with aggregation over DMUs (oblasts in our case). For the aggregate quality efficiency estimations we will use the same assumptions and arguments as for quality efficiency estimations (group Farrell- type efficiency measures, output orientation, concentration on quality parameter, etc).

Now, the aggregated technology of all firms within a sub-group[7] is represented as

$$\overline{TE}^{l} \equiv \sum_{k=1}^{k_l} TE^{l,k}(x^{l,k}, y^{l,k}) * S^{l,k}$$

where l is sub-group of n_l DMUs taken from the original group of n DMUs; $\overline{TE}^{l}$ is estimated aggregated technical efficiency score for the sub-group l, l =1,…,L; $TE^{l,k}(x^{l,k}, y^{l,k})$ is technical efficiency score for each k DMU in the sub-group l; $S^{l,k} = \sum_{m=1}^{M} a_m \varpi_m^k$, k=1,…,n [with $\varpi_m^k = y_m^k / \overline{Y_m}$ and $\sum_{m=1}^{M} a_m = 1$] is price independent weights for each k DMU in l sub-group (ϖ_m^k is the share of k's firm in the sub-group in terms of m^{th}-output, m=1,…,M and n-inputs, n =1,…,N) (Fare and Zelenyuk, 2003). In other words, DMU's weight is the weighted average over all output- shares of the outlet in the sub-group.

Weights are very important in this context. The choice of more efficient way of regulation used in practice depends on the choice of weights in the aggregation.

[7] Decision and reasoning about the size of each group will be made in later chapters while estimating.

These weights are distributed among the estimated efficiencies of each economic unit of the system. Simar and Zelenyuk (2003) showed dramatically different conclusions from the example of use simple average and weighted average with certain weights. We use group efficiency measure that is derived as average of the efficiencies of individual units weighted by their realized shares in the group.

As before, we need to correct our obtained quality efficiency scores for the bias. Simar and Zelenyuk (2003) in their paper suggest "group-wise heterogeneous sub-sampling bootstrap of aggregated DEA efficiency scores":

$$\overline{T\hat{E}}^{*} - \overline{T\hat{E}} \;\; |\hat{\xi} \;\; \overset{asy.}{\approx} \;\; \overline{T\hat{E}} - \overline{TE} \;\; |\xi$$

where $\overline{T\hat{E}}^{*}$ is bootstrap estimate of the aggregate efficiency score, $\overline{T\hat{E}}$ is empirical estimate of the aggregate efficiency score, $\overline{TE}$ unknown true aggregate efficiency score, $\xi, \hat{\xi}$ are criteria of the true and pseudo-population.

One reason of using criteria of 'heterogeneity' is due to the fact that DMUs (gasoline stations) differ in size, capital, labor, infrastructure, and we can not make one efficiency frontier for all outlets. Further step is to conclude from the result of Li test. Conclusions about aggregate quality efficient representation of the sub-samples can be made from the comparison of estimated aggregate quality scores to the unity. The more a score is closer to unity, the more sub-group is efficient.

Summarizing all above information, we will estimate quality efficiency scores for each DMU and aggregate quality efficiency scores, corrected both types of scores for bias, and then perform Li test to compare true densities of the concerned groups.

Chapter 4

DATA DESCRIPTION

This work relies on the basic oblast' level data from the State Consumer Policy Committee of Ukraine (SCPC), State Statistical Committee (SSC) and Scientific Centre "Psyheya". All the data is represented quarterly for years 2003 and 2004 by 27 "oblasts", with Autonomous Republic of Crimea (AR of Crimea) and city of Kyiv (total number of observations is 216[8]). The reports of SCPC provide detailed aggregated information from gasoline market. This quarterly information contains the following information:

- total value of litres of gasoline sold by all gasoline stations in each oblast';
- total number of litres of gasoline that was withdrawn from the market by government regulatory organizations in each oblast' because of three criteria:
    - Problems with gasoline quality;
    - Problems with documents on the gasoline that is on sale;
    - Problems with documents of gasoline stations on their activity[9].

These withdrawals are made by the SCPC based on the results of examinations of the main parameters of gasoline. The procedure is the following: a 'special' car equipped by different sensors and quality monitoring devices takes some amount of gasoline of each type and tests it. The results are not always accurate in the

[8] While the minimal number of observations is 48, counted by the following formula 3* (# of inputs +# of outputs)^2 = 3* (3 + 1)^2

[9] We can use the last two criteria to form the proxy for "gasoline quality" because these problems with documents are mainly connected with degradation of gasoline quality, which was the effect of government regulation.

sense that it takes five days to get them, so during this time all this tested (and maybe low-quality) gasoline can be bought by customers. This question will be discussed in more detail in the next chapter.

Total number of litres of gasoline that was withdrawn from the market is the proxy for "quality" of the gasoline in Ukraine. More detailed information concerning gasoline quality can be taken from such parameters of gasoline as "steam pressure" – the level of combustion of specific carbohydrates - the deviations from the standard level of which leads to a number of problems in the internal-combustion engine work: in starting the car, increase in the amount of smoke; "octane number" – the level of detonating durability of gasoline which is determined by the speed of combustion of specific carbohydrates (the measure was discovered in USA in 1930's, and lies between zero and 100) - the octane number can be artificially increased by different admixtures that decrease the quality of gasoline; "fractionating measure" – the parameter that influences the speed of the car starting; "the mass fraction of sulfur " – the fraction of sulfur in gasoline; and "content of lead" – the parameter increase in content of which means the deterioration of car work, and increase in toxicity of smoke produced by a car. In Ukraine these quality parameters come up with the "Standard No. 4063-2001" (there 17 main parameters, and if the examination at least one of them shows low characteristic the gasoline should be legally withdrawn from the market). The tests on this quality measure are done by Institute of examinations for consumer, but they cover very small sample of observations and data is gathered selectively.

Economic theory suggests using labor and capital as the main inputs in such kind of model. So, we will add two more variables as inputs which are the proxies for real "labor" and "capital" variables. For "labor" we will take total number of employees at all gasoline stations in each oblast'; for "capital" we will take aggregate capital of gasoline stations in each oblast'. This data was kindly provided by the Scientific Centre "Psyheya". In the concerned context, the problem for this kind of data is that gasoline stations can vary in size, so, in labor and capital size.

Taking into consideration all the information above, in our model we will use three inputs and one output.

The inputs are:

- labor;
- capital;
- proxy for quality parameter (due to quality of gasoline, due to documents on gasoline and due to documents of gasoline stations).

The quality measure in our model is taken as the reciprocal of proxy for quality parameter due to fact that increase of the inputs need to lead to the increase in output in the before discussed framework.

The output is:

- total value of litres of gasoline that was sold;

Descriptive statistics of the data can be found in the Appendix, Table 1.

Chapter 5

THE SITUATION ON THE UKRAINIAN GASOLINE MARKET

The structure of the Ukrainian gasoline market is quite similar to the structure of the gasoline market in USA (see the features of US gasoline market in Borenstein and Shepard (1996) paper). Six plants in Ukraine process oil and produce gasoline, which are: Ukrtatnafta, Linos, Galichina, Lukoil-Odesa, Naftohimic Prikarpattya and Hersonnaftopererobka. Then gasoline is delivered to the terminals, from which gasoline stations or gasoline networks purchase it from the so-called "wholesales houses" (in US "jobbers") for further retail sales. In contrast to US, gasoline in Ukraine does not belong to plants, but is the property of private "wholesales houses" (WH). WH can also have its own gasoline stations and networks, and in this context we can point to absence of large differences in transaction costs for all gasoline stations in Ukraine (Borenstein and Shepard, 1996) noted larger transaction costs for those gasoline stations that are not owned by refiners in US, because of the presence of "dealer tankwagon price" for which refiners sell gasoline to these stations). This is the important issue to consider in the current research in order to have equal pricing conditions for Ukrainian gasoline stations.

Also, the important issue to mention is delivery of oil to the country. Ukraine, as a country that mostly imports oil from abroad, is heavily depend out on the world prices of the latter in general and prices of Russia's export in particular (experts declare the presence of 75%-80% of Russian oil in Ukrainian oil market , *Kyiv Telegraph*, 2003-2004). Scientific Research Institute "Masma", which is subordinated to Ministry of Power and Energy of Ukraine, confirm this fact by providing information that in 2004 Russia delivered in Ukraine 87,6% (86,6% in

2003, and 77,8% in 2002) of all amount of oil for further proceeding, while from Ukraine the share of oil for processing was only 9,6% (8,8% in 2003, and 11,3 in 2002) and from Kazakhstan it was 3,3% (4,6% in 2003, 10,9% in 2002) (for more detailed statistics see Appendix, Table 2). So, we can conclude that Ukraine depends mainly on the Russian oil market in this case. On one hand, there was agreement between Ukraine and Russia about the sale price for the barrel of oil (in November 2004, while New-York stock exchange experienced historical record since 1983 of oil price over 51,09 USD/barrel, the price Russian oil to Ukraine was 35 USD/barrel, when, at the same time, Russian oil "Urals" on the world market costs 39,79 USD/barrel; export to Europe was at the price level of 39,64 USD/barrel for "Urals" and 44,09 USD/barrel for "Siberian Light"). On the other hand, at the beginning of May 2004, Cabinet of Ministers of Ukraine and presidents of the Russian leaders on the market, such as TNK, Lukoil and Ukrtatnafta, signed the Memorandum of 2004 about price-cap regulation on the retail gasoline market for the stability, regulation and development of oil products market in Ukraine (price-cap levels for gasoline can be seen in Appendix, Table 3). It means that collusion behavior[10] of the government and the main Russian suppliers about price-cap regulation of gasoline in retail was one of the main reasons of the shock with negative consequences (in our research we concentrate our attention on the question of decrease in quality of the gasoline) in the gasoline market at the beginning of year 2004.

This fact was confirmed by Leonid Scholnik, the chairman of State Standard of Ukraine (SSTU), the main purpose of which is to increase the efficiency of government policy in the protection of consumers. According to Mr. Scholnik, while in the first quarter of the year 2004 around 12% of gasoline was withdrawn

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[10] this behavior can be called like this because government was prepared for the Autumn Elections of 2004 and it was a good step in "consumers' eyes", and along with this fact Russian suppliers were forced to set the prices according to the regulation described in the Memorandum because otherwise they would "lose" Ukrainian market.

from selling (at retail of all amount of examined gasoline) at gasoline stations in Ukraine, in June this ratio already reached around 35%. For comparison, in the beginning of 2003 it was only 7,3% (see Appendix, Graph 1) of gasoline with the low quality which not correspond to standard (*Segodnya*, 2004). Leonid Scholnic also declared that the main reason for this deterioration for gasoline was connected with illegal acts of gasoline stations. Numerous gasoline examinations done by SSTU found a lot of components that should not be present at gasoline: from antiknock compound (for increase of octane number) to acetone. Different mixtures are added to gasoline with the purpose of increase the profitability of the gasoline stations. The same was claimed by director of energy programs in Razymkov Ukrainian Center, Volodymyr Saprykin (K*orespondent*, 2004). He pointed that after Memorandum of 2004 was constituted, the profitability of gasoline stations in Ukraine reached at that time almost zero level, which they tried to improve sometimes by illegal actions.

We can give another argument against the price-cap regulation policy by looking at the relationship between retail, terminal, and crude oil prices. Borenstein and Shepard (1996) showed the monthly movement in retail, terminal, and crude oil prices for 1986 – 1991 in USA. They stated that "a large share of volatility in terminal prices (and therefore in retail prices) is the result of shocks to the price of crude oil". So, establishing the maximum of gasoline 'price at the pump' (retail price) without taking shocks in crude oil market into consideration can lead to underperformance of gasoline stations or, in other words, to inefficient business activity in the retail market. These links are observed through degradation in gasoline quality when, in order not to be inefficient, outlets made illegal transformation of the product.

Illegal actions can be clearly seen in analytical reports of SSTU during 2003-2004. The cumulative quarter data about withdrawal gasoline is gathered by governmental organizations in charge of consumer protection (see Appendix, Graph 2). During 2003 14,8 mln litres of different types of gasoline were examined from which 1,6 mln litres (or 11%) were withdrawn. Out of the withdrawn gasoline 35,6% didn't correspond to the normative requirements of quality and safety, 19,4% due to absence of needed information, 44% - due to the absence of accompanying documents. Examinations found that almost in half of the oblast's the gasoline was sold without the appropriate documentation verifying the quality of the gasoline. Major production defects due to which gasoline was withdrawn are the inconsistency with SSTU 4063–2001 "Automobile Fuels. Technical Conditions", an understated octane number, an overstated carbon oil mass fraction, and unsatisfactory gasoline distillation.

Almost all examined gasoline stations were found violating the law concerning the provision of needed, accessible, reliable and timely information for customers (absence of manufacturing date, expiration date, name of the producer, etc.). 88% of the examined stations were found to violate oil products retail sales rules; major violations were selling of low quality products, selling of smaller amount of product, etc (see SSTU reports, 2003-2004).

These violations lead to another important problem. State metrological control registers violations that can endanger citizens' lives and environment. First, the use of metrologically untested pumps and pump explosion hazard; second, threat of decrease in health for people (for example, mass fraction of benzol which is higher in 4-5 times due to examinations of gasoline stations can provoke the appearance of malignant growth in human organism); third, regulated "cheap" Ukrainian gasoline becomes extremely "expensive" for the society – big cities suffer from air pollution due to automobile exhausts that transforms the cities into the zones of ecological disaster (*Pravda*, 2005).

The efficiency of gasoline quality and safety control depends on the quickness of gasoline sample selection and laboratory examinations. To a great extent the existence of mobile laboratories for express methods of quality and safety measurement will support this. Ivano-Frankivs'k Oil and Gas University developed such a laboratory, but the government did not allot money for this project. At this moment 6 laboratories of this kind exist, which belong to Russian private gasoline network. Information on the conducted examinations by these laboratories is not publicly available. The only information on gasoline quality that is publicly available comes from the examinations conducted on the state level, but is not represented the facts due to the long period needed for quality determination.

Analysis of the consumer market for oil products in focusing on the quality and safety in 2004 shows that the situation changed for the worse compared to 2003. SSTU examinations highlight the following offences on the gasoline market: discrepancy of quality to the standards; sales without accompanying documents and certificates of correspondence; and sales of gasoline filling not full ordered amount. The cumulative quarter data about withdrawal of gasoline is gathered by territorial form of government in charge of consumers protection. During 2004 18,04 mln litres of different type of gasoline were examined from which 2,9 mln litres (or 16,1%) were withdrawn, which is much greater in comparison with year 2003. Among 1145 examined gasoline stations, 905 (or 79%) were accused of different kinds of infringements discussed previously (see SSTU reports, 2003-2004), and comparing to 2003 in 2004 the number of exanimations increased by only 7% but the ratio of withdrawn gasoline rose up to 47%.

In almost all oblasts it was found that oil products were sold without appropriate certificates of correspondence, documentation on quality and without important and full information on the product. The greatest weight of oil product found to be faulty and withdrawn was recorded in Kirovohrads'ka, Kyivs'ka, Khersons'ka, and Vinnyts'ka oblasts' in which 65.9%, 51.2%, 51.7%, and 42.7% of examined quantity was found to be faulty and withdrawn respectively.

Taking into considerations this information, we can expand this idea and think of the shadow economy of the gasoline market in Ukraine. There is no data or some statistics on this issue, on one hand, but there is no information what is done with the withdrawn gasoline from the market, on the other hand. This means that with the political regulation, government by indirection forces the increase in shadow economy and decrease in gasoline quality, because it is not possible to make high-quality gasoline from the low-quality one.

Chapter 6

EMPIRICAL RESULTS

To determine whether the quality of gasoline under price-cap regulation in 2004 degraded we need to follow the step-by-step structure of the Methodology. All steps can be summarized into the following procedure:

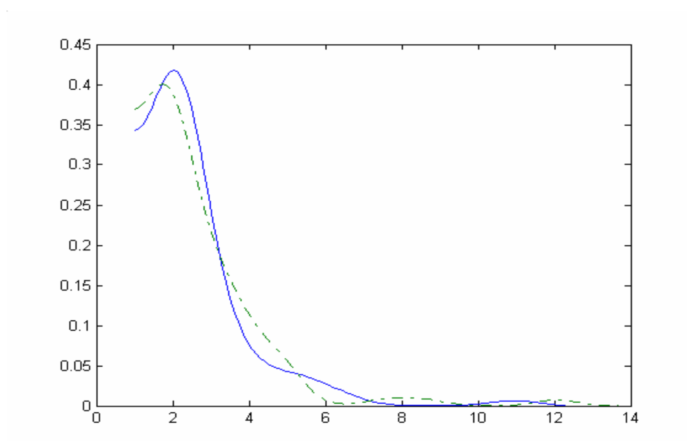
- Estimate the efficiency scores (DEA scores) for DMUs (oblasts, in our case) for each group (periods of 2003 and 2004, quarterly data). The total number of quarters is 8. We split our data in two periods with four quarters in each (and not by 5 quarters in the first group and 3 quarters in the second one) in spite of the date of signing out the Memorandum (May 2004). This choice is caused by the fact that people working on/with gasoline stations knew about the future regulation about price-cap on retail gasoline prices from the beginning of 2004 (from the fifth quarter), so they start to 'prepare' for this regulation.
- For each group we need to follow Jackstrap procedure for detecting outliers that have unrealistically "too" efficient scores, and that strongly affect the inefficiency of other DMUs while constructing best frontier;
- Estimate the efficiency scores for DMUs without DMU-outliers for each group;
- Execute Bootstrap procedure to correct for the bias in our obtained efficiency scores in order to approach the "true" best frontier with our constructed best frontier;
- Build Kernel density from the bias corrected efficiency scores for the visual comparison of efficiency of the two groups;
- Statistical comparison is made by Li test in order to determines whether the two independent samples are generated from the same probability

distribution dealing with the quality efficiency frontiers across the groups with different regimes (without price-cap regulation in 2003 and after it was established at the beginning of 2004).

- Perform all the steps above for the aggregate data of group 2003-2004.

Before starting the analysis of the main question of this work and determining how the price-cap regulation affected the product quality of the decision making units (oblast') on Ukrainian gasoline market, we will show that it is really possible to use "quality efficiency frontiers" for assessing the gasoline quality factor. Let us try to do the estimations above without quality factor as the input. So, to show the results of "efficiency frontiers" we will use two input - one output case with all the assumptions made before. Results of the DEA efficiency scores estimation for the data without quality factor can be seen on the Graph 1.

Graph[11] *1* *: Efficiency scores for DMUs by quarters of 2003-2004 (two inputs-one output case).

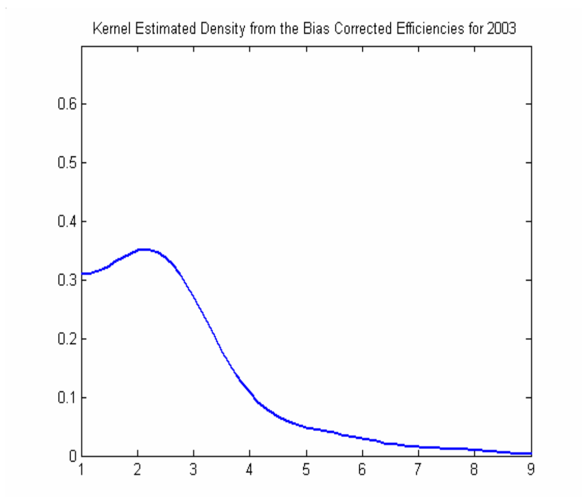


* where solid line in kernel for 2003, and dotted line is Kernel for 2004.

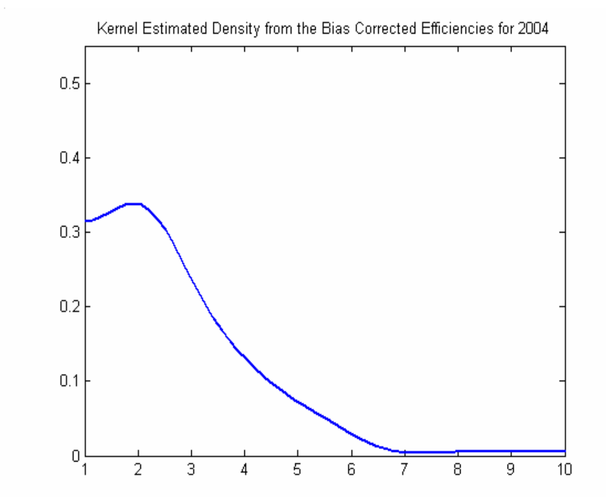
[11] Now and further in the text we present kernel density graphs with efficiency score on horizontal axes, and kernel density estimates on vertical axes.

From this graph we see that two densities are not significantly different from each other (excluding outliers). But these estimated efficiency scores are biased by the reason we discussed in the Methodology. That is why we proceed with Smooth Bootstrap for DMUs efficiency scores. The bias-corrected efficiency scores after Smooth Bootstrap for both groups appeared to be significant at 1% confidence interval (as well as on the 5% and 10% confidence intervals). The bias corrected efficiency scores can be seen on Graphs 2-4.

Graph 2.

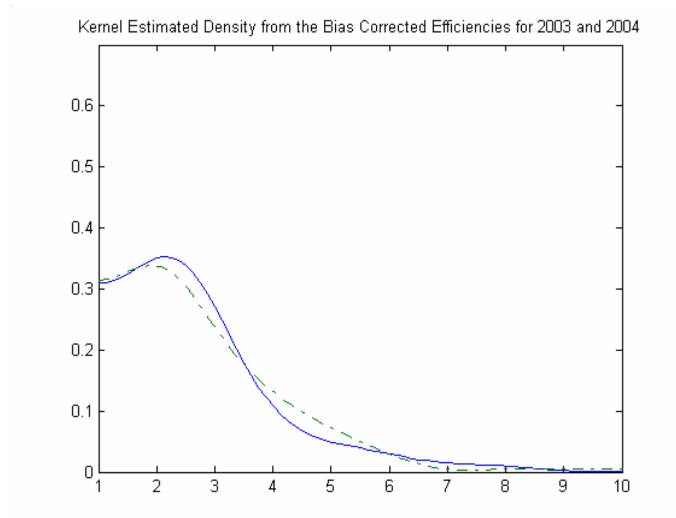


Graph 3.



Graph 2 and Graph 3 are constructed from the bias-corrected estimated efficiencies for group 2003 and group 2004 respectively. We see that kernel densities are uni-models (have only one hump – each describes one group). The mean for the first group is 2.4902, and for the second is 2.5801. This results tell us that the group 2003 was efficient only for 40,2% ($\frac{1}{T\hat{E}}\%$) and the group 2004 was efficient for 38,8% due to given labor and capital inputs and gasoline selling output for these periods. We consider these estimations are correct representation of the reality (gasoline market), because we obtained them from the “true” efficiency frontiers. The comparison of two groups can be seen jinn Graph 4.

Graph 4.



Following the result of Li test we obtain p-value = 0.145 (or 14,5%). According to description of Li test in the Methodology, we can not reject the null hypothesis that our two true densities are different from each other due to critical value of 2,4% (which kernel-based estimates we see on Graph 4). This means that without considering quality parameter in our estimations, we found no difference between efficiency of DMUs in Ukrainian gasoline market in 2003 and 2004. Further, in the research we expect to see difference between these two densities after including quality parameter.

Now, according to our framework we present the estimation, which includes quality parameter as the third input (with labor and capital). Table 2 presents the DEA efficiency scores computed for the data with quality indicators using all listed inputs and output, and Graph 5 shown the results graphically.

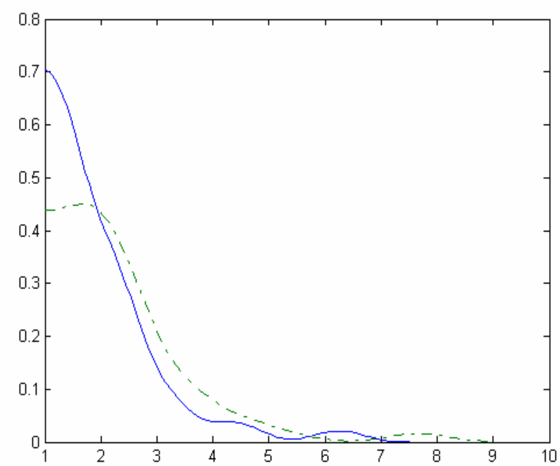
Table 2: Efficiency scores for DMUs by quarters of 2003-2004.

Oblasts and 2 cities	I 2003	II 2003	III 2003	IV 2003	I 2004	II 2004	III 2004	IV 2004
Vinnyts'ka	2.1999	2.5768	2.0227	4.4841	4.5562	3.0121	2.1819	2.1351
Volyns'ka	3.2285	3.836	3.7961	3.6997	3.6983	2.9578	2.389	2.0899
Dnipropetrovs'ka	1.0522	1.0000	2.1559	2.5076	1.7828	1.4202	1.1112	1.1565
Donets'ka	1.8696	1.6112	1.2843	3.5502	2.8036	1.8934	1.355	1.3715
Gitomirs'ka	2.8926	2.7008	2.4278	2.4683	5.1981	3.9474	3.2163	2.9364
Zakarpats'ka	1.488	1.4879	1.5983	2.4117	2.1399	1.521	1.0000	1.0000
Zaporiz'ka	5.3348	4.9209	3.2012	2.9247	3.0342	2.304	1.3001	1.5588
Ivano-Frankivs'ka	1.5356	1.8659	1.5349	2.0767	1.3753	3.0283	2.7952	2.2651
Kyivs'ka	1.5325	2.0907	1.9401	1.0000	2.8049	1.634	1.2958	1.0365
Kirovograds'ka	2.1933	2.1136	1.8744	5.9725	5.4403	4.8663	3.2887	3.4802
Lugans'ka	2.142	1.8657	2.0359	6.0397	4.801	3.4372	2.7842	2.709
Lvivs'ka	1.0000	2.4914	2.0926	2.2008	1.5834	1.2085	1.1386	1.0000
Mykolaïvs'ka	1.7636	2.3706	2.4103	2.6571	5.6529	4.4725	3.2417	2.8884
Odes'ka	4.4574	4.7257	5.621	2.7959	2.8118	1.8718	1.539	1.1014
Poltavs'ka	1.8304	4.1177	3.9621	4.779	5.0561	3.3334	2.5771	2.6822
Rivnens'ka	3.0104	4.2263	4.5318	7.5075	6.819	4.7257	3.7817	3.1751
Sums'ka	1.3112	7.1926	4.4606	5.8764	6.6547	4.145	3.3094	3.0345
Ternopil's'ka	3.1879	4.0624	3.1614	7.3517	6.5252	4.7594	3.3655	3.1612
Harkivs'ka	6.5215	4.9042	4.139	4.6955	3.7763	2.7726	2.1149	1.9918
Hersons'ka	3.0536	2.8307	5.1936	6.4467	4.3893	3.0608	1.7424	2.3586
Hmel'nyts'ka	3.1321	3.4602	3.3634	5.0563	4.2983	3.0913	2.3123	2.4604
Cherkas'ka	1.9952	1.9743	1.6407	1.8515	4.5975	2.9105	2.3006	2.329
Chernivets'ka	1.0000	1.4089	1.5004	1.896	5.5767	4.163	3.1853	2.8805
Chernygivs'ka	11.547	9.5848	7.7704	3.4442	10.179	6.5063	4.9932	4.4011
Kyiv, city	4.9037	4.2026	4.5737	1.873	2.3695	1.542	1.1884	1.2787
Sevastopol', city	5.3316	5.2104	4.6666	9.5812	21.098	16.468	7.1106	1.0000
AR of Crimea	11.009	7.5103	4.9098	4.2283	5.0481	3.508	1.7705	2.5561

We see that some DMU are too inefficient. For example, Chernygivs'ka oblast' in the first quarter of 2004 is efficient only by 10%, AR of Crimea in the first quarter of 2003 is efficient by 9%, and Sevastopol' in the second quarter of 2004 is efficient by 6%, and in the first quarter of 2004 is efficient only by 4,7%. This can happen because of presence of outliers (small oblasts with inefficient activity compared to large ones (as can be seen from the results of quality efficiency representation of Chernygivs'ka oblast' and city of Sevastopol'); or sufficiently efficient DMU, like Poltavs'ka oblast', where more than thousand not official ("underground") private refineries supply gasoline almost to all gasoline stations in this region[12]).

Graph 5 *: Efficiency scores for DMUs by quarters of 2003-2004

(three inputs-one output case).



* where solid line in kernel for 2003, and dotted line is Kernel for 2004.

It turns out that conclusions do not change with Jackstrap test for outliers. Among the other DMUs we removed from our estimation are Chernygivs'ka oblast' and AR of Crimea, on one hand. On the other hand, Poltavs'ka, Zakarpats'ka and Dnipropetrovs'ka oblasts were outliers as the most efficient oblasts in this sample.

The next step is to estimate quality efficiency scores without outliers, and use Smooth Bootstrap mechanism to correct them for bias. We need to stress that by

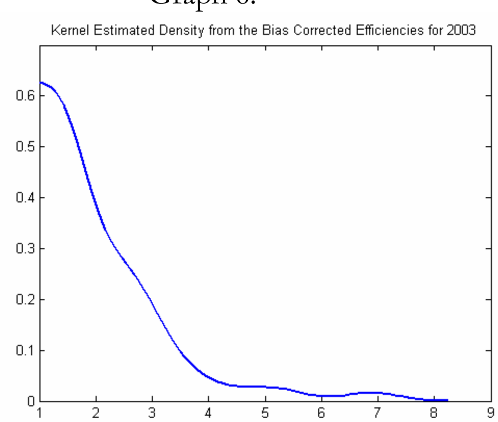
12 This fact was revealed by law machinery of Ukraine in 2004. After this illegal enterprise was stopped, in Poltavs'ka and Sums'ka oblasts almost all gasoline stations were closed because of absence of the main product - gasoline.

non-parametric theory the bias is downward, so it is not surprising that we obtained even more inefficient bias-corrected quality efficiency scores than before Bootstrap.

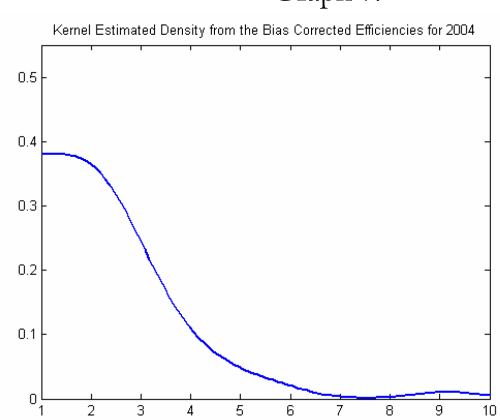
New estimated efficiency scores (without outliers and bias-corrected) can be seen on graphs (Graph 6 for 2003, and Graph 7 for 2004, and Graph 8 for 2003 and 2004 periods). The important issue to mention here is the removal from each of the group of the estimated DEA scores that are equal to unity before Bootstrap. It is important for our estimations, because such absolute efficiency scores are not natural in the context of biased unrealistic best practice (frontier). Plotting bias-corrected numerical results with Kernel, we conclude that in 2003 high density of quality efficiency scores are between one and four, while in 2004 high density of quality efficiency scores are between one and five. This preliminary result can be interpreted as degradation of quality efficiency performance for DMUs in 2004 comparing to 2003, so after price-cap regulation.

Also, the corrected efficiency scores after Smooth Bootstrap for both groups appeared to be significant at 1% confidence interval.

Graph 6.

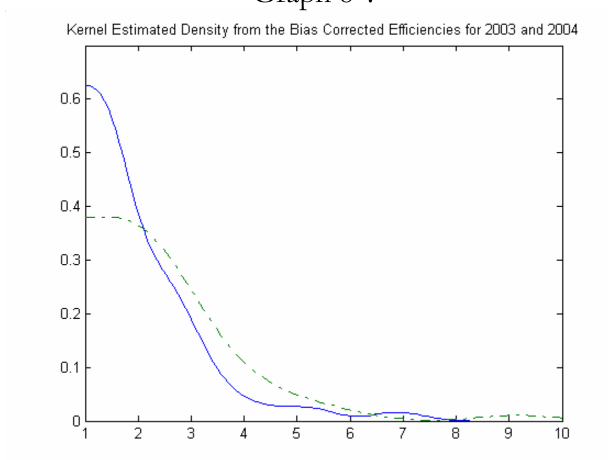


Graph 7.



Graph 6 and Graph 7 are constructed from the bias-corrected estimated quality efficiencies for group 2003 and group 2004 respectively. We see that kernel densities are uni-models (have only one hump – each describes one group). The mean for the first group is 2.1752, and for the second is 2.6082. This results tell us that the group 2003 was efficient for around 46% and the group 2004 was efficient for around 38% due to given labor, capital and quality inputs and gasoline selling output for these periods. We consider these estimations are correct representation of the reality (gasoline market), because we obtained them from the "true" efficiency frontiers. The comparison of two groups can be seen in Graph 8.

Graph 8*.



* where solid line in kernel for 2003, and dotted line is Kernel for 2004.

Following the result of Li test to test whether two independent samples (of 2003-2004) are generated from the same probability distribution, we obtain p-value = 0.015 (or 1,5%). According to the Li test, we can reject the null hypothesis that the true densities are the same. This means that we can not discard the possibility of a change in quality efficiency performance under price-cap regulation. This conclusion can be made more precisely from the analysis of Table 3. It can be seen that the mean of the group 2003 is closer to unity comparing to the mean of the group 2004, which means decrease in quality efficiency scores and verify our 'hypothesis' of quality degradation in the Ukrainian gasoline market after price-cap regulation in 2004.

Table 3: Main characteristics of the bias-corrected quality efficiency scores for 2003 and 2004 groups.

	group 2003	group 2004
mean	2.1752	2.6082
st.dev.	1.1416	1.4114

To confirm our results, we analyze the issue of quality degradation also from the aggregate efficiency of DMUs across the period of 2003-2004. Aggregate efficiency scores are computed from pooled data for the two groups with weighs of 0.4832 (or around 48%) for 2003 and 0.5168 (or around 52%) for 2004. Visual representation and be found in Appendix, Graph 3 and Graph 4. These graphs are constructed from the bias-corrected estimated quality efficiencies for sub-group 2003 and sub-group 2004 respectively from the group 2003-2004. We consider these estimations are correct representation of the reality (gasoline market) by the same reasons as before. Results of the estimations can be seen in Appendix, Table 4. The conclusions are the same: efficiency for the first sub-group (year 2003) is greater than for the second sub-group (year 2004), meaning that in 2003 DMUs were more efficient in quality than in 2004.

To generalize, we determined the efficiency of gasoline market in two periods (2003 and 2004) looking at labor, capital, quality inputs and total gasoline selling for each of 27 oblasts (24 oblasts, city of Kyiv, city of Sevastopol' and AR of Crimea). The choice of these two periods was based on implementation of government price-cap regulation in the beginning of 2004. We tested the hypothesis of the study that gasoline quality degradated because of price-cap regulation by adding quality parameter in the DEA estimations. The results were obtained by not-aggregation and aggregation efficiency measurements, and in both cases showed the degradation of gasoline quality in 2004 (comparing to 2003) by lower quality efficiency frontier in 2004 comparing to the quality efficiency frontier in 2003 after price-cap regulation.

Chapter 7

CONCLUSIONS, POLICY RECOMMENDATIONS AND EXTENSIONS FOR FURTHER RESEARCH

In this research we consider retail gasoline market in Ukraine focusing our attention on the quality efficiency performance of the industry in 2003 and 2004 periods. The following split is made due to the price-cap regulation – government regulation of the ceiling prices on gasoline at retail – that was established with Memorandum at the beginning of 2004. Specifically, we examine the gasoline quality change in 2004 (comparing to 2003) after price-cap regulation applying advance efficiency analysis methods including non-parametric Data Envelopment Analysis and Smooth Bootstrap. Based on data with gasoline quality factor it was found that we can not discard the possibility of a degradation in quality efficiency performance of retail gasoline industry under price-cap regulation after 2004. We also investigate efficiencies of the sub-group 2003 and sub-group 2004 of the period 2003-2004, and it turns out that conclusions do not change: we detect higher aggregate quality efficiency for 2003 than for 2004. So, I argue that the price-cap regulation in the beginning of 2004 was the political step that led to quality degradation of gasoline in Ukraine.

At the beginning of May 2005 the government returned back to the Memorandum of 2004 and established new law with new (higher than in Memorandum, 2004) price level of gasoline. Now, retail prices of "A-95" is 3,20 UAH per liter, of "A-92" and diesel is 2,99 UAH per liter (for comparison see Appendix, Table 3).

Even in conditions of strict government price regulation, gasoline stations competed in prices. Talking about competition we conclude that the effective instrument of economy improvement is gasoline quality decrease (*Oil review,* 2005). This means that higher price-cap levels for retail selling on gasoline stations gives more opportunity for release price and quality maneuvers.

And today we see the negative consequences on the retail gasoline market of the new wave of government price-cap regulation. For consumers the most acceptable way of payment for the gasoline became cashless settlement, which means that the actual price of the gasoline is 20% more than the one is written on the stations steles (*Pravda*, May 2005). We can see also illegal actions of the gasoline stations (also stations that are located out of cities) which offer gasoline for cash but by higher prices than in the law, otherwise, gasoline stations refuse to sell the products (increase in shadow economy). Now on the market it is almost usual case to see the absence of gasoline on stations. Stations that still sell gasoline suffer from huge queues, when customers buy in store.

According to this, we can assume that gasoline stations, where prices are high, sell foreign high-quality gasoline, but by the appraisal of Scientific Institute "Psyheya" new level of retail prices do not allow to sell foreign oil product even with zero profit (*Oil review*, 2005). So we can suggest to create competition conditions on the market. And, foremost, it concerns the quality. The consumer can not to check the quality parameter of the product on different gasoline stations, so the main basis of their choice becomes the price. The government role is important here while establishing real competition conditions for the foreign and domestic oil products production, and also while control the quality of oil products due to standards of the country.

Today, the new government of Victor Yuschenko understands possible negative effects of the non-market regulation on the economy. Cabinet of Ministers of Ukraine make the forecast about increase in the price level of gasoline in Ukraine, and project to approach them to the world price level. The Minister of Economy of Ukraine, Sergey Terehin, spoke on the subject of such mechanism of fixing the price. He states that it will be possible when the oil reserves is made for three months, but this process will take three years. The question of reserve creating was brought up at the beginning of 2004 when the oil pipe line "Odessa-Brody", as well as refineries and military bases were regarded as terminals.

However, the Prime-Minister of Ukraine, Yulya Timoshenko, claimed that the prices in Ukraine should stay unchanged in spite of record increase in Russian export duty for Ukraine. She stated that Russia became the monopolist supplier of the oil (guarantee up to 77% of the demand), and the Russian oil price levels are higher for Ukraine as the world prices (Russian price level is $340 per tone, while the world price level is $318 per tone). Moreover, Russian oil suppliers are the owners of the majority of refineries in Ukraine that assures their monopoly status on Ukrainian oil product market (*Oil review*, 2005).

The Prime-Minister highlighted that the new price-cap levels guarantee the efficient activity of gasoline stations on the market. Also, the government works on strategy of energy and fuel direction up to 2010, that will allow to diversify the oil supply to Ukraine and creation of the balance between supply and demand on oil products market in the country.

Further research can be improved by using firm-level data of retail gasoline market in Ukraine. Nowadays, this data is not collected neither by government nor by private organizations. Firm level data makes possible the discussion of many interesting issues. Between the letters are the influence of ownership structure (private/public, domestic/foreign, etc.) on efficiency and quality efficiency of gasoline stations; the influence on efficiency and quality efficiency of gasoline stations the fact of their belonging or not to the wide chains (as Lukoil, WOG, Alliance, TNK, Galneftegas, Ukrtatnafta, Neftegasukr)[13]; whether gasoline stations are big or small by the number of their petrol pumps and by capital size; whether the capital is Russian or Ukrainian; and also, whether a gasoline station has developed infrastructure (the main directions can be found in the non-permanent gasoline market investigations made by the State Committee of Statistics, e.g. April 2004). Moreover, we can add to our model new variables as "number of cars per person" and "average spendings on the gasoline" in Ukraine. The answer to these questions are of high importance not only to researches but also, perhaps even more important, for policy makers, for voters, for educators in related areas, for many other.

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[13] It is always stated by these companies that they keep the high level of their retail gasoline on all stations in each chain and constantly check the quality of their products.

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Appendix.

Table 1 : Descriptive statistics.

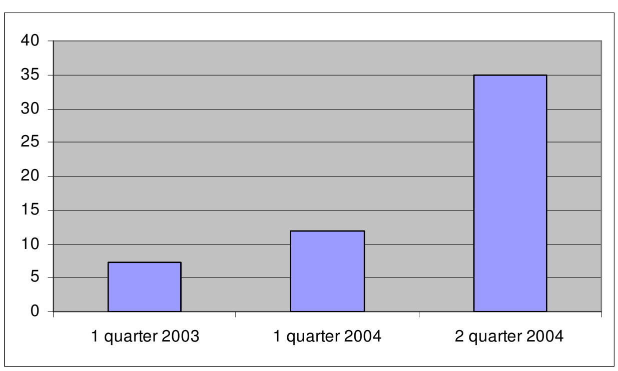
	Labor, th. people	Capital, th. UAH	Quality, %	Output, th. UAH
Mean	1728.333	43208.33	16.33833	97001.39
Median	1505.000	37625.00	4.550000	80700.00
Maximum	4980.000	124500.0	100.0000	427120.0
Minimum	580.0000	14500.00	0.000000	9722.000
St. Dev.	861.1869	21529.67	24.44623	65256.06
# of observations	216	216	216	216

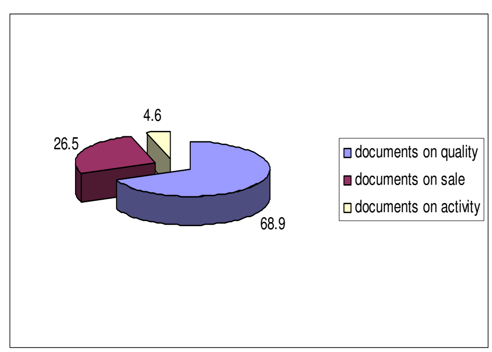
Table 2* : Arrival of oil to Ukrainian refiners in years 2002 - 2004.

Year	Total	including:					
		Ukrainian		Russian		Kazakhstan	
		th.tons	%	th.tons	%	th.tons	%
2002	21257,2	2398,6	11,3	16536,7	77,8	2321,9	10,9
2003	24619,6	2166,4	8,8	21319,5	86,6	1133,7	4,6
2004	23996,7	2303,6	9,6	20889,3	87,1	803,8	3,3

*Source: Scientific Research Institute “Masma”, Ministry of Power and Energy.

Graph 1*: The ratio of gasoline withdrawn to total amount at retail and reasons of these withdrawals from sales





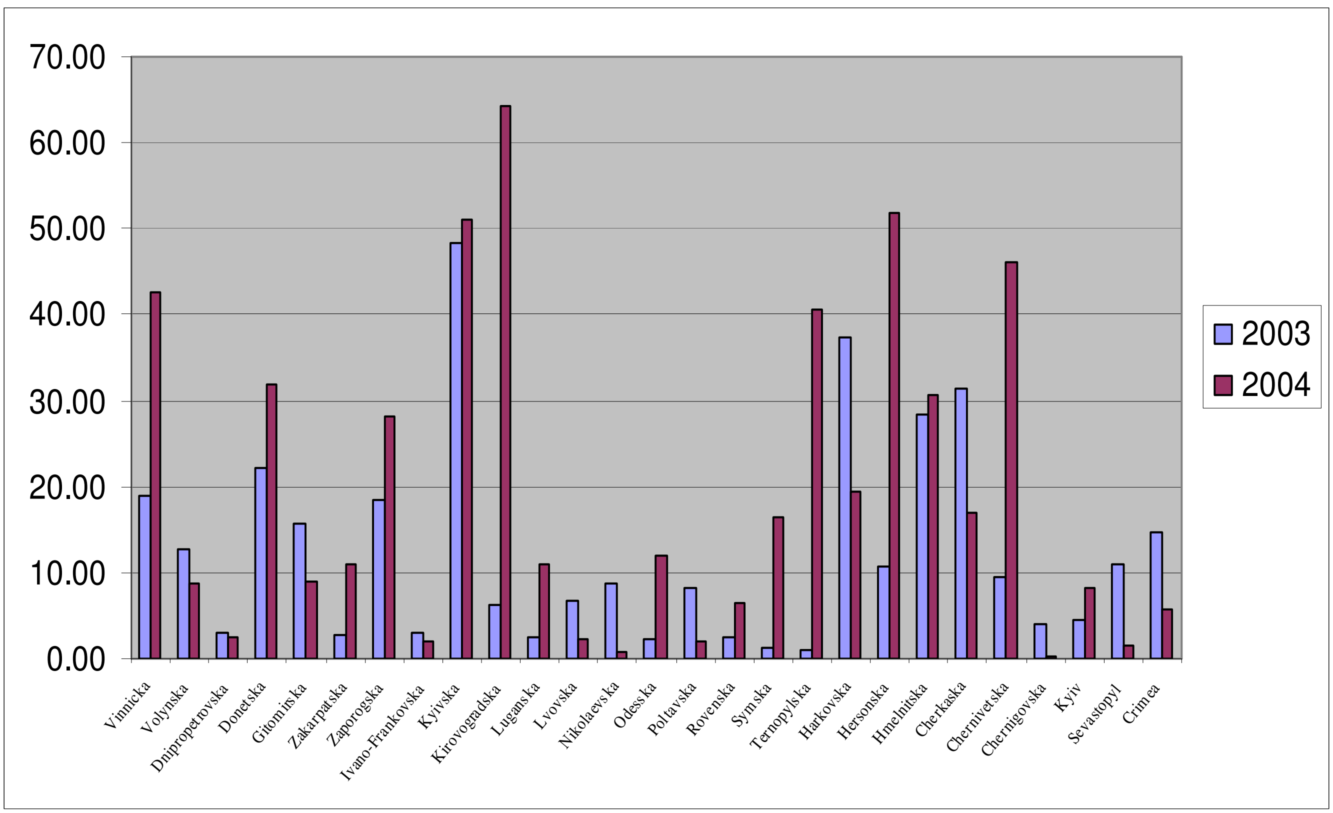
* Source: Consumer Expertise Institute

Table 3*: Price-cap levels for gasoline in Ukraine according to the Memorandum of 2004.

Gasoline' mark	Price, UAH/litre
A-98	2,95
A-95	2,90
A-92	2,75
A-76	2,65
Diesel	2,50

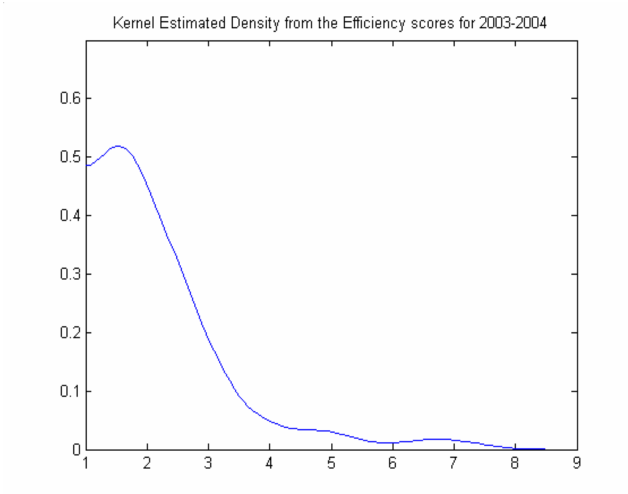
*Source: Ukrainian Magazine "Korespondent", Octobre 2004.

Graph 2*: The ratio of gasoline withdrawn in each oblast'



* Source: Dergspogivstandard

Graph 3



Graph 4

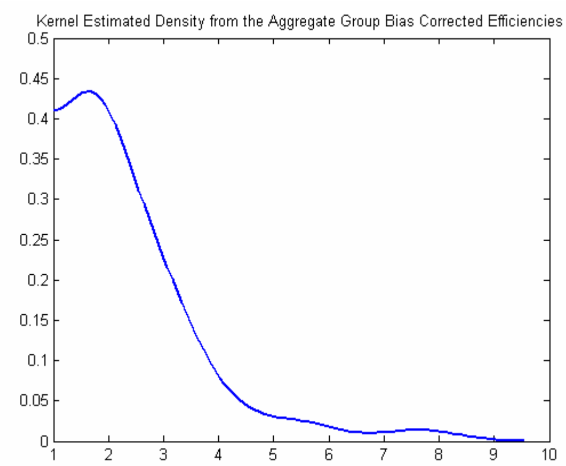


Table 4: Aggregate efficiency scores and bias- corrected aggregate efficiency scores for two sub-groups (2003 and 2004).

	Efficiency	Corrected scores	Lower bound	Upper bound
Group1	1.9880	1.9925	1.6084	2.3572
Group2	2.0022	2.2593	1.9374	2.5245
Aggregate	1.9828	2.1321	1.9120	2.3595