Economic Efficiency of Ukrainian Regions: How Far are They Apart?*

By Pavlo Demchuk[a] and Valentin Zelenyuk[b]

Abstract

Current work concerns with the issues of economic performance of Ukraine and in particular deals with estimation of efficiency of its regions employing Data Envelopment Analysis. One of the main goals of the research is to find out whether there exists a convergence between the Ukrainian regions. We find that in the year 2002 regions diverged in terms of efficiency. We find evidence that efficiency of a region does not depend on the nature of output or its location. Truncated regression with bootstrap, following Simar and Wilson (2003), gives us floor to argue that efficiency scores positively depend on foreign direct investment and negatively on the density of population in the region. An interesting observation is made, i.e. the efficiency score is positively influenced by the rate of criminality this observation is explained by the self-preservation instinct.

20 June, 2005

a - UPEG (Ukrainian Productivity and Efficiency Group) at EROC of EERC-Kiev at the National University "Kyiv-Mohyla Academy," pdemchuk@eerc.kiev.ua
b - Institut de Statistique, Université Catholique de Louvain, 20 voie du Roman Pays, B 1348, Louvain-la-Neuve, Belgium and UPEG (Ukrainian Productivity and Efficiency Group) at EROC of EERC-Kiev at the National University "Kyiv-Mohyla Academy," zelenyuk@stat.ucl.ac.be

* We would like to thank Tom Coupé, Volodymyr Bilotkach, Polina Vlasenko, Kateryna Turchyns'ka, Olexandr Romanov, Aliaksandr Abrashkevych, Oleh Nivyevs'kyj and Kateryna Zyzak for helpful comments and suggestions

1. Introuction

In light of current developments in Ukrainian policial life and especially the change of the ruling party, which is supported by a different set of regions compared to the parties ruling before there is an opinion that highly polarized economy will experience redistribution of power, wealth and resources from one part of the economy to another. But, will it be most efficient shift? Is the current situation efficient?

The proposed research is aimed at the investigation of the questions asked above in the way that will enable us to identify regional patterns of efficiency growth, which in turn will give us information about the lagging regions and the extent of divergence.

Our main hypothesis is comprised of two parts: first - agrarian regions of Ukraine are far behind in their development; second - there is a pattern of convergence between them.

Little attention was devoted to studying the interregional development in Ukraine. This is partly due to the fact that the topic of convergence/divergence of Ukrainian regions is quite new, and partly because data sufficient for the analysis is hard to find. Tsyrennikov (2002), studying regional economic growth during 1997-2000 finds that the establishment of small and medium enterprises, viewed as a factor that alters the incentives structure, is positively related to the region's performance, and its effect is the largest among the growth determinants. He also claims that the effect of human capital is positive but less important relative to the other determinants. Markova (2004) finds the speed of convergence in income per capita to be about 5.3 -7 %, from 4.7 to 8.4% for real gross value added per person employed and 26% for the index of welfare.

Issues of economic growth have received substantial attention from theorists and practitioners in recent years. Solow (1957), was one of the first to consider such an issue. In his work he is concerned with "segregations in output per head due to technical change from those due to changes in the availability of capital per head"[1], meaning that economic growth can be ascribed to technological change and capital deepening. Baumol (1986) finds that there exists a convergence pattern among industrialized countries in the way that productivity levels of these countries become closer with the flow of time. Beginning with the work of Fare et. al. (1994) a new approach came into life and received wide recognition among economists. Data Envelopment Analysis (DEA) which estimates efficiency of the DMU assumes no particular functional form of the efficient production frontier, it is designed to estimate. It also assumes that the frontier is linear on all segments. This method was used by Kumar and Russel (2002), who construct a world production frontier and "analyze the evolution of the cross-country distribution of labor productivity in terms of the tripartite decomposition, finding that

[1] Solow (1957, p.312)

technological change is decidedly nonneutral and that both growth and bipolar international divergence are driven primarily by capital deepening". Henderson and Zelenyuk (2004) continue this practice and "use advances in DEA techniques to examine efficiency scores and investigate the issue of convergence/divergence in a cross-country analysis" and find that "the efficiency scores are significantly different between the groups and that there is some evidence of convergence of efficiency scores within each group". Summarizing all previous studies we may conclude that several gaps have not been filled yet: 1) No studies conducted previously considered issues of "pure" regional convergence of Ukraine, meaning the comparison of production levels and their "behaviour" across regions over time. 2) DEA was never applied in the studies of Ukraine's growth. Our study is aimed at filling these gaps.

The rest of the paper is as follows: next chapter will provide a review of the research conducted before and will include the overview of the studies in which authors used different methodological approaches, as well as different objects of study. Chapter three contains a description of the method which will be employed in the research. It describes its drawbacks and also suggests solutions that will help in combating these drawbacks. This chapter also contains the description of the data used in the study. Empirical results obtained during the course of the research are presented in Chapter 4. We conclude with the next chapter.

2. Methodology

2.1. Efficiency Estimation

In our analysis we follow the two step approach. At the first stage of our analysis of the development of Ukrainian regions and their possible convergence over time we will employ Data Envelopment Analysis (DEA) for calculating efficiencies of the regions, correct bias by the bootstrap techniques, and test for convergence/divergence or its absence.

First consider a country within which the decision making units (DMU), where each particular DMU uses N inputs to produce M outputs. The technology used for converting inputs, in our case capital and labor, into outputs, gross value added for every DMU is accessible to all units and can be characterized by the technology set:

$$T \equiv \{(x, y) \in \Re^N \times \Re^M \,|\, x^i \text{ can produce } y^i\}$$

In order to make our analysis relevant to real life, technology should comply with common laws of physics; therefore we assume that technology follows the axioms, which are known as Main Regularity Conditions (see Färe and Primont (1995)).

In order to find the efficiency of regions we solve the following maximization problem:

$$TE(x^j, y^j) \equiv \max_{\theta}\{\theta : (x^j, \theta y^j) \in T\}$$

Due to the fact that we do not know the true technology and therefore output, we have to estimate the efficiency measures of individual DMU's. This is possible by employing DEA originally proposed by Charnes et al. (1978). In practice we estimate our unobserved T with its DEA-estimate, $\hat{T}$

$$\hat{T} \equiv \{(x, y) \in \Re^N \times \Re^M : \sum_{k=1}^{n} z_k y_m^k \geq y_m, \quad m = \overline{1, M}, \quad \sum_{k=1}^{n} z_k x_i^k \leq x_i, \quad i = \overline{1, N}, \quad z_k \geq 0, \quad k = \overline{1, n}\}$$

where $z_k \geq 0$, $(k = \overline{1, n})$ are the variables we are optimizing over. $\hat{T}$ is a consistent estimator of an unobserved true technology set under constant returns to scale (CRS) assumption. Although we know that the true individual efficiencies are not observed, although they can be approximated by the biased estimators found employing DEA. In turn the estimated efficiency scores can be corrected for bias employing bootstrap procedure, which also allows us to estimate standard errors of efficiency scores and construct corresponding confidence intervals. In general the procedure, thoroughly described in Simar and Zelenyuk (2003) is followed this way: after estimating individual efficiency scores, using the observed sample data, we aggregate them as in the preceding section and obtain $\overline{T\hat{E}}$ as an estimator of $\overline{TE}$; then we would like to find out the sampling distribution of $\overline{T\hat{E}} - \overline{TE}|\wp$, where $\wp$ is unknown data generating process which created our observed sample $\Xi_n = \{(x^i, y^i) : i = \overline{1, n}\}$; next we employ bootstrap in order to approximate the distribution we need by treating Ξ_n as the population, the properties of which can be learned from pseudo-samples, $\Xi_n^* = \{(x^{*i}, y^{*i}) : i = \overline{1, n}\}$, drawn randomly (with replacement) from this population Ξ_n; applying the formula for estimating technical efficiency to the pseudo-sample we obtain $T\hat{E}^{*i}$ - bootstrap estimates of $T\hat{E}^i$ and aggregate them using the aggregation method described for DEA with weights based on the pseudo-sample, now $\overline{T\hat{E}^*}$ is a bootstrap estimate of $\overline{T\hat{E}}$. Kneip et al. (2003) showed that sub-sampling bootstrap is consistent for any sub-sample that is of smaller size than the original one, then we are able to say that the relationship between bootstrap estimate and the original estimate will imitate the relationship between the original estimate and the true unobserved value of the parameter we want to estimate, i.e.,

$$\overline{T\hat{E}^*} - \overline{T\hat{E}}|\hat{\wp} \overset{asy}{\sim} \overline{T\hat{E}} - \overline{TE}|\wp.$$

2.2. Evaluation of Efficiency Determinants

Second step of the analysis will be concerned with the dependency of efficiency scores on region specific factors, in our case these are human and economic factors. Regression analysis will be employed at this stage. We assume the following specification of the model:

$$TE_j = Z_j\delta + \varepsilon_j, \quad j = 1,\ldots,n$$

here Zj is a row vector of region-specific variables for region j which are thought to have an influence on the efficiency score TE_j through the vector of parameters δ which we will estimate, with some statistical errors ε_j. Simar and Wilson (2003) have shown that the most appropriate approach to estimating the coefficients of the above regression is truncated regression with bootstrap. In this study we will employ their "Algorithm 2". In this algorithm the unobserved true efficiency scores, TE_j, are replaced with bias corrected (via heterogeneous bootstrap) estimates $T\hat{E}_j$. It should be also noted that since both sides of the regression are bounded by unity, the distribution of the error term is restricted by the following condition - $\varepsilon_j \geq 1 - Z_j\delta$. We follow Simar and Wilson (2003) in the assumption that this is truncated normal distribution with zero mean and unknown variance, the truncation point (left in this case) is determined by the condition we already mentioned. The model now is given by

$$T\hat{E}_j \approx Z_j\delta + \varepsilon_{j,} \quad j = 1,\ldots,n$$

where

$$\varepsilon_j \sim N(0,\sigma_\varepsilon^2), \text{ such that } \varepsilon_j \geq 1 - Z_j\delta, \quad j = 1,\ldots,n$$

We estimate the model by maximization of the corresponding likelihood function with our data, with respect to $(\delta,\sigma_\varepsilon^2)$. After the estimation the coefficients we employ parametric bootstrap in order to obtain confidence intervals of the estimated parameters.

3. Data and Model Specification

The empirical estimation in the study will be completed in two steps. As the first step we will estimate the efficiency scores of individual DMU's as well as of the groups of DMU's. At the second stage we will analyze the influence of several factors of interest on the technical efficiency scores. Thus, in order for this section to more comprehensive we split it into two parts. In the first part we describe the data we will employ at the first stage, while the second part will contain the description of the variables we use at the second stage.

For the empirical estimation of the model we will use the data on "input-output" variables. We consider the "conventional" division of Ukraine into 24 oblasts, Autonomous Republic of Crimea, cities: Kyiv and Sevastopol'. As an indicator of output for each region we take Gross Value Added (GVA), which constitutes the difference between gross output and intermediate consumption. Labor and Capital will be used as inputs in the model. Labor variable is measured as the product of employment in all areas of economic activity and average monthly compensation. Finding an indicator, which will give us a good representation of capital, may be a tricky process. One of the possible ways is to proxy the value of capital with fixed capital investment less depreciation, which closely relates to it and use a "Perpetual inventory method" in order to construct the capital stock series. Fortunately, we are able to recover the value of capital stock as collected by the Statistical Committee of Ukraine, although it is not perfect, it is thought to be the closest in representation of the variable we need, since it includes the value of operating and non-operating capital. All the variables are calculated in millions of Ukrainian Hryvnya. Statistical Committee of Ukraine provides information on GVA, Labor and Capital in nominal terms, therefore we use the data on inflation, provided by the National Bank of Ukraine, to deflate the series and present them in prices of the year 1996. Seven-year span (1996-2002) widens our sample to 189 observations.

It is important to note that our observations start with year 1996, due to the fact that the Statistical Committee began to collect data on GVA only in that year. Another good reason for starting the analysis from 1996 is that Hryvnya, the national currency, was introduced in 1996 and the rate of inflation stabilized.

Table 1. General Data Description

	Obs	Mean	Median	St. Dev.	Min	Max
Input Variables						
Capital (mln. UAH)	189	21699.4	16012	17006.45	2579	94582
Labor (mln. UAH)	189	106.96	73.9	85.36	20.15	439.86
Output Variable						
Gross Value Added (GVA) (mln. UAH)	189	2767.7	1846	2454.44	284	16847

Table 1 summarizes the general descriptive statistics of the variables. One can observe from the data that capital across regions is very different, while labor is not. This means that in general regions have rather big difference in capital stock they own and due to the fact that the state is a major employer in the country labor cost is less volatile. Through the course of the years we see some change in the volatility of the two variables, although the change is experienced in different directions. The volatility of capital diminishes, most likely due to the depreciation and low level of investment, while labor becomes more volatile as salaries in the country increase drawing closer to the cost of living. We also observe a drop in capital stock over the year, which is due to the fact that a substantial amount of capital was depreciated, while capital investment did not cover the depreciation. Regional output is rather stable, with Donets'ka oblast' producing a lot and Chernivets'ka oblast' producing little. We also see the rise in volatility starting with the year 2000, when a resource export driven production of eastern regions increased dramatically. Table 1, presented below provides a good summary of the statistics and serves as generalization of the data.

One of the major issues of our research is to compare the economic development of Ukrainian regions through the ability to utilize the available resources and produce the greatest amount of output possible. In order to do so, we divide the regions into two subgroups. There are a number of ways to divide the regions, i.e. according to the geographical location, nature of output, etc. In our research we will consider to divisions. Fist, division according to the nature of output, in other words due to dominating agrarian or industrial share of output. When we take a look at the yearly data of the regional output type we are able to identify the agrarian – industrial regions, although some regions exhibit clear pattern of output type others change it from year to year. We tackle this problem in the following way – we choose the type of output that dominates through the range of years. By doing this we are able to compose two groups. Second, division is made according to the covenant between Russia and Poland in 1667 due to which Right Bank Ukraine became part of Poland, while Left Bank Ukraine remained under the reign of Russia. It is worth noticing that groups in both divisions contain approximately the same number of units.

At the second stage we want to analyze the dependence of the estimated technical efficiency scores on the variables, which are thought to influence the abilities of people, as well as variables, which may influence the efficiency of a separately taken region. In our estimation to the variables that influence the ability of a person belong alcohol and cigarettes consumption. These variables are taken from the surveys of consumption patterns conducted by the Statistical Committee of Ukraine. From the data we observe a rather high volatility of foreign direct investment. This observation is due to the fact that the distribution of investments around the country is not normal. FEZ and PT are quite attractive to foreign capital. Criminality in the country is also unevenly distributed. High crime rate is observed in eastern regions of Ukraine, where social problems have more economic background than those in central or western Ukraine.

Table 2. Independent Variables Description

	Obs	Mean	Median	St. Dev.	Min	Max
Alcohol Consumption (mln. UAH)	108	2.73	1.83	2.11	0.61	10.18
Cigarettes Consumption (mln. UAH)	108	2.44	1.72	1.79	0.48	9.16
Criminality (number of crimes, thou)	108	18.78	14.05	14.25	3.60	65.60
Number of Students in Higher Education (thou. pers)	108	54.84	28.60	60.19	10.20	322.40
Foreign Direct Investment (mln. UAH)	108	21.63	6.20	50.22	-34.90	307.20
Population Density (number of people per sq.km)	108	209.80	72.04	607.00	39.04	3272.88

Density of population is higher than the average in eastern and western parts of the country. Density decreases in the course of years. Major source of the decrease is depopulation. The number of students involved in higher education studies is concentrated around scientific centers of Ukraine. The biggest shares of students from the whole student population are located in Kyiv and Kharkiv.

Despite the fact that we have a rather good data set one should be aware that we use only the official statistics provided by the government. Many economists argue on the size, but agree on the existence of the shadow economy in Ukraine. Johnson et al. (1997) find that the unofficial economy in Ukraine accounts for approximately 49%, which means that if all the economy operated officially the GDP of the country would be almost twice as big. Later, Johnson et al. (1999) find the improvement of the economy and conclude that almost 41% of the economy is in the shadow. Schneider (2002) finds that the informal economy in Ukraine is as big as 52%. From these facts we can conclude, that about a half of the Ukrainian economy is in the shadow. It is impossible to state which part of the economy is "hiding" – more or less efficient one. Knowing this and having only official statistics at our disposal we explicitly declare that our research concerns the "visible" part of the economy. We also assume that shadow activities are evenly distributed among the regions; otherwise we will be not able to compare the results with high confidence.

At the first stage we will estimate the efficiency scores of oblasts using the DEA method. Later we will correct the scores for bias and compare them.

The choice of the model's orientation usually depends on the object under study. It is possible to consider two types of orientation: input and output. Input orientation is used in the cases when one wants to find, given constant output, by how much input(s) can be decreased in order to receive the same amount of output(s). On the other hand, output orientation gives us the information on by how much the output(s) can be increased using the fixed given amount of input(s). In our research we will employ output orientation, since we are interested in the growth of production not in the rate of saved inputs.

Second, we define the return to scale under which our DMU's operate. CRS is a common assumption used in economic theory and empirics. The choice of CRS gives us greater discriminatory power of the DEA, the fact that will be used later.

We consider the technology used in the year 2002 as a reference technology, comparing to which all our units operate. We would like to find out whether oblasts in different time periods were close to the frontier of the year 2002. We calculate the efficiency scores for each oblast' during separate years and also aggregate efficiencies of the groups during these time periods. Taking into the account the fact that some oblasts' can be the outliers in the sense that they have and extremely high level of output, while having an average amount of inputs, we define two models in which Kyiv and Sevastopol' cities are excluded from the estimation (Model 1). This way we are able to compare the efficiencies of regions only, with no outside influence of state important cities. In Model 2 we include all observation in order to find out the efficiencies of all the DMU's operating in the country. Within each model, when comparing the groups of regions we assign the regions, as described in the "Data Description" section, into Agrarian vs. Industrial regions groups and Right Bank vs. Left Bank of Ukraine regions groups.

Table 3. Model specification

Model	DMU's	Groups
Model 1	Without observations for cities Kyiv and Sevastopol'	Agrarian vs. Industrial Right Bank vs. Left Bank Ukraine
Model 2	All observations	Agrarian vs. Industrial Right Bank vs. Left Bank Ukraine

After obtaining the efficiency scores and correcting them for bias we are ready for the second stage evaluation. At this stage we will analyze the dependency of the efficiency scores we obtained at the first stage on human and region specific factors. We hypothesize that to human specific factors that influence the efficiency belong alcohol and tobacco consumption, while to region specific factors belong criminality level, yearly FDI, number of students involved in high education and density of population. We expect negative impact of alcohol and tobacco consumption, as well as criminality on the efficiency levels of the regions, while foreign direct investment, number of students and density of population are thought to have a positive influence. We employ Algorithm II proposed by Simar and Wilson (2002).

4. Results

4.1. Stage One – Efficiency Scores

First of all we estimate the efficiency scores of Ukraine's regions under the assumption that technology of 2002 is used in the production process. We set this technology as a reference point to which we compare the performance of regions. Appendix A lists all DMU's efficiency levels under Model 1. We notice that the majority of regions are substantially below the frontier and exhibit high levels of inefficiency. The regions that define the frontier are Poltavs'ka oblast' in year 2000, Volyns'ka oblast' in years 2001 and 2002 and Zakarpats'ka oblast' in 2002 (note that Poltavs'ka oblast' in 1999, Volyns'ka in 2000, Vinnyts'ka in 2001, Donets'ka and Odes'ka oblast's in 2002 are close to the frontier). When we estimate the scores for each separate year (see Table 5) and find that Poltavs'ka oblast is the one that defines all the frontiers, except for 2001, when it is very close to the frontier. As we see the regions that define the frontier in year 2002 also define the overall, pulled efficiency frontier.

In the Model 2 (Appendix B) we see change of the DMU defining the overall frontier, i.e. city Kyiv. A year-by-year analysis allows us to say that Kyiv is also the major determinant, together with Poltavs'ka oblast', of the frontiers during these years. Other units exhibit even greater inefficiency compared to the one in Model 1. It is worth noting that some small agrarian regions, such as Volyns'ka, Zakarpats'ka, Zhytomyrs'ka oblasts define frontier. And most of the cases big and rich industrial regions are inefficient with the respect to the frontier. This somewhat unexpected result should not be interpreted as a drawback of the DEA method. On the contrary, the advantage of the method is such that it allows comparing different types of units. And the fact that agrarian regions are better in terms of efficiency does not imply higher well being of the regions population. It means that regions with higher efficiency are able to utilize the resources at hand the most optimal way.

Now let's look at what characterizes the nature of output of each efficient region in order to draw more reliable conclusions. Шаблій (2000) provides the best socio-economic description of Ukraine as a whole and its regions in particular. We will follow his work together with personal knowledge in describing the situation in regions that are found to be defining the frontier or close to it.

Table 4. Regions of Ukraine Defining the Frontier or Close to it (Model 1).

1996	On the frontier	Zhytomyrs'ka, Poltavs'ka, Khmel'nyts'ka
	Close to the frontier	Zaporiz'ka, Kyivs'ka, Cherkas'ka, Chernihivs'ka
1997	On the frontier	Poltavs'ka, Khmel'nyts'ka
	Close to the frontier	Zaporiz'ka
1998	On the frontier	Poltavs'ka
	Close to the frontier	Vinnyts'ka, Kyivs'ka, Khmel'nyts'ka, Chernihivs'ka
1999	On the frontier	Poltavs'ka
	Close to the frontier	Vinnyts'ka, Zakarpats'ka
2000	On the frontier	Kyivs'ka, Poltavs'ka
	Close to the frontier	Vinnyts'ka, Volyns'ka, Zakarpats'ka
2001	On the frontier	Vinnyts'ka, Volyns'ka
	Close to the frontier	Donets'ka, Zakarpats'ka, Kirovohrads'ka, Poltavs'ka
2002	On the frontier	Volyns'ka, Zakarpats'ka, Poltavs'ka
	Close to the frontier	Donets'ka, Odes'ka

Zhytomyrs'ka oblast', located in the Northern part of the country possesses rich, high quality soil that determines its specialization. In agriculture the main products are: long-fibred flax, sugar beet and cereals. Meat and milk production and processing plays an important role in the region. Machinery building, chemical and wood processing are the main drivers of industrial production of the region. Also one of the most valuable assets is the location of titanium ore mines near Irshans'k. Being the region with low density of population - 48 people per sq. km with average in Ukraine 85 p. sq. km the Zhytomyrs'ka oblast has lost its advantage since 1996 and today is one of the most inefficient regions in the country. **Poltavs'ka oblast'**, which defines the frontier in both models, is a developed industrial region. Oil and gas are the regions most valuable resources. Poltava – centre of the region has a number of country important sites: Poltavs'kyj ore mining and processing plant, artificial diamonds and cutting diamond instruments plant, light bulb plant, etc. Electrical engines, turbines, agricultural machinery are also produced here. Sugar-, vegetable oil-, meat-processing plants are located in the city. Light industry is developed across the region. City of Kremenchuk is an important iron ore source of Ukraine, but is important not only for this. Famous truck building plant KrAZ is located here. One of the six major oil processing plants and cart building factories are situated in the city premises, technical carbon and wood are produced here as well. The highly capitalized oil and gas extraction and processing facilities as well as machine building and food processing enable the region to produce the highest possible amount given the inputs. **Khmel'nyts'ka oblast'**, the major asset of the region is a nuclear plant with two blocks put into operation. Together with Rivnens'ka AES (second nuclear power plant in western Ukraine) it is one of the biggest energy suppliers in the area. Hydroelectric station is located in the south. Construction materials, machinery building and energy processing are the main industrial specialization. The region also has a developed light and food industry. Khmel'nyts'ka oblast' defined the frontier until 1998 and later operated slightly above the average. This is most likely due to the fact that people, in the search of better life moved from the region, as well as the capital deteriorated and was not replaced by the new one. The production in **Volyns'ka oblast'** is characterized by a number of features. Industrial production is concentrated around machine and automobile building, coal mining, construction materials, wood processing. On agrarian side of production long-fibred flax, hops, potatoes, milk and meat are the major products the region produces. As we see the region became the one defining the frontier only in years 2001 and 2002 (in pulled case), before this period the region exhibited average efficiency. Although, when we estimate the scores on the yearly basis, the efficiency is always close to the frontier. Unfortunately we can not claim the same when we include Kyiv and Sevastopol' into the model. This observation can be explained by the fact that the region utilized its natural resources, i.e. forests, coal, etc. and later (1998) became an investment site; we do observe the same pattern in Model 2, although because the level of input output ratio is higher in Kyiv, Volyns'ka oblast' is not on the frontier. Distinctive feature of **Zakarpats'ka oblast'** is its location. The region borders with Poland, Slovakia, Hungary and Romania. The region was always famous for its agriculture, especially wine. Agricultural production dominates the production patterns of the region. The industry is represented by hydro-electricity generation, wood processing and extraction of a wide range of mineral resources, such as gold, salt, marble, mineral dyes, etc. Machinery building is located in Mukachevo. In 1998 a major Czech car making company "Škoda" opened its assembly plant in the region. Being mostly the "extraction" region with the inexpensive production Zakarpats'ka oblast draws near the frontier in 1999 after the Cabinet of Ministers of Ukraine defined the priority sectors of economy with privilege conditions for investment in the region and in 2002 turns into one that defines it. Although being small it gives way to Kyiv and Poltavs'ka oblast in Model 2. **Zaporiz'ka oblast'**, is one of the highly developed regions of central-eastern Ukraine. The biggest Ukrainian energy supplier Zaporiz'ka AES is located here, as well as two hydro-electric stations situated on the Dnipro River. Factories such as "Zaporizhstal'", "Dniprospetsstal'", ferroalloy, aluminium, and titanium-manganese are the core of Ukrainian metallurgical industry. Transformer, engine building and electric instrument plants are situated in Zaporizhzhya. Big cable plant "Azovkabel"' and diesel factory operates in the south of the region. Although the region is never on the frontier, it has been close to it at the beginning of our observation period. The fact that so highly capitalized region, with high scientific potential is decreasing in efficiency can be explained by the following statement – the bigger part of the economy of highly industrialized regions is hiding in the shadow (for instance see Міхов (2003)). This fact enables us to claim that highly industrialized regions will exhibit less than fully efficient level of production, because of the shadow operations the producers are involved in.

Table 5. Regions of Ukraine Defining the Frontier or close to it (Model 2).

1996	On the frontier	Zhytomyrs'ka, Poltavs'ka, Kyiv
	Close to the frontier	Zaporiz'ka, Kyivs'ka, Khmel'nyts'ka, Cherkas'ka, Chernihivs'ka
1997	On the frontier	Poltavs'ka, Kyiv
	Close to the frontier	Zaporiz'ka
1998	On the frontier	Poltavs'ka, Kyiv
	Close to the frontier	-
1999	On the frontier	Poltavs'ka, Kyiv
	Close to the frontier	-
2000	On the frontier	Poltavs'ka, Kyiv
	Close to the frontier	Volyns'ka, Kyivs'ka
2001	On the frontier	Kyiv
	Close to the frontier	-
2002	On the frontier	Kyiv
	Close to the frontier	-

Vinnyts'ka oblast', which exhibits the efficiency of close to unity for three years and then moves to the frontier in 2001, is a region with clearly distinguishable agrarian output. Agricultural, as well industrial production resembles that of Zhytomyrs'ka oblast'. In the regions capital – Vinnytsya machinery building is highly developed (electrical engineering, instruments, bearings, spare parts to tractors and grain harvesters). Chemical industry is represented by Super phosphate plant, which supplies the fertilizers to several regions of the country. In 1998 first state weapon manufacturing plant was opened in Vinnytsya. The riches of local soil and agricultural machine building supported by the state authorities (for instance see Presidential Decree "On the Simplification of Taxation to small businesses and agricultural producers" (1998)) enable the region to produce close to the 'best practice' frontier. **Donets'ka oblast'**, is a powerful regional production complex with specialization in coal, black metallurgy, chemical and petrochemical, by-product-coking industry, machine building (heavy engineering) industries and industry of construction materials. Agriculture in Donets'k is suburban. Agriculture is more developed in the southern part of the region.Approximately 35% of Ukrainian power stations use Donbas coal, Шаблій (2000). "Donbasenergo" company produces approximately 30% of all energy of the country. One of the biggest metallurgical works is the Yenakievo metallurgical mill. Mercury mill is located in Mykytivka. Shipbuilding is developed in Mariupol', Notorious "Azovstal'" and "Zavod imeni Illicha" operate in Mariupol' premises. A unique fluorite[2] deposits in Europe are located near Donets'k. As one can conclude the region is highly industrialized, but draws to the frontier only in year 2001. In order to explain this fact we can use the argument about the shadow activities (see explanation in Zaporiz'ka oblast' case). Although is it also known that the level of depreciation of capital in black metallurgy at the moment constitutes approximately 57%, Шаблій (2000). The level of investments is above the country's average, but is not sufficient to recover the capital used. Wage arrears in coal industry are the highest among other industries in the economy (Ukrainian Economic Tends). Due to these negative developments, Donets'ka oblast comes closer to the frontier, since there is "less mouth to feed" and the prices of metal and coal on local and world markets were extremely favorable. **Odes'ka oblast'** is the major maritime region of the country. Harbors of Odesa and Illichivs'k are of international importance. Agricultural sector is concentrated around wine, sunflower, tobacco, sugar-beat, vegetable oil production**,** sea fishing. Industrial production Oil refinery, agricultural and industrial machine building, ship repairing determines the industrial production of the region. In the capital of the region – Odesa light industry factories, drugs plant, steel cable plant are located. Although the major part of region's income comes from recreation and tourism. Highly developed facilities and infrastructure for running such business together with growing wellbeing of Ukrainian and FSU countries' citizens, who visit Odes'ka oblast' enabled the region to draw closer to the 'best practice' frontier and in general case even define it. Rich black soil, near Dnipro river position, as well as lignite deposits determine agricultural and industrial production patterns of **Cherkas'ka' oblast'**. The region has a developed energy sector to which belong lignite extraction and processing facilities as well as Kanivs'ka hydro-electric station. Sunflower, sugar-beet, cereals production dominates the crop production part of agriculture, while cattle and sheep rearing define the cattle-raising part. Cherkasy plant of nitric fertilizers belongs to the major suppliers of fertilizers in the northern part of Ukraine. Being one of the smallest regions located near the capital the region supplies its labor resources to more developed regions, thus leaving itself without one of the production factors and positioning itself behind the production frontier. Oil and gas belong to the main resources of **Chernihivs'ka oblast'**. Big synthetic fibers production plant and a big worsted industrial complex

[2] Used for obtaining precious non-ferrous metals

are situated in **C**hernihiv area. In agricultural and industrial output it resembles Zhytomyrs'ka and Vinnyts'a oblasts. Pryluky cigarette plant is the major producer of cigarettes in Ukraine. Despite the fact that the region possesses the deposits of oil and gas the region moves away from the frontier in the course of time. We can explain this by the fact that all extracted energy sources are processed in Poltavs'ka oblast', non-modernized facilities do not allow for the efficiency improvement, but on the contrary draw the scores downwards. In **Kirovohrads'ka oblast'** agriculture is oriented on grain, sugar-beat and sunflowers production. The region has highly developed food industry: 10 sugar processing plants, Kirovohrad sunflower seed oil industrial complex, number of meet processing and vegetable oil plants, confectionery; flour, spirit and bread baking plants. Closely relate to agriculture industrial facilities - repair factories for agricultural machinery across region and agricultural machines and supplies plant in Kirovohrad. Lignite and graphite production characterize the extraction sector. Major Ukrainian Nickel plant operates in the west of the region. Being the agrarian region, Kirovohrads'ka oblast' has more than 85% tillage land (optimal tillage should not exceed 75%), Шаблій, 2000, meaning that this resource is used inefficiently. The recovering industrial production, shifted the overall efficiency upwards and Kirovohrads'ka oblast' shifted closer to the frontier in 2001. The biggest regional complex was formed in the center of Ukraine - on the territory of **Kyivs'ka oblast'**. Major industrial production is concentrated around machinery building, chemical, food and light industry. In agricultural sector more than 20 sorts of cereals, flax, sugar-beet and potatoes are cultivated, meet and milk production is one of the highest in the country Шаблій (2000). Power generating facilities are represented by Chornobyl's'ka AES and Kyivs'ka HES. The most important driver of the economic development of the region was and is Kyiv. The companies, which come to Kyiv and want to establish their operations in Ukraine, find it more appropriate to locate their production facilities in the region (for instance Coca-Cola Co.). Kyivs'ka oblast' has exhibited efficiency levels close to unity and in year 2000 it defined a part of the frontier. Although in model 2 it is dominated by Kyiv, the location of the region is very close to the frontier. **City Kyiv** – capital of Ukraine is one of the highly developed cities in the country. It is characterized by "skilled" production: precision engineering (aircraft building), mechanical engineering. Well developed chemical industry (for example biggest drug producing plant), food and light industry. National Academy of Sciences, number of research institutions, institutes of higher education, high schools and other institutions are located in Kyiv. All the cities in the oblast "concentrate" around Kyiv. Another important feature of Kyiv is that it is a "construction site" and is constantly growing. Being the capital – Kyiv has all the advantages and what is more important is able to utilize them the most efficient way, when included into the model (Model 2) it is the only unit that defines the frontier in all years. In the pulled data efficiency estimation Kyiv of year 2001 has the score of one, while Kyiv of year 2002 already has a lower score. This is due to the fact that relatively to year 2000 in 2001 output increased by 80%, while capital increased by 20% and labor by 29%; and in year 2002, relatively to the year 2001 output increased only by 30%, while capital increased by 25% and labor by 24%.

Before we continue, let's make some comments to the results presented above. First of all the regions described do not stand apart from each other. Zhytomyrs'ka, Vinnyts'ka, Cherkas'ka, Chernihivs'ka and Kyivs'ka oblasts constitute Central economic region of Ukraine. Volyns'ka, Zakarpats'ka and Khmel'nyts'ka oblasts constitute part of the Western economic region of Ukraine. Another important observation is that except for Kyivs'ka and Khmel'nyts'ka all other oblasts' are of the agrarian type production patterns.

Since the regions are interconnected some of the problems which exist in the current situation apply to all of them. There is a huge number of problems, but to name just a few: 1) Central economic region is influenced by the results of Chornobyl' problem: younger generation moves from the regions in Kyiv direction, while older people move in, which creates a problem of depopulation of the regions. 2) Western economic region experiences the migration of rural residents into cities. Since the area has the urbanization level below the Ukrainian average Шаблій (2000) there exists a threat of depopulation. 3) L'vivs'ka oblast' being the scientific and economic center of Western economic region of Ukraine experiences a high outflow of high skilled labor, the region supplies the biggest share of modern "ostarbeiters" to European countries. A high level of remittances which are deposited in the western region banks are transferred to "more profitable" regions, where investments bring higher payoffs, thus leaving the region without most important resources, which in turn may drive the efficiency down. 4) Eastern region of Ukraine experiences problems with highly depreciated capital and old technologies. The coal extracted costs not only the price of inputs used but also dozens of miners lives. Pollution is the major cause of diseases in the region.

In order to improve the economic life of some regions Ukrainian president together with Cabinet of Ministers and Verkhovna Rada decided to establish Special (free) Economic Zones and Priority Territories with advantages for the investors compared to those investing somewhere else in the country.

Now let's compare the efficiency scores of the regions where SEZ or PT were established. We will use the common interview question: "Where do You see yourself three years from now?", with only modification – we check the difference in one, two, three, etc. years from the date SEZ or PT was established. Table 6 presents the list of regions where the SEZ and PT are located. Appendices H and I list the efficiency scores of each oblast' for two pulled years. It is worth noting that the change can be driven by other factors we do not account for, but this will be tested later using the truncated regression (see section Truncated Regression Results), thus by saying that the introduction of FEZ of PT has lead to the improvement of efficiency we mean that "possibly" it was the cause of change (we believe this is the truth). A usual assumption applies that the regions operate under the same technology frontier in the sample. We also run the estimation for two specifications. Here we present the results and explanation for the Model 1 starting with the earliest SEZ – "Syvash" in **AR Crym**. The efficiency score of the region improved with years and started declining after year 2000 while compared to the year 2002 it dropped by 4 percentage points. This drop is possibly due to the decree of Cabinet of Ministers of Ukraine issued in year 2000, by which all foreign currency operations were controlled by the government. The introduction of "Port Krym" as a FEZ in 2000 has lead to the improvement of efficiency in the following year, but diminished in two years. **Donets'ka oblast'** after the introduction of FEZ "Donetsk" and "Azov" as well as PT in Donets'ka oblast' has experienced a dramatic improvement in efficiency in one and two years in 2000 the improvement constituted 50%, although in the following years it experienced a slight decline. The introduction of FEZ "Slavutych" in 1998 caused the efficiency of **Kyivs'ka oblast'** to increase until year 2000, when it hit the frontier. Next year it dropped and didn't change after that. The drop in efficiency after such an increase was most likely influenced by the shutdown of the 3rd and the last operating block of Chornobyl's'ka AES in 2000. Introduction of FEZ "Zakarpattya" and PT in **Zakarpats'ka oblast'** positively influenced the efficiency till 2001 and reached almost 50% improvement, but the next year the improvement declined by 9% and the region turned to have the score of one, relatively to other units. This decline can be explained as a degradation of efficiency in the whole country. **L'vivs'ka oblast'** after introduction of FEZ "Yavoriv" in 1999 grew in efficiency next year, but experienced a decline in 2001, in 2002 it recovered 3% of its efficiency. When FEZ "Kurortpolis Truskavets'" was approved in 2000, the efficiency dropped by 2% and didn't change after. **Luhan'ska oblast'** saw an improvement of 9% in a year after PT was approved and remained on the same level in two years. A year after FEZ "Interport Kovel'" and PT were established in **Volyns'ka oblast'** the efficiency of the region improved by 5%, but a year later it slightly diminished and was caught by the 'best practice' frontier. In year 2000 FEZ "Mykolayiv" was set up in **Mykolayivs'ka oblast'**. It followed the pattern exhibited by other regions, i.e. in a year the efficiency rose, but in 2002 slightly declined. **Odes'ka oblast'** after the introduction of FEZ "Porto Franko" and "Reni" increased its efficiency in two of the following years. When PT "Shostka" was established in **Sums'ka oblast'** it started increasing the score of the region and reached a 12% improvement in 2002. To the regions with unfavorable experience with allocation of PT belongs **Zhytomyrs'ka oblast'**, because after the installation of the priority territory in

2000, the efficiency dropped by 11% and recovered 4% a year later (for explanation see 1) in explanations provided above).

Table 6. List of Special (free) Economic Zones (SEZ) and Priority Territories (PT)

Special (free) Economic Zones	Priority Territories
"Azov" (Mariupol') (1998)	In AR Crym (2000)
"Donets'k" (1998)	In Volyns'ka oblast' (2000)
"Zakarpattya" (1999)	In Donets'ka oblast' (1998)
"Interport Kovel'" (Volyns'ka oblast') (2000)	In Zakarpats'ka oblast (1999)
"Kurortpolis Truskavets'" (L'vivs'ka oblast') (2000)	In Zhytomyrs'ka oblast' (2000)
"Mykolayiv" (Mykolayivs'ka oblast') (2000)	In Luhans'ka oblast' (1999)
"Porto-Franko" (Odesa) (2000)	In Chernihivs'ka oblast' (2000)
"Port Crym" (AR Crym) (2000)	In Kharkiv (2000)
"Reni" (Odes'ka oblast') (2000)	In Shostka, Sums'ka oblast' (2000)
"Syvash" (AR Crym) (1996)	
"Slavutych" (Kyivs'ka oblast') (1998)	
"Yavoriv" L'vivs'ka oblast' (1999)	

Source: Kabinet of Ministers of Ukraine (www.kmu.gov.ua)

Kharkivs'ka oblast's score, after the introduction of PT "city Kharkiv" in 2000, experienced a decline of 4% in one year span but later recovered 3%. A PT created on the territory of **Chernihivs'ka oblast'** caused a 21% decline in efficiency of the region. The next year score improved by a percentage point. We will not present the results of the Model 2 estimation for the reason that the patterns of score movement between the years are preserved even after inclusion of Kyiv and Sevastopol' into the estimation.

From the description of the possible influence of FEZ and PT introduction on the regional efficiency scores we clearly see one interesting pattern, i.e. FEZ and PT induce positive changes in the efficiency scores (if they do).

Finally, the results presented above are biased, thus the conclusions about the true scores will be obtained after we perform a bootstrap-based bias correction of all individual DEA scores.

4.2. Bootstrap-based Bias Corrected DEA Scores

In order to continue with bias correction via Simar and Wilson (1998) smooth homogeneous bootstrap technique we need to make certain assumptions about the distribution (density) of estimated efficiency scores. There is a possibility that our assumption is inappropriate and group-wise heterogeneous bootstrap would be more efficient in this situation, and then the homogeneous bootstrap is inconsistent. To test the equality of densities of groups we employ

Simar and Zelenyuk (2004) adapted Li (1996) test. The results of the test are provided in Appendix E. Since we have little samples to compare, the test gives the p-values such that we do not reject the null hypothesis about equal distributions of group efficiency scores. We observe the fact that on average the densities come from the same distribution, with the exception of Right and Left bank Ukraine efficiency scores distributions in years 1998, 1999 and 2002 for which we reject the null hypothesis at 5%, 4% and 3% confidence intervals. It is possible to compare the densities of groups on the basis of the pulled observations and then make the conclusion about yearly distributions, but the p-values for pulled data provide us with the same information, meaning that the groups indeed come from the same distribution. This justifies the choice of homogeneous bootstrap. As we expected the bias corrected scores exhibit lower level of efficiency and the regions which operated on the boundary now fall below the frontier. The overall efficiency of regions has diminished by 7% on average.

4.3. Density Distribution Analysis

Now let's turn to the examination of density distributions, which may shed light on the patterns of efficiency development in the country. In constructing the nonparametric densities we act according to the following scheme: first, we correct for bias the estimated efficiency scores using bootstrap technique; second we estimate densities using the reflection method, with Gaussian kernel and bandwidth selected according to Sheather and Jones (1991) method. At the beginning we estimate the densities of the whole economy and later we do that for groups of regions (agrarian vs. industrial and right bank vs. left bank Ukraine). Appendix G contains the results of estimation which provide evidence of no significant difference between the distributions of efficiencies across the country (Model 1), although the results obtained for Model 2 show a drastic change in the distribution of efficiency in year 2001, which is supported by Li (1996) test (Appendix E). This means that when all the regions are considered together there is a clear sign of overall lagging behind within the country, the explanation might be found in the fact that Kyiv being the center of economic activity significantly departs from other regions in terms of efficiency. Next we consider the groups of regions and also observe no substantial differences between the groups. Agrarian and industrial regions are on average the same, meaning that they operate at the same level of "inefficiency", a word more appropriate in this case. Similar picture is with the Right vs. Left bank Ukraine, where both groups differ insignificantly from each other, the fact that may be caused by similar distribution of productive facilities among regions, as well as stagnation of the same industries among regions. It is worth noting that some of the regions improved efficiency, while others have deteriorated, but in general the distributions remained the same. This fact points to the conclusion of no 'Catching-up within the groups' as well as between the groups. Li (1996) test shows no significant difference, because it has very low power in small samples, which is exactly our case.

4.4. Aggregate efficiency Analysis

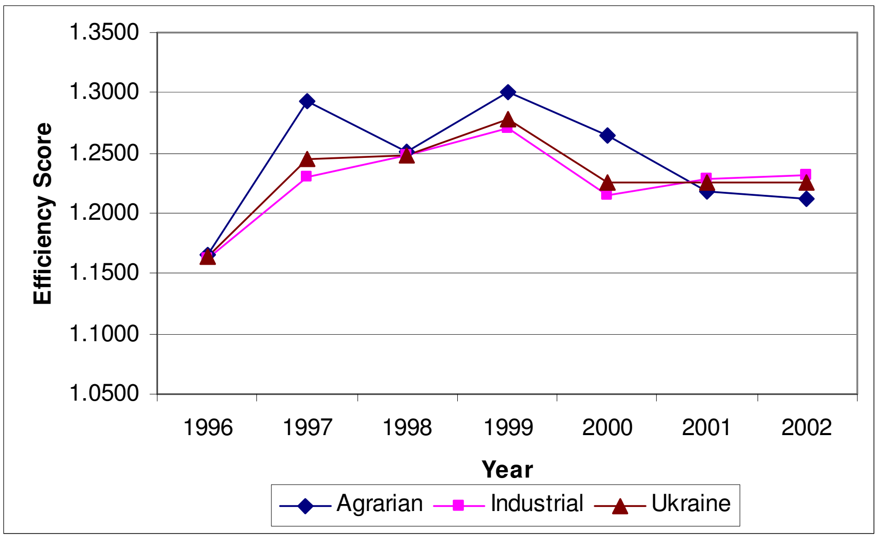
Being sceptical about the power of Li(1996) test in small samples and bearing in mind the main purpose of this study we assume that agrarian and industrial regions, as well as Right bank and Left bank Ukrainian regions are indeed different from each other, meaning that they may have different distributions of efficiency. We use the group-wise heterogeneous sub-sampling bootstrap in order to find out the differences between the groups of regions. Appendix F provides the results for Model 1 and Model 2. The common perception that industrial regions are more efficient than agricultural is supported by the results we have obtained; this is true for the whole period under study. We also find that Right bank Ukraine on average has similar efficiency level as the Left bank Ukraine. Estimated group efficiencies of both divisions are not statistically different from unity; we cannot reject the null hypotheses (at 5% confidence level) that the groups of regions are efficient.

Interesting fact is revealed by the bias corrected efficiency scores of the agrarian and industrial groups – the weighted means reveal higher efficiency of the country as a whole than that of non-weighted means. This is due to the fact that the weight of industrial regions, which are more efficient, in the entire sample, is approximately 70%.

When we analyze the development of estimated weighted average efficiency of the industrial group we see a clear pattern of growth of the statistic. We also reject the hypotheses that the efficiency score is not different from unity. The same observation is true for Left bank Ukraine in Model 1 specification. Similar patterns are exhibited by all groups under Model 2 specification. Although confidence intervals for $R\hat{D}$ statistic overlap unity, meaning that there is no significant difference in efficiencies between the groups.

An interesting fact is observed in the case of agrarian and industrial regions groups in Model 1. There is a clear path of convergence in years 1996-1998 and 1998-2001. A number of measures to prevent the financial crisis spillovers were taken in 1998. These measures comprised of stimulation of production and exports, limitations of imports, support of national agri-business companies (UET). Agricultural producers received cheap credits as well fertilizers and gasoline from the government (UET). This support substantially decreased the costs of agri-businesses making it more efficient. In year 2000 a series of agriculture support measures were taken by the parliament, government and president (for instance a major agricultural development program was initiated by the Ministry of Agricultural Policy in July 2000). Although in general we cannot distinguish between the groups of regions, the only time period we are able to so is year 1998, when the groups exhibit similar patterns in efficiency, we still can claim that in the country that experienced a substantial downturn in production and started recovering only in year 2000, the production patterns were not tuned up yet and majority of regions independently of location or production specialization operates equally inefficiently with the exception of regions which were "blessed by nature" and possess valuable and easily extractable resources.

Figure 1. Bias Corrected Weighted Average Efficiencies



4.5. Truncated Regression Analysis

Finally our analysis advances to the parametric estimation, namely the estimation of human and regional factors influence on the efficiency scores of Ukrainian oblast's. Table 7 presents results of regression analysis. For the sake of robustness of our claims, we have tried four specifications. First specification includes six regressors: constant term, regional dummy, log of Criminality, FDI, log of the number of Students, log Density of population. For this model, the bootstrap confidence intervals show no significance of regional dummy even at 10%. Thus later we estimated the models without these variables. It is worth noting that all the specifications return similar results suggesting that the same unambiguous conclusions can be made.

First of all no significance of regional dummy supports our previous conclusions about the same distribution of efficiency scores across regions independently of its production patterns.

Foreign direct investment into the region has an expected positive impact on efficiency. It implies that indeed FEZ or PT with foreign investment are expected to be more efficient compared to other regions were there is small or no FDI.

Not surprisingly the number of students in each region does not influence the efficiency; only in one of the specifications it turns significant at 10% level with expected negative sign, suggesting that with more students the region will be more efficient. Why the result is not surprising? Students are able-bodied people out of the workforce. Although when they enter the workforce are expected to be more efficient than people with lower level of education.

The results of the regression suggest that the more densely populated region is less efficient compared to other regions. This result may serve as an explanation to the fact that most of the Western Ukraine regions, which are densely populated, have low efficiency scores.

Table 7. Results of Truncated Regression Analysis

Independent Variable	Estimated Coefficients			
	Spec. 1	Spec. 2	Spec. 3	Spec. 4
Const	1.5799*	1.1374*	1.4017*	1.3192*
Industrial	0.0754	-	-	0.0850
Agricultural	-	-	-0.0844	-
Log (Alcohol)	0.1251	0.0443	-	-
Log (Criminality)	-0.1800***	-	-0.1279***	-0.1292***
FDI	-0.0037*	-0.0040*	-0.0036*	-0.0036*
Log (Students)	-0.0604	-0.1260***	-0.0171	-0.0167
Density	0.1934*	0.2600*	0.2048*	0.2053*
σ^2_{ε}	0.0785*	0.0820*	0.0803*	0.0808*

Notes: (i) The regressand is the bootstrap-bias-corrected DEA estimate of the unobserved *inefficiency score* of region j
(ii) *, **, *** - significance from zero at 1%, 5%, 10% level, according to bootstrap confidence intervals
(iii) Estimation according to Algorithm 2 of Simar and Wilson (2003), with 1000 bootstrap replications both for bias correction and for confidence intervals of the estimated regression coefficients

Finally we observe one very interesting result. Criminality, significant at 10% level (in all specifications), exhibits positive influence of on the efficiency level. This result enables us to conclude about the presence of, let's call it the "fear factor" in the economic activities. Meaning that knowing about the possibility of being robbed, kidnapped or blackmailed entrepreneurs tend to be more efficient, receive higher profits and share them, in the case of "urgent necessity" with criminals. Bigger income will deteriorate the perception of loss of its share. In simple words, given all other things equal, being obliged to pay some fixed amount of money a person with higher income will perceive the loss of this fixed amount less painfully than a person with smaller income.

Overall, the regression specifications returned quantitatively similar results, thus suggesting same qualitative conclusions.

5. Conclusions

In our study we find that the efficiency levels of regions overall are the same independently of location or production patterns. The analysis of kernel density distributions suggests that there is divergence between the efficiency levels of regions in year 2002 in one of the models.

We also find that in Ukraine to the efficient belong mostly agrarian regions with developed mineral resources extraction. In one of the specification the capital of Ukraine – Kyiv dominates all other regions and is a sole frontier defining decision making unit. This fact is due to high levels of investment by local and foreign companies into the city and high level of immigration of Ukrainians from all the country. The inefficiency of regions is mostly due to old capital stock and technology, as well as depopulation.

Truncated regression analysis supports the hypothesis of positive influence of Free Economic Zones and Priority Territories on the efficiency levels, by the fact that FDI coefficient has a negative sign, meaning positive effect on efficiency. Regional impact on efficiency distribution, as well as alcohol and tobacco consumption is negligible. The density of population is found to negatively affect the efficiency. The hypothesis of positive influence of students in the region on efficiency received small support. A so-called "fear factor" was found to be statistically significant at 10% level. This result means that people are afraid of criminals and criminality as a whole and prefer to utilize their resources more efficiently in order to be prepared when the ”urgent need" comes.

In the research we have employed two divisions of Ukrainian regions into groups, although there are many other ways to divide them, for instance regions with dominating urban vs. rural population, amount of small and medium enterprises vs. the amount of big enterprises in the region, etc. It is also interesting how the results of parametric, i.e. Stochastic Frontier Analysis, compare to the ones we have obtained in this research, although these are the topics of further studies.

References

[1] Abramovitz, Moses. (1986). Catching Up, Forging Ahead, and Falling Behind, Journal of Economic History, vol. 46, no.2, pp. 385-406.

[2] Barro, Robert J. Economic Growth in a Cross Section of Countries, The Quarterly Journal of Economics, May 1991, vol. 106, no. 2, pp. 407-443.

[3] Barro, Robert J and Sala-i-Martin, Xavier (1995). Economic Growth, - New York: McGraw-Hill.

[4] Baumol. J. William. (1986). Productivity Growth, Convergence, and Welfare: What the Long-Run Data Show, American Economic Review, vol. 76, no. 5, pp. 1072-1085.

[5] Caves, D., L. Christensen and W. E. Diewert (1982). The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity, Econometrica, vol. 50, pp. 1393-1414.

[6] Charnes, A., Cooper, W. W., Rhodes, E. (1978). Measuring the Efficiency of Decision Making Units, European Journal of Operational Research 2, 429-444.

[7] Dolishniy, M., Poburko, Y. and Karpov, V. (2002) Про рівномірність економічного розвитку регіонів України (On the equality of Ukrainian regions economic development), "Регіональна економіка", no.2.

[8] Färe, Rolf; Grosskopf, Shawna; Norris, M. and Zhang, Z. (1994). Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries, American Economic Review, vol. 84, no. 1, pp. 63-83.

[9] Färe, R. and D. Primont (1995), Multi-Output Production and Duality: Theory and Applications, Kluwer Academic Publishers, Boston.

[10] Färe, R.., and V. Zelenyuk, 2002, "Input Aggregation and Technical Efficiency," Applied Economics Letters, 9,635-636.

[11] Henderson, D. J. and Zelenyk, V. (2004). Testing for Catching-up: Statistical Analysis of DEA Efficiency Estimates, North American Productivity Workshop, University of Toronto.

[12] Kneip, A., B. Park and L. Simar (1998), A Note on the Convergence of Nonparametric DEA Estimators for Production Efficiency Scores, Econometric Theory 14, 783-793.

[13] Kneip, A., L. Simar and P. Wilson (2003b), "A simplified bootstrap for DEA estimators", paper presented at the 8th European Workshop on Efficiency and Productivity Analysis, Oviedo, Spain, September 2003.

[14] Kumar Subodh and Russell R. Robert. (2002). Technological Change, Technological Catch-up, and Capital Deepening: Relative contributions to Growth and Convergence. American Economic Review, vol. 92, no. 3, pp. 527-548.

[15] Li, Q. (1996). Nonparametric testing of Closeness between two Unknown Distribution Functions. Econometric Reviews, no.15, pp.261-274.

[16] Mankiw, N. Gregory, Romer, David, Weil, David N. A (1992). Contribution to the Empirics of Economic Growth. Quarterly Journal of Economics, vol. 107, pp. 407-437.

[17] Markova, T (2004) "An Analysis of Regional Income Disparities In Ukraine During Transition". A thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts. Kyiv, EERC.

[18] Romer, Paul (1986). Increasing Returns and Long Run Growth. Journal of Political

Economy, vol. 99, pp. 500-521.

[19] Sala-i-Martin, Xavier. (1990). On Growth and States, PhD Dissertation, Harvard University.

[20] Sala-i-Martin, Xavier. (1996) The classical analysis to Convergence Analysis, Economic Journal, vol. 106, no. 437, pp. 1019-1036.

[21] Sheather, S.J. and M.C. Jones (1991), Areliable Data Based Bandwidth Selection Method for Kernel Density Estimation, Journal of Royal Statistical Society, Series B, 3, 683-690.

[22] Silverman, B. W. (1986), Density Estimation for Statistics and Data Analysis, Chapman and Hall, London.

[23] Simar, L. and P. Wilson (1998), Sensitivity of efficiency scores: How to bootstrap in Nonparametric frontier models, Management Sciences, 44, 1, 49-61

[24] Simar, L. and V. Zelenyuk (2003), Statistical Inference for Aggregates of Farrell-type Efficiencies, Discussion Paper #0324 of Institute of Statistics, University Catholique de Louvain, Belgium.

[25] Simar, L. and V. Zelenyuk (2004), On Testing Equality of Distributions of Technical Efficiency Scores, Discussion Paper #0434 of Institute of Statistics, University Catholique de Louvain, Belgium.

[26] Solow, Robert. (1957). Technical Change and the Aggregate Production function. The review of Economics and Statistics, vol. 39, no. 3, pp. 312-320.

[27] Tsyrennikov, Victor (2002). Determinants of Regional Growth, A thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts. Kyiv, EERC.

[28] Ukrainian Economic Trends, UEPLAC. Various issues.

[29] Міхов, А. (2003). Бізнес по-українськи. www.for-ua.com

[30] Шаблій, О.І. (2000). Соціально – економічна географія України. Львів, Світ. стор. 680

[31] www.kmu.gov.ua

<u>APPENDIX A.</u> Efficiencies of Oblast's under the technology of year 2002 (Model 1)

AR Crym	1.6365	1.6127	1.6008	1.4276	1.5054	1.4126	1.5249
Vinnyts'ka	1.4092	1.4576	1.4134	1.3219	1.1379	1.0250	1.1460
Volyns'ka	1.4124	1.4500	1.3648	1.2091	1.0490	1.0000	1.0000
Dnipropetrovs'ka	1.5202	1.5439	1.4639	1.2809	1.2135	1.2601	1.2606
Donets'ka	1.5961	1.6076	1.6214	1.3449	1.2033	1.0652	1.0242
Zhytomyrs'ka	1.2390	1.3047	1.2966	1.1911	1.1231	1.2302	1.2450
Zakarpats'ka	1.8567	1.9669	1.8272	1.5063	1.2603	1.0700	1.0000
Zaporiz'ka	1.2729	1.2059	1.2168	1.1046	1.1276	1.3398	1.4609
Ivano-Frankivs'ka	1.5298	1.4686	1.3549	1.2001	1.0969	1.0818	1.1980
Kyivs'ka	1.3626	1.3573	1.2782	1.2507	1.0367	1.2010	1.1293
Kirovohrads'ka	1.4891	1.4901	1.4546	1.3904	1.2750	1.1324	1.2469
Luhans'ka	1.6415	1.5773	1.5936	1.3649	1.2776	1.3455	1.2965
L'vivs'ka	1.5506	1.6731	1.6411	1.4577	1.2736	1.3050	1.2333
Mykolayivs'ka	1.4954	1.5218	1.6433	1.4978	1.3547	1.2572	1.2182
Odes'ka	1.3251	1.3388	1.4029	1.3369	1.2191	1.1135	1.0442
Poltavs'ka	1.2499	1.1840	1.1438	1.0303	1.0000	1.0653	1.0646
Rivnens'ka	1.5140	1.5558	1.4906	1.3090	1.2280	1.1767	1.1267
Sums'ka	1.4481	1.4139	1.3629	1.3169	1.1900	1.2404	1.3419
Ternopil'sk'a	1.5132	1.6073	1.5335	1.3318	1.2181	1.1574	1.1793
Kharkivs'ka	1.5139	1.5313	1.4949	1.3815	1.3191	1.3555	1.3679
Khersons'ka	1.4548	1.4597	1.5597	1.4699	1.3174	1.2622	1.2860
Khmel'nyts'ka	1.3597	1.4041	1.4470	1.3605	1.2644	1.2283	1.1658
Cherkas'ka	1.2917	1.2781	1.2687	1.2553	1.1669	1.2444	1.3055
Chernivets'ka	1.6644	1.7199	1.7062	1.6510	1.6358	1.4689	1.3967
Chernihivs'ka	1.3687	1.3903	1.3599	1.2397	1.1554	1.3608	1.3836
MEAN							1.3446
STD							0.1850

Appendix B. Efficiencies of Oblast's under the technology of year 2002 (Model 2)

AR Crym	1,9712	1,9425	1,9281	1,7196	1,8133	1,8076	2,0463
Vinnyts'ka	1,6974	1,7557	1,7025	1,6012	1,4662	1,4920	1,7686
Volyns'ka	1,7012	1,7465	1,6439	1,4564	1,2825	1,3132	1,5309
Dnipropetrovs'ka	1,8311	1,8596	1,7633	1,5428	1,4622	1,6159	1,7668
Donets'ka	1,9226	1,9363	1,9529	1,6199	1,5301	1,4830	1,5482
Zhytomyrs'ka	1,4924	1,5716	1,5618	1,4346	1,3528	1,5484	1,7086
Zakarpats'ka	2,2364	2,3691	2,2775	1,9581	1,8590	1,8810	1,7055
Zaporiz'ka	1,5332	1,4525	1,4657	1,3305	1,3759	1,6885	1,9177
Ivano-Frankivs'ka	1,8427	1,7689	1,6320	1,4455	1,3660	1,4686	1,5767
Kyivs'ka	1,6412	1,6348	1,5395	1,5064	1,2980	1,5568	1,7669
Kirovohrads'ka	1,7937	1,7948	1,7521	1,6747	1,5358	1,3770	1,6044
Luhans'ka	1,9771	1,8998	1,9195	1,6440	1,5421	1,7379	1,8924
L'vivs'ka	1,8676	2,0153	1,9767	1,7558	1,6182	1,7822	1,8771
Mykolayivs'ka	1,8012	1,8330	1,9794	1,8041	1,7103	1,8795	2,1429
Odes'ka	1,5961	1,6126	1,6898	1,6103	1,5340	1,4849	1,6637
Poltavs'ka	1,5055	1,4262	1,3777	1,2410	1,2045	1,3586	1,4034
Rivnens'ka	1,8236	1,8739	1,7954	1,5767	1,5556	1,7436	1,9772
Sums'ka	1,7443	1,7030	1,6416	1,5862	1,4699	1,6094	1,8675
Ternopil'sk'a	1,8226	1,9360	1,8471	1,6041	1,4672	1,5065	1,6353
Kharkivs'ka	1,8235	1,8445	1,8006	1,6640	1,5889	1,6888	1,8119
Khersons'ka	1,7523	1,7582	1,8787	1,7705	1,5868	1,6417	1,9357
Khmel'nyts'ka	1,6378	1,6913	1,7429	1,6388	1,6027	1,7763	2,0037
Cherkas'ka	1,5559	1,5394	1,5282	1,5120	1,4055	1,5696	1,7857
Chernivets'ka	2,0048	2,0716	2,0552	1,9886	2,0052	1,9124	2,0616
Chernihivs'ka	1,6487	1,6746	1,6380	1,4932	1,4078	1,6391	1,7418
City Kyiv	1,9774	1,6348	1,6769	1,5237	1,4428	1,0000	1,0980
City Sevastopol'	2,9948	2,8897	3,1190	2,9905	2,8494	2,0603	1,8702
MEAN							1,7232
STD							0,2983

Appendix C. Efficiencies of Oblast's by year (Model 1)

	1996	1997	1998	1999	2000	2001	2002
AR Crym	1.3208	1.3621	1.3996	1.3856	1.5054	1.3765	1.4427
Vinnyts'ka	1.0604	1.2060	1.0084	1.0483	1.0228	1.0000	1.1460
Volyns'ka	1.1349	1.2246	1.1065	1.1531	1.0349	1.0000	1.0000
Dnipropetrovs'ka	1.2198	1.2796	1.2799	1.2432	1.2131	1.2306	1.2141
Donets'ka	1.0761	1.1800	1.1803	1.1953	1.1180	1.0508	1.0186
Zhytomyrs'ka	1.0000	1.1019	1.1337	1.1560	1.1231	1.1792	1.1887
Zakarpats'ka	1.2187	1.4160	1.1032	1.0108	1.0371	1.0055	1.0000
Zaporiz'ka	1.0233	1.0185	1.0639	1.0721	1.1144	1.2858	1.3664
Ivano-Frankivs'ka	1.2246	1.1959	1.1840	1.1455	1.0634	1.0736	1.1234
Kyivs'ka	1.0340	1.0821	1.0594	1.0728	1.0000	1.1856	1.1293
Kirovohrads'ka	1.2019	1.2585	1.2718	1.3495	1.2750	1.0486	1.1432
Luhans'ka	1.2818	1.3321	1.3933	1.3247	1.2751	1.3234	1.2701
L'vivs'ka	1.2515	1.2827	1.1990	1.2068	1.1858	1.2933	1.2302
Mykolayivs'ka	1.1991	1.2853	1.3238	1.3376	1.2809	1.2152	1.2182
Odes'ka	1.0607	1.0711	1.1802	1.1763	1.1620	1.1096	1.0442
Poltavs'ka	1.0000	1.0000	1.0000	1.0000	1.0000	1.0346	1.0000
Rivnens'ka	1.0834	1.1516	1.0607	1.1134	1.1520	1.1409	1.1267
Sums'ka	1.1622	1.1637	1.1357	1.2508	1.1628	1.2256	1.2886
Ternopil'sk'a	1.2117	1.3256	1.2073	1.2656	1.2181	1.1473	1.1308
Kharkivs'ka	1.1720	1.2525	1.3070	1.3408	1.3191	1.2860	1.2874
Khersons'ka	1.1742	1.2328	1.3433	1.4196	1.3174	1.2502	1.2765
Khmel'nyts'ka	1.0000	1.0000	1.0504	1.1429	1.1841	1.2004	1.1658
Cherkas'ka	1.0358	1.0794	1.1092	1.2183	1.1669	1.1953	1.2448
Chernivets'ka	1.3434	1.4526	1.4918	1.6024	1.6099	1.4564	1.3748
Chernihivs'ka	1.0420	1.1042	1.0440	1.0667	1.1434	1.2482	1.2411
MEAN	1.1413	1.2024	1.1855	1.2119	1.1874	1.1825	1.1869
STD	0.1052	0.1257	0.1343	0.1435	0.1468	0.1218	0.1207

<u>Appendix D</u>. Efficiencies of Oblast's by year (Model 2)

	1996	1997	1998	1999	2000	2001	2002
AR Crym	1,3208	1,3621	1,3996	1,3856	1,5054	1,8076	1,8636
Vinnyts'ka	1,0717	1,2223	1,1436	1,1821	1,1266	1,4920	1,6107
Volyns'ka	1,1349	1,2246	1,1581	1,1644	1,0468	1,3132	1,3943
Dnipropetrovs'ka	1,2198	1,2954	1,2799	1,2432	1,2134	1,6159	1,6091
Donets'ka	1,1209	1,2959	1,3214	1,2561	1,1936	1,4830	1,4100
Zhytomyrs'ka	1,0000	1,1019	1,1337	1,1560	1,1231	1,5484	1,5561
Zakarpats'ka	1,2801	1,5759	1,4302	1,3243	1,3362	1,8810	1,5500
Zaporiz'ka	1,0233	1,0185	1,0639	1,0721	1,1255	1,6885	1,7465
Ivano-Frankivs'ka	1,2246	1,2248	1,1844	1,1562	1,0915	1,4686	1,4359
Kyivs'ka	1,0434	1,1240	1,0939	1,1508	1,0309	1,5568	1,6092
Kirovohrads'ka	1,2019	1,2585	1,2718	1,3495	1,2750	1,3770	1,4612
Luhans'ka	1,2871	1,3321	1,3933	1,3247	1,2772	1,7379	1,7234
L'vivs'ka	1,2515	1,3677	1,3392	1,3218	1,2636	1,7822	1,7095
Mykolayivs'ka	1,1991	1,2853	1,3910	1,4018	1,3453	1,8795	1,9475
Odes'ka	1,0607	1,1100	1,2078	1,2433	1,2113	1,4849	1,5152
Poltavs'ka	1,0000	1,0000	1,0000	1,0000	1,0000	1,3586	1,2781
Rivnens'ka	1,1082	1,2575	1,2049	1,2002	1,2190	1,7436	1,8006
Sums'ka	1,1622	1,1835	1,1690	1,2659	1,1857	1,6094	1,7008
Ternopil'sk'a	1,2117	1,3464	1,2867	1,2805	1,2181	1,5065	1,4893
Kharkivs'ka	1,1786	1,2791	1,3070	1,3408	1,3191	1,6888	1,6501
Khersons'ka	1,1742	1,2328	1,3554	1,4235	1,3174	1,6417	1,7628
Khmel'nyts'ka	1,0147	1,1213	1,1781	1,2411	1,2549	1,7763	1,8248
Cherkas'ka	1,0358	1,0794	1,1092	1,2183	1,1669	1,5696	1,6263
Chernivets'ka	1,3434	1,4526	1,4918	1,6024	1,6317	1,9124	1,8775
Chernihivs'ka	1,0509	1,1499	1,1302	1,1422	1,1535	1,6391	1,5863
City Kyiv	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
City Sevastopol'	1,6249	1,8366	2,0121	2,1038	2,0236	2,0603	1,6997
MEAN	1,1609	1,2496	1,2613	1,2797	1,2465	1,6157	1,6088
STD	0,1399	0,1796	0,1993	0,2101	0,2104	0,2190	0,2026

Appendix E. Results of the Li-test

Agrarian (A) vs Industrial (I) Regions (Model 1)

	Test statistic	P-value
f(A) = f(I) (pulled years)	-0.3758	0.5670
f(A) = f(I) (1996)	-0.6129	0.3045
f(A) = f(I) (1997)	-0.0558	0.9395
f(A) = f(I) (1998)	-0.4441	0.5305
f(A) = f(I) (1999)	-0.0600	0.9410
f(A) = f(I) (2000)	-0.1778	0.8025
f(A) = f(I) (2001)	-0.3719	0.6080
f(A) = f(I) (2002)	-1.0700	0.0935

Right (R) vs Left (L) Bank Regions (Model 1)

	Test statistic	P-value
f(R) = f(L) (pulled years)	-0.8798	0.1485
f(R) = f(L) (1996)	-0.5927	0.3495
f(R) = f(L) (1997)	-0.4906	0.4530
f(R) = f(L) (1998)	1.4315	0.0505
f(R) = f(L) (1999)	1.5649	0.0465
f(R) = f(L) (2000)	0.9174	0.1190
f(R) = f(L) (2001)	0.6469	0.2920
f(R) = f(L) (2002)	1.7663	0.0345

Agrarian (A) vs Industrial (I) Regions (Model 2)

	Test statistic	P-value
f(A) = f(I) (pulled years)	-0.7041	0.2600
f(A) = f(I) (1996)	-0.4894	0.4190
f(A) = f(I) (1997)	-0.4767	0.4445
f(A) = f(I) (1998)	-0.4929	0.4400
f(A) = f(I) (1999)	-0.2172	0.7545
f(A) = f(I) (2000)	-0.3192	0.6340
f(A) = f(I) (2001)	-0.5940	0.3100
f(A) = f(I) (2002)	0.0346	0.9625

Right (R) vs Left (L) Bank Regions (Model 2)

	Test statistic	P-value
f(R) = f(L) (pulled years)	-0.7746	0.1955
f(R) = f(L) (1996)	-0.0775	0.9185
f(R) = f(L) (1997)	-0.5185	0.3960
f(R) = f(L) (1998)	0.1090	0.8805
f(R) = f(L) (1999)	1.0878	0.0875
f(R) = f(L) (2000)	-0.5747	0.3630
f(R) = f(L) (2001)	-0.3657	0.5960
f(R) = f(L) (2002)	-0.4724	0.4440

Appendix F. Results for Group-Wise Heterogeneous Sub-Sampling Bootstrap for Aggregate Efficiencies: Agrarian vs. Industrial Regions (Model 1)

	Estimated Score	Corrected Score	Est Bias	Est std	Lower Bound	Upper Bound
Aggregate Efficiency (A)	1.3501	1.4219	-0.0718	0.0593	1.2970	1.5320
Aggregate Efficiency (I)	1.3193	1.3950	-0.0757	0.0561	1.2874	1.4957
Entire Aggregate Efficiency	1.3269	1.4013	-0.0744	0.0506	1.3093	1.4950
Mean Efficiency (A)	1.3685	1.4414	-0.0729	0.0633	1.3061	1.5526
Mean Efficiency (I)	1.3258	1.4028	-0.0770	0.0523	1.3054	1.4969
Mean All	1.3446	1.4191	-0.0745	0.0498	1.3212	1.5166
RD for Ag Eff	1.0233	1.0177	0.0056	0.0496	0.9036	1.1033
RD for Mean All	1.0408	1.0435	-0.0027	0.0468	0.9400	1.1295

Results for Group-Wise Heterogeneous Sub-Sampling Bootstrap for Aggregate Efficiencies: Right vs. Left Bank Regions (Model 1)

	Estimated Score	Corrected Score	Est Bias	Est std	Lower Bound	Upper Bound
Aggregate Efficiency (R)	1.3126	1.3805	-0.0679	0.0527	1.2670	1.4695
Aggregate Efficiency (L)	1.3333	1.4059	-0.0726	0.0589	1.2739	1.5229
Entire Aggregate Efficiency	1.3269	1.3985	-0.0716	0.0497	1.2975	1.4972
Mean Efficiency (R)	1.3383	1.4091	-0.0708	0.0559	1.2951	1.5111
Mean Efficiency (L)	1.3504	1.4289	-0.0785	0.0498	1.3272	1.5259
Mean All	1.3446	1.4194	-0.0748	0.0450	1.3360	1.5078
RD for Ag Eff	0.9844	0.9803	0.0041	0.0476	0.8848	1.0671
RD for Mean All	0.9975	0.9976	-0.0001	0.0439	0.9159	1.0746

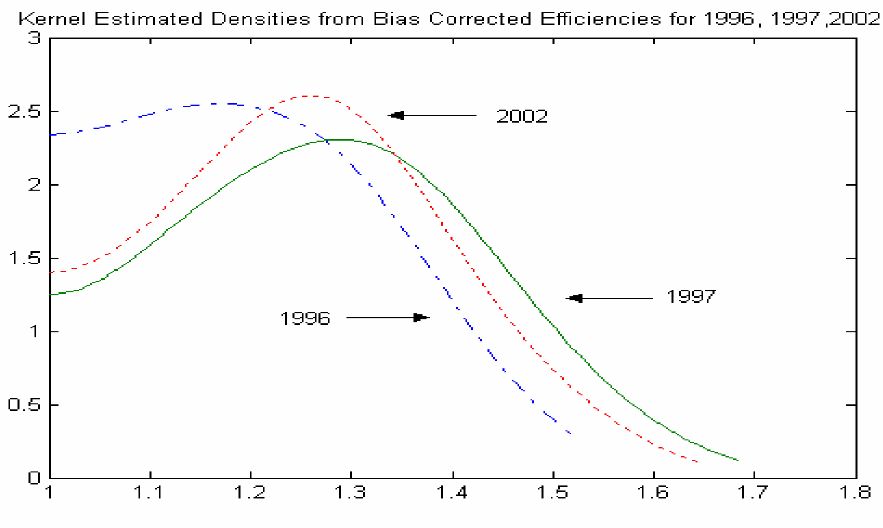
Results for Group-Wise Heterogeneous Sub-Sampling Bootstrap for Aggregate Efficiencies: Agrarian vs. Industrial Regions (Model 2)

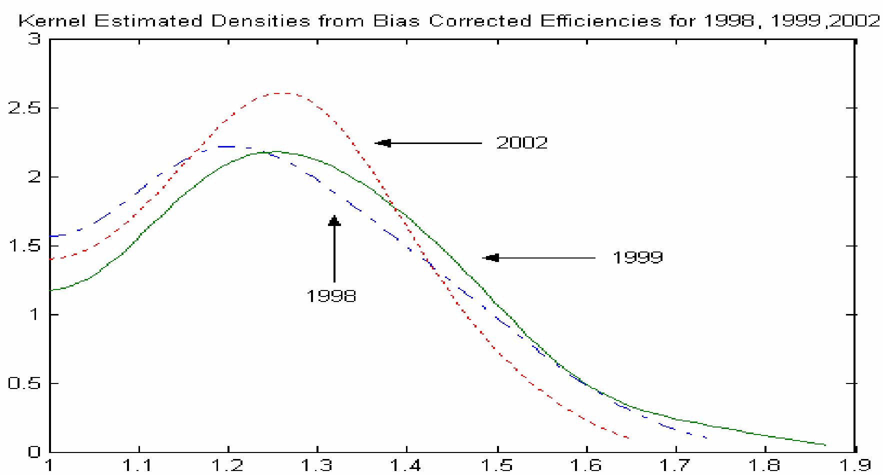
	Estimated Score	Corrected Score	Est Bias	Est std	Lower Bound	Upper Bound
Aggregate Efficiency (A)	1.7019	1.9860	-0.2841	0.1849	1.6580	2.2215
Aggregate Efficiency (I)	1.6275	1.9109	-0.2834	0.1327	1.6503	2.0892
Entire Aggregate Efficiency	1.6435	1.9275	-0.2840	0.1411	1.6628	2.1078
Mean Efficiency (A)	1.7176	2.0009	-0.2833	0.1859	1.6545	2.2394
Mean Efficiency (I)	1.7269	2.0288	-0.3019	0.1737	1.7105	2.2688
Mean All	1.7232	2.0173	-0.2941	0.1750	1.7062	2.2385
RD for Ag Eff	1.0457	1.0387	0.0070	0.0565	0.9141	1.1417
RD for Mean All	0.9909	0.9747	0.0161	0.0537	0.8627	1.0754

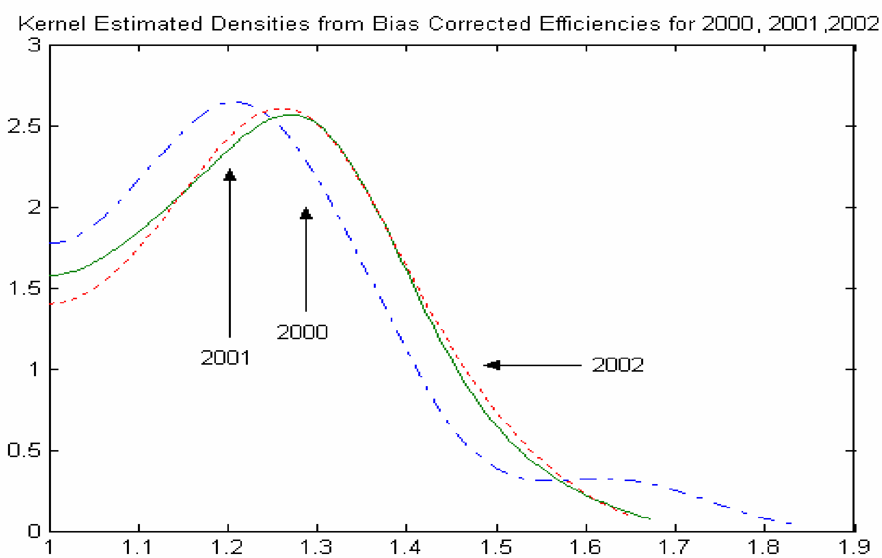
Results for Group-Wise Heterogeneous Sub-Sampling Bootstrap for Aggregate Efficiencies: Right vs. Left Bank Regions (Model 2)

	Estimated Score	Corrected Score	Est Bias	Est std	Lower Bound	Upper Bound
Aggregate Efficiency (R)	1.6864	1.9922	-0.3058	0.1836	1.6557	2.2126
Aggregate Efficiency (L)	1.6275	1.9105	-0.2830	0.1290	1.6376	2.0860
Entire Aggregate Efficiency	1.6435	1.9332	-0.2897	0.1413	1.6568	2.1113
Mean Efficiency (R)	1.7060	2.0114	-0.3054	0.1833	1.6649	2.2342
Mean Efficiency (L)	1.7369	2.0361	-0.2992	0.1724	1.7118	2.2704
Mean All	1.7232	2.0260	-0.3028	0.1745	1.7089	2.2476
RD for Ag Eff	1.0362	1.0480	-0.0118	0.0586	0.9297	1.1442
RD for Mean All	0.9783	0.9825	-0.0042	0.0454	0.8971	1.0692

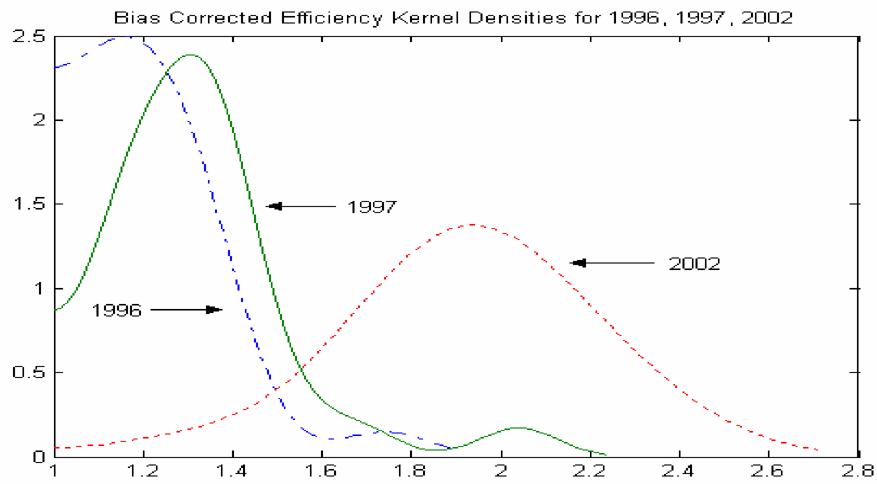
Appendix G. Kernel Densities for Ukraine (Model 1)

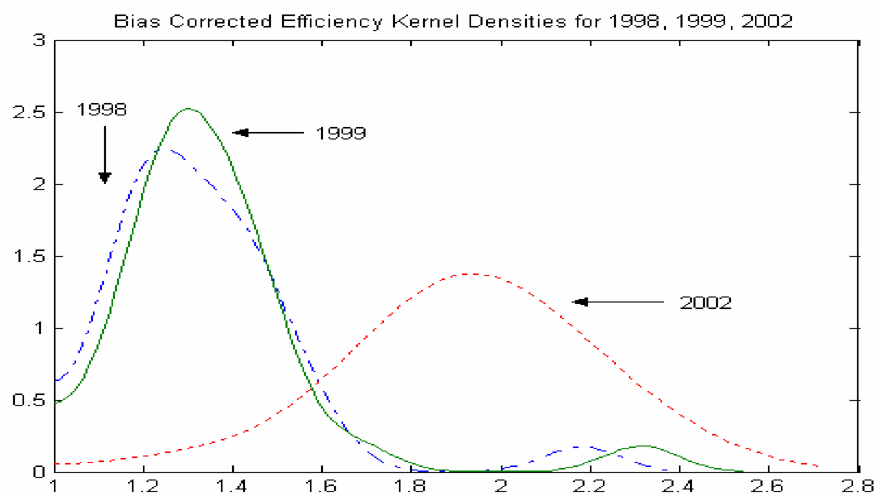


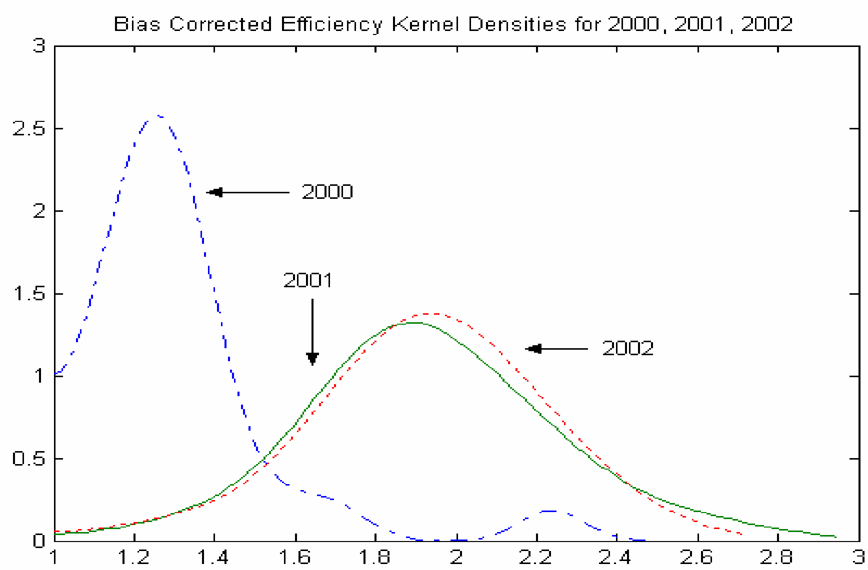




<u>Appendix G</u>. Kernel Densities for Ukraine (Model 2)(Cont'd)







Appendix H. Kernel Density Distributions (Model 1)