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Comparative Analysis Of Healthcare Performance In West And South Regions Of Ukraine

Abstract

This study examines variations in efficiency among hospitals located in western and southern Ukraine. We estimated efficiency using a nonparemetric modeling technique known as data envelopment analysis (DEA). DEA is a very powerful tool to compare relative efficiency among several economic units of study, known as decision making units (DMUS). In our current and previous research we have focused attention on comparative efficiency among hospitals and then explained variation in efficiency based on historical and cultural differences that influence managerial behavior at the hospital level of decision making. This study using current data and an expanded geographic territory provides further support to our findings from previous studies.

Keywords: *data envelopment analysis (DEA), healthcare performance, comparative efficiency*

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1. Introduction

The World Bank (Fan 2015) has identified health sector reform in Ukraine as necessary for health improvement in light of lagging health indicators. To date Ukraine has not undertaken a serious effort to reform the health system, despite repeated calls to do so. Recommendations of the World Bank include:

- Removing legal obstacles for more efficient allocation of resources and to move from input-based, focused on number of hospital beds, to patient-based financing models; and
- Starting practical steps to eliminate extreme duplication and reduce waste by restructuring and consolidating facilities.

In other words, Ukrainian healthcare must become more efficient. Our research will be useful to policy makers in Ukraine when they make a determined effort to reform the health system.

2. Why Study Ukraine?

Ukraine provides a natural laboratory for examining changing managerial behaviors in light of political and economic changes in that country. Ukraine has undergone extraordinary change since becoming independent from the Soviet Union in 1991. Ukraine's history and position in Europe provide an opportunity to examine differences in the potential effects of health policy reforms that can be related to cultural biases with respect to economic behavior. West Ukraine experienced 45 years of communism following the close of the Second World War. However, it was previously part of democratic Poland between the two great wars. Prior to that it was a region within the Austrian Empire, which was by far the most liberal of the three Central & Eastern European empires of the 19th century.

Central, southern and eastern Ukraine were part of the Ukrainian Socialist Republic for 70 years, and previously were subject to 500 years of Russian domination as a territory in the Russian Empire. The current conflict in eastern Ukraine and the annexation of Crimea are emblematic of Russian domination and influence in the south and east of the country.

In our previous studies we focused our research on the east-west divide. Current research is focused on comparison of hospital efficiency between western and southern Ukraine. We contend that the difference between western and southern Ukraine will be similar to the difference between western and eastern Ukraine due to commonality of historical and cultural influences between southern and eastern Ukraine.

3. Previous Research

This study is a follow-on study to one completed previously by the authors comparing hospital efficiency in one western and two eastern regions of Ukraine (Pilyavskyy et al, 2006; Bernet et al, 2008). We used an output-oriented DEA model to test hypotheses that western Ukraine with a greater propensity to respond to strategic exigencies would increase efficiency to a greater extent in response to financial constraints. The model outputs included patient days and medical and surgical admissions while the inputs included numbers of beds, nurses and physicians. As hypothesize we found that in response to a cut in financial inputs and resultant institutional changes in 2000, hospitals operating in western Ukraine demonstrated greater and more rapid improvement in efficiency compared to hospitals operating in the East.

In response to cut in inputs and institutional changes in 2000, hospitals operating in the West demonstrated a faster improvement in efficiency over the DEA in hospitals operating in the East. West demonstrated faster increases in efficiency than East in the model with patient days as an output. We also noted a shift in inputs from capital (beds) to labor with the shift being more pronounced in western than eastern Ukraine. The faster increase in efficiency and more pronounced shift to labor in western Ukraine were attributed to more strategic and entrepreneurial behavior of managers and physicians in the west, which we attributed to the historical and cultural influences described in the study.

These findings were consistent with the hypothesis that western Ukraine, having a greater western influence, may be better suited to deliver hospital care more efficiently and behave more productively when there are exogenous changes towards a market economy in Ukraine. The findings also make sense in light of decreasing state budgets. Physicians (and to a lesser extent nurses) can substitute informal income (under-the-table payments) for state wages if entrepreneurial. But, on a positive note, average length of stay (ALOS) was observed to be declining more rapidly in west than in east, a desirable result which needs to be taken into consideration when serious health reform is initiated.

However, there were several limitations to our previous research. Healthcare facilities in only 3 oblasts were included; current study includes 6 oblasts. Only standard DEA method and decomposition of Malmquist index were applied to efficiency and productivity assessment.

In the present study we expanded the dataset, shifted geographic focus and bootstrapped the data to reduce bias.

4. Data and model

Ukraine is divided into 25 oblasts each consisting of about 20 rayons. With few exceptions, each rayon has one central rayon hospital that provides medical care mainly to the village and rural population of that rayon. The hospitals provide both inpatient and ambulatory care through affiliated polyclinics. Data was drawn from Ministry of Health records for each of 105 central rayon hospitals (Western Ukraine Oblasts: Lutsk (16 rayons), Rivne (16 rayons), Chernivtsi (11 rayons), Lviv (19 rayons) and Southern Ukraine Oblasts: Herson (17 rayons), Odessa (26 rayons)). Hospitals are obliged to provide these data to the Ministry of Health.

The distribution of the hospitals is illustrated in Figure 1. There are 105 observations per year. Total observations for the 5 years (2006 to 2010) included in the study are 525. In our research we consider the following model of hospitals activity. Number of beds, physicians and nurses are inputs of the model. Number of discharged patients and surgical operations are outputs of the model. Descriptive statistics are shown in figures 1 to 3.

5. Hypotheses

In keeping with our previous findings we hypothesize that healthcare institutions in West Ukraine will have higher efficiency scores than in South Ukraine.

We further tested the difference in results using a bootstrapping technique compared to standard DEA scores. The purpose of this comparison was to analyze the added value of the bootstrapping technique in reducing bias inherent in the DEA estimators.

6. Methods

To measure hospital performance we used DEA to estimate technical efficiency for 61 central rayon hospitals located in our three reference oblasts. DEA scores were computed using beds, physicians and nurses as inputs and medical admissions and surgical admissions as the two outputs.

We chose the output-based orientation as we are interested in how to value the hospitals' resources and whether some hospitals are underutilizing their inputs, i.e., given a set of inputs, outputs are not maximized. This latter situation would suggest poor managerial decision-making.

We use the output distance function offered by Shephard (1970) for the analysis of efficiency and productivity changes in the hospitals. The function allows to measure technical efficiency of a hospital with respect to the production frontier and allows to answer the following question: to what extent output quantities can be proportionally expanded without changing the input quantities? We evaluate the output distance functions on the basis of a non-parametric method of frontier analysis – Data Envelopment Analysis (DEA). We use these functions for efficiency measurement and for creating Malmquist index that is used for productivity comparison.

Let us consider N hospitals, each of them uses n inputs for producing of m outputs. Then, let $x_i \in \Re_+^n$ and $y_i \in \Re_+^m$ denote input and output vectors for the i-th hospital. We consider each hospital in two periods of time $t = 0$ and $t = 1$. Then a production technology transforming inputs into outputs can be presented in the form of the following set $S^t \subset \Re_+^n \times \Re_+^m$:

$$S^t = \{(x^t, y^t) \mid x^t \; can \quad produce \quad y^t\} \tag{1}$$

A set of outputs $P^t(x)$ is defined as:

$$P^t(x^t) = \{y^t \mid (x^t, y^t) \in S^t\} \tag{2}$$

Note that the set S^t can represent a certain production technology only when it meets some properties (for more details see (Fare and Primont, 1995)). Shephard's output distance function $D_i^t(x_i^t, y_i^t)$ (Shephard, 1970) for hospital i is defined on the output set $P^t(x)$ as:

$$D_i^t(x_i^t, y_i^t) = \inf\{\theta \mid \theta > 0, y_i^t / \theta \in P^t(x^t)\} \tag{3}$$

In practice the function (3) for hospital *i* can be calculated with the help of DEA, solving the following linear programming (LP) problem:

$$[D_i^t(x_i^t, y_i^t)]^{-1} = \max\{\varphi_i \mid -\varphi_i y_i^t + Y^t \lambda \geq 0, x_i^t - X^t \lambda \geq 0, \vec{1}\lambda = 1, \lambda \geq 0\} \tag{4}$$

LP problem (4) makes it possible to receive a value of parameter φ_i that measures hospital's efficiency, if a technology is characterized by variable return to scale (VRS). But in case it is characterized by constant return to scale (CRS), the problem (4) must be solved without the constraint: $\vec{1}\lambda = 1$.

The production technology under assumption of CRS ($\hat{S}^t$) can be defined from set S^t:

$$\hat{S}^t = \{(\lambda x^t, \lambda y^t) | (x^t, y^t) \in S^t, \lambda > 0\} \tag{5}$$

The technology (5) is also called a cone technology. For set $\hat{S}^t$, analogically as for set S^t the following notions are introduced: a set of outputs $\hat{P}^t$ and output distance functions $\hat{D}^t$.

Technical efficiency (TE) of a hospital measured under assumption of CRS can be presented as a product of pure technical efficiency (PTE) (the result of solution of the LP problem (4)) and scale efficiency. Scale efficiency (SE) is calculated as follows:

$$SE^t = \frac{\hat{D}^t(x^t, y^t)}{D^t(x^t, y^t)} \tag{6}$$

If there are data about activity of a hospital for two periods of time $t = 0$ and $t = 1$, outputs distance function $D_i^1(x_i^0, y_i^0)$ for hospital i in the period $t = 0$ can be defined with respect to the technology of the period $t = 1$:

$$D_i^1(x_i^0, y_i^0) = \inf\{\theta \mid \theta > 0,\ y_i^0 / \theta \in P^1(x^1)\} \tag{7}$$

Distance function $D_i^0(x_i^1, y_i^1)$ is built analogically. Building of such functions allows us to use Malmquist's idea (Fare and Primont, 1995) for analysis of hospital productivity. In the papers (Fare et al 1991) and (Fare et al 1992) the following Malmquist-type index (Total Factor of Productivity (TFP)) was suggested to be used:

$$TFP^{0,1} = \left(\frac{D^0(x^1, y^1)}{D^0(x^0, y^0)} \cdot \frac{D^1(x^1, y^1)}{D^1(x^0, y^0)} \right)^{1/2} \tag{8}$$

A value of the index (8) greater than 1 indicates increasing of productivity, a value less than 1 – decreasing.

Decomposition of the index (8) is rather a significant point of productivity changes analysis for discovering the potential sources of increasing total factor of productivity. In the papers (Fare et al, 1991) and (Fare et al, 1992), decomposition of TFP onto two components – efficiency change and technological change was performed. Technical efficiency change (EC) is measured in the following way:

$$EC^{0,1} = \frac{D^1(x^1, y^1)}{D^0(x^0, y^0)} \tag{9}$$

Technological change (TC) is measured as follows:

$$TC^{0,1} = \left(\frac{D^0(x^1, y^1)}{D^1(x^1, y^1)} \cdot \frac{D^0(x^0, y^0)}{D^1(x^0, y^0)} \right)^{1/2} \tag{10}$$

As in the case with the index (7) (Fare et al, 1994), the fact that values (8) and (9) are greater (less) than 1 indicates positive (negative) changes of efficiency and technology respectively. So

$$TFP^{0,1} = EC^{0,1} \cdot TC^{0,1} \tag{11}$$

Decomposition of the index (8) in the form (11) can be supplemented with scale efficiency changes and thus we obtain one more source of the total factor of productivity increasing. One of the first decompositions of the index (8) taking into consideration all the scale changes, the one we make use of, is considered in the paper (Fare et al, 1994). Among the other approaches are – Rey and Desley's approach (1997), Zofio and Lowell's approach (1999), Griffell-Tatje and Lowell's approach (1999) and also Balk's approach (2001).

In the approach (Fare et al, 1994) that we consider, technological change is measured with the help of the formula (10), but certainly under assumption of CRS. Two more sources of increase are pure technical efficiency change and scale efficiency change. Pure technical efficiency change (PEC) is measured in the following way:

$$PEC = \frac{D^1(x^1, y^1)}{D^0(x^0, y^0)} \tag{12}$$

Scale efficiency change (SEC) is then calculated as follows:

$$SEC = \left[\frac{D^1(x^1, y^1) / \hat{D}^1(x^1, y^1)}{D^1(x^0, y^0) / \hat{D}^1(x^0, y^0)} \cdot \frac{D^0(x^1, y^1) / \hat{D}^0(x^1, y^1)}{D^0(x^0, y^0) / \hat{D}^0(x^0, y^0)} \right]^{1/2} \tag{13}$$

Then TFP looks in the following manner:

$$TFP^{0,1} = TC^{0,1} \cdot PEC^{0,1} \cdot SEC^{0,1} = \left(\frac{\hat{D}^0(x^1, y^1)}{\hat{D}^0(x^0, y^0)} \cdot \frac{\hat{D}^1(x^1, y^1)}{\hat{D}^1(x^0, y^0)} \right)^{1/2} \tag{14}$$

7. Results

As can be seen in Figure 2 average technical efficiency was greater for western Ukrainian hospitals than for those in the southern oblasts in the study. Average technical efficiency was slightly higher in western than in southern Ukraine, but trending upward. Efficiency scores under the assumption of constant returns to scale and variable returns to scale started roughly equal between western and southern Ukraine in 2006. However the scores for western Ukrainian hospitals trended upward during the study period while they remained constant for hospitals in southern Ukraine. By 2010 differences in efficiency scores were substantial. When broken down by oblast, it is evident that western Ukrainian hospitals were demonstrating even greater growth in efficiency. Both oblasts in southern Ukraine demonstrated flat efficiency scores. Of the three western Ukrainian oblasts, efficiency scores for Chernivtsi oblast declined and recovered to be flat for the study period, whereas scores for Volyn, Riven and Lviv oblasts were trending upward.

Of greater interest to health policy makers is that size of hospitals and ALOS in hospitals in western Ukraine continue to trend downward compared to southern Ukraine. This finding is important since the World Bank has urged Ukraine to shift focus away from hospital beds to health services delivered in the community. While our study does not answer that question, the decline in hospital use represents a shift in resource use.

We also looked at the Total Factor of Productivity (Table 4). TFP for the entire sample of hospitals increased slightly by 1.4%. However, of greater importance to our analysis, hospitals in western Ukraine trended upward by 2.7% while TFP for southern Ukrainian hospitals remained flat during the study period. Thus it is clear that western Ukrainian hospitals were gaining in efficiency relative to hospitals in southern Ukraine supporting our hypothesis.

We also looked at the impact of bootstrapping on our results. In Table 5 it is clear that reduction in bias using the resource intensive bootstrapping technique does not warrant its use. The technique does not significantly change the results. A growing body of literature is also supporting the contention that bootstrapping does not sufficiently improve results and reduce bias to an extent that would justify the use of this labor intensive technique.

8. Conclusion

We employed DEA, a non-parametric frontier method that has been applied in a number of studies on hospital efficiency to the study of hospitals in Ukraine. We based this study on our previous research from 10 years earlier in

which we identified a relationship between regions within Ukraine and hospital efficiency. Our current study provide further support to our earlier conclusion that hospitals in the western region of Ukraine are more likely more efficient than hospitals in the eastern and southern regions of the country.

Technical efficiency was higher in western Ukraine during the entire period of the study. However, efficiency among hospitals in western Ukraine increased while hospital efficiency in southern Ukraine remained flat. This supported our hypothesis. However, our findings will be very useful for health policy makers as health reform is initiated. Health reform is inevitable and success of health reform will depend on the responsiveness to DMUs to policy incentives. That these responses vary by region will need to be taken into account in order to assure successful health reform, especially if reform includes any degree of privatization.

Finally, our results provide further evidence that the resource intensive bootstrapping technique does bear sufficient benefit in reduction in bias and improved results to warrant its use. In order to enhance the usefulness of our findings further research is required that includes more geographic regions within Ukraine. We need to account for local economic developments and migration trends as well cost and quality variation across the country. It is also important for us to study how resources are shifting away from hospitals and to where they are shifting if we are more meaningfully inform health policy. In order to engage in this level of resource we must identify valid sources of financial and quality data. Efficiency is important since it impacts cost. However, we must also answer questions that can help us untangle the complex relationship among cost, quality and access, as well as effectiveness in managing population health if the research is to adequately inform health policy reform.

Figure 1. Study area

Western Ukraine Oblasts: Lutsk (16 rayons), Rivne (16 rayons), Chernivtsi (11 rayons), Lviv (19 rayons)
Southern Ukraine Oblasts: Herson (17 rayons), Odessa (26 rayons)

Source: own elaboration.

Table 1. Descriptive statistics of beds

	Western Ukraine				**Southern Ukraine**				**Total Sample**			
Year	Mean	StD	Min	Max	Mean	StD	Min	Max	Mean	StD	Min	Max
2006	332	19.3	100	1000	270	22	90	595	307	14.6	90	1000
2007	298	17.8	100	985	266	22	90	595	286	13.7	90	985
2008	291	16.6	100	838	260	21	90	595	279	12.9	90	838
2009	285	15.5	90	769	260	21	90	595	276	12.4	90	769
2010	282	15.2	90	740	256	21	90	595	272	12.4	90	740

Source: own elaboration.

Table 2. Descriptive statistics of surgical operations

	Year	**Mean**	**StD**	**Min**	**Max**
West	2006	1478.68	82.61	299	4572
	2007	1511.63	82.33	314	5162
	2008	1563.39	96.04	295	6221
	2009	1517.40	86.53	331	6386
	2010	1483.31	86.27	329	6817

South	2006	1522.98	100.11	299	4550
	2007	1567.48	102.73	314	5162
	2008	1572.26	108.72	295	5541
	2009	1607.95	114.73	331	6386
	2010	1596.16	117.70	329	6817

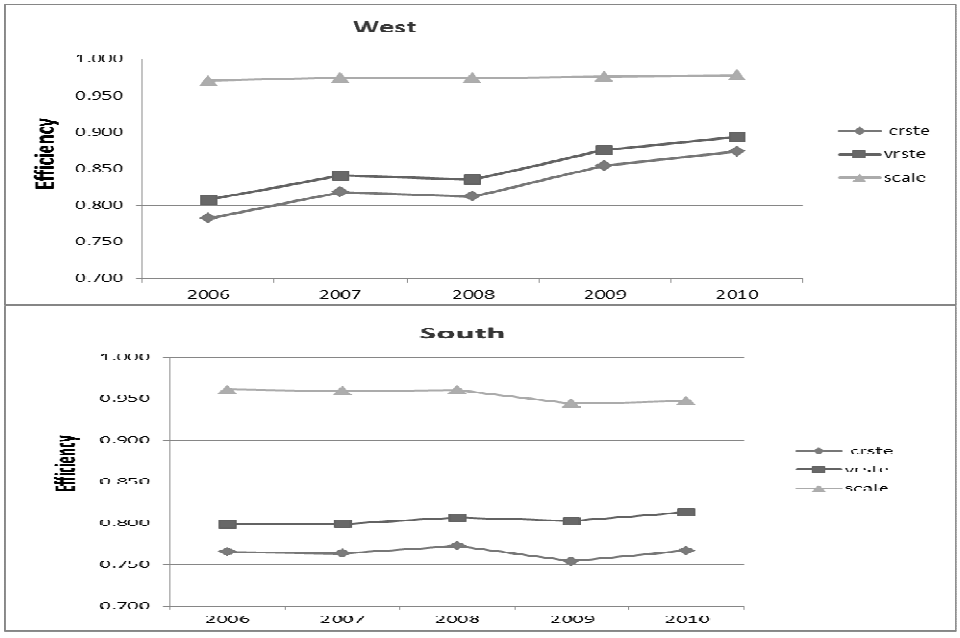
Source: own elaboration.

Table 3. Descriptive statistics of average length of stay

ALOS	Total	West	South
		13.04	
2006	13.62	13.88	13.26
2007	13.34	13.41	13.26
2008	12.95	12.94	12.96
2009	12.70	12.56	12.90
2010	12.57	12.18	13.14

Source: own elaboration.

Figure 2. Comparative efficiency scores West and South oblasts of Ukraine



Here: crste – efficiency for constant return to scale model, vrste – efficiency forvariable returne to scale model, scale – scale efficiency

Source: own elaboration.

Table 4. Changes in technical efficiency

Total Factor of Productivity		effch	techch	pech	sech	tfpch
Total		1.009	1.005	1.008	1.002	1.014
West		1.021	1.006	1.015	1.006	1.027
	Lutsk	1.035	1.003	1.024	1.010	1.038
	Chernivtsi	1.037	1.001	1.024	1.012	1.038
	Rivne	0.991	1.005	0.989	1.002	0.996
	L'viv	1.013	1.015	1.013	1.000	1.028
South		0.994	1.003	0.998	0.996	0.998
	Herson	1.001	0.999	1.008	0.992	1.000
	Odessa	0.990	1.006	0.992	0.998	0.996
Technical Efficiency Change (Relative to CRS Technology)						
Technological Change						
Pure Technical Efficiency Change (i.e. Relative to VRS Technology)						
Scale Efficiency Change						
Total Factor Productivity (TFP) Change						

Source: own elaboration.

Table 5. Comparison with and without bootstrapping

Total	CRS EFF	Bootstrap	tmp.bias	VRS EFF	Bootstrap	tmp.bias
2006	0.775	0.755	0.020	0.803	0.770	0.033
2007	0.796	0.776	0.020	0.821	0.791	0.030
2008	0.796	0.774	0.022	0.818	0.787	0.031
2009	0.813	0.792	0.021	0.839	0.805	0.034
2010	0.830	0.806	0.024	0.856	0.816	0.040

Source: own elaboration.

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Streszczenie

ANALIZA PORÓWNAWCZA WYDAJNOŚCI OPIEKI ZDROWOTNEJ W ZACHODNICH ORAZ POŁUDNIOYCH REGIONACH UKRAINY

W artykule przedstawiono wyniki analiz różnic w wydajności opieki zdrowotnej świadczonej w szpitalach zlokalizowanych w zachodnich i południowych regionach Ukrainy. Oszacowano poziom wydajności przy użyciu techniki modelowania nieparametrycznego – metody DEA. Metoda ta stanowi narzędzie stosowane do porównań i oceny względnej skuteczności kilku jednostek gospodarczych będących jednostkami decyzyjnymie (DMU). W badaniu skupiono uwagę na różnicach w poziomie efektywności szpitali.

***Słowa kluczowe**: DEA, efektywność opieki zdrowotnej porównawcza*