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## THE COMPARATIVE EFFICIENCY OF CENTRAL REGION HOSPITALS AND POLYCLINICS IN UKRAINE

**Abstract.** The study analyses the technical efficiency and the efficiency change of 193 community hospitals and polyclinics across Ukraine, for the years 1997 to 2001. These facilities are a subset of the medical institutions in rural Ukraine; they are identical w.r.t. their function in the health system and share the same departmental structure.

The data comprise the number of physicians and the number of nurses employed in the departments as well as the polyclinics attached to the hospitals, the number of inpatient and outpatient admissions as well as the number of surgical procedures, lab tests and x-rays performed. Finally, the number of deaths and deaths after surgery are used as quality proxies.

We employ an order- $m$  estimator, a robust nonparametric technique to assess the efficiency of health care providers as well as possible changes of their productivity. The efficiency scores are calculated with an output-oriented model. Efficiency scores are close to unity for hospitals whereas polyclinics are somewhat less efficient. The Malmquist index exceeds unity for three out of four periods for both hospitals and polyclinics indicating improved productivity on average.

**Keywords:** *hospital efficiency, health reform, Ukraine / Eastern Europe*

### 1. INTRODUCTION

While the Ukrainian health care system was deemed to be one of the best in the former Soviet Union, in 1997, when our observation period begins, the health care spending amounted to less than half of the 5.8% of GDP, which is suggested as a minimum by the WHO. This figure rose to about 3.5%, but the real GDP of Ukraine dropped by nearly a half during the 1990s. It is around US\$ 2,200 per capita, one fifth of the EU average<sup>1</sup>.

Despite the fact that per capita spending on health care is second only to Belarus among the CIS countries, it is less than 10% of the EU average. As a result, all health indicators show a dramatic deterioration for Ukraine<sup>2</sup>.

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<sup>1</sup> WHO, [2000], *Highlights on Health in Ukraine*, Rome.

<sup>2</sup> Ibidem.

The health services continue to be publicly funded in Ukraine and they are organized at the region-oblast-state levels. In each region (rayon)<sup>3</sup>, a Central Region Hospital (with a polyclinic) operates, which provides medical care to the rural population in Ukraine that represents more than a third of the country's population (16.1 of 49.5 million). These hospitals offer over one fourth of all beds in Ukraine and treat almost one fourth of the country's hospitalized patients. The Central Region Hospitals (CRH) provide direct patient care, administer public health programs, and formulate some types of health policies.

The study reported in this paper focuses on the technical efficiency with which the Central Region Hospitals operated in twelve oblasts (Cherkasy, Crimea, Dnipropetrovsk, Kherson, Kiev, Kirovograd, Luhansk, Odessa, Volyn, Transcarpathia, Zaporizha, Zhytomir) between 1997 and 2001. It is worth noting that during these years Ukraine was looking for a way to recover from the deep depression of the years 1991-1996 and the economic macrostabilization was starting to emerge.

Our study is organized as follows: the next section describes the data available for the analysis. The third section describes the method used, specifically the input-oriented specification of the DEA model as well as the calculation of the Malmquist-indices. Section 4 presents our results and section 5 is the conclusion.

## 2. DATA

The data we analyze describe the facilities of the central region hospitals and polyclinics in twelve districts in the period 1997-2001; the hospitals and the polyclinics are obliged to submit these data to the Ministry of Health. We have between 168 and 175 observations per year and from 7 to 20 observations per district, so our sample contains 858 observations altogether. Only the hospitals with the internal medicine, surgery, pediatric, gynecological and obstetric departments were considered; in other words, the hospitals are identical with respect to the function they perform in the system. Some hospitals have other departments too, but specific information on the departments is not available.

The inputs for the hospitals are the numbers of beds and the numbers of physicians and nurses. Interestingly, while the number of nurses slightly dropped over the years, the number of physicians in the hospitals remained largely the same. We also use information on the number of deaths and post-surgery deaths as a proxy for quality.

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<sup>3</sup> Each oblast has about 20 regions (rayons) and therefore about 20 CRH.

The outputs include the numbers of general admissions, the numbers of cases admitted for surgery, as well as the numbers of surgical procedures performed. Only the average number of patients admitted for surgery rose over the years whereas the other two outputs decreased over time.

The indicators for the polyclinics are again the staff levels (inputs), the inpatient visits in the polyclinics, the numbers of outpatient visits, and the number of surgical procedures performed, as well as the number of lab tests and x-rays made (outputs).

Unlike the hospitals, the numbers of physicians employed in the polyclinics decreased. The average number of nurses also fell by more than 10%. With this reduction in the inputs, it is remarkable that all outputs rose by nearly 10% on average and the number of the surgical procedures performed rose by nearly 20% over the observation period.

In the sequel, separate models will be estimated for the hospitals and the polyclinics. Before we present our results, we need to discuss the details of our empirical methodology.

### 3. MODEL SPECIFICATION

Our efficiency analysis is based on the works by Cazals, Florens and Simar<sup>4</sup>. We define the production capacities set of production units at time  $t$ , where  $t$  is the time period, as  $P_t = \{(x, y) | x \text{ can produce } y\}$ , where  $x$  is a vector of  $p$  inputs and  $y$  is a vector of  $q$  outputs. The input requirements of  $P_t$  are:

$$X_t(y) = \{x \in R_+^p | (x, y) \in P_t\},$$

whereas  $Y_t(x) = \{y \in R_+^q | (x, y) \in P_t\}$  are the output capacities.

The radial (output-oriented) efficiency boundary (“efficient frontier”) is then defined as:  $\partial Y_t(x) = \{y | y \in Y_t(x), \theta y \notin Y_t(x), \forall \theta > 1\}$

The efficiency boundary defines the “radially efficient” pairs  $(x, y)$  and the Farrell output measure of efficiency  $\theta(x, y | P_t)$  for a given point  $(x, y)$  is now defined as:  $\theta(x, y | P_t) = \sup\{\theta | (x, \theta y) \in P_t\}$ .

In the applied work, when a particular activity is analyzed, the attainable set of  $P_t$  is unknown, and so are  $Y_t(x)$ ,  $\partial Y_t(x)$  and  $\theta(x, y | P_t)$ . Typically, only a sam-

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<sup>4</sup> Cazals C., Florens J.P., Simar L., [2002], *Nonparametric frontier estimation: A robust approach*, Journal of Econometrics 106, pp.1-25.

ple of production units is observed:  $S_n = \{(x_i, y_i), i=1, \dots, n\}$ . The problem is to estimate the unknown quantities listed above given  $S_n$ .

The most popular nonparametric estimators of  $P_t$  are defined as the minimal sets containing the observed data,  $S_n$ . The Free Disposable Hull (FDH) estimator is based on the free disposability assumptions on  $P_t$ , while the Data Envelopment Analysis (DEA) estimator relies on the additional assumption of convexity<sup>5</sup>.

The main reason for choosing the DEA as the analytical tool is its flexibility with respect to the functional form of the technology. This is a major advantage considering that the specific production process of a health care provider is uncertain. However, a major drawback of the DEA-type estimators is their potentially extreme sensitivity to outliers on the frontier. We therefore opt for a more robust approach to efficiency measurement, the so-called order- $m$  estimator<sup>6</sup> and use the method introduced by Wheelock and Wilson<sup>7</sup> to derive Malmquist-indices and their decomposition. We maintain that, given the situation described in the introduction, there is more demand than is presently met. Therefore, we use an output-oriented specification. The section below draws substantially on Wheelock and Wilson<sup>8</sup>.

### 3.1. DEA, FDH and order- $m$ estimators

Several estimators, among them the standard DEA estimators based on the convexity assumption with respect to the technology and the FDH (Free Disposal Hull) estimator where convexity is not maintained, can be derived. Note that an output-oriented FDH score for some observation  $(x_0, y_0)$  can be calculated as simply as:

$$\theta_{\text{FDH}}(x_0, y_0) = \min_{i=1, \dots, J^*} [\max_{l=1, \dots, q} \frac{y_l^*}{y_{l0}}], \quad (1)$$

where  $J^*$  is a set of observations dominating  $(x_0, y_0)$  in the input, i.e. they use at most  $x_0$ . When there is no other observation in the data set that dominates  $(x_0, y_0)$  in the input or produces more output with the input being within  $x_0$ , just as the with DEA  $(x_0, y_0)$  will be its own benchmark and the score will equal unity. It is

<sup>5</sup> For details, see: Simar L., Wilson P.W., [2000], *Statistical Inference in Nonparametric Frontier Models: The State of the Art*, Journal of Productivity Analysis, Vol. 13, pp.49-78.

<sup>6</sup> Cazals C., Florens J.P., Simar L., [2002].

<sup>7</sup> Wheelock D.C., Wilson P.W, [2003], *Robust Nonparametric Estimation of Efficiency and Technical Change in U. S. Commercial Banking*, Working Paper 2003-037A, Federal Reserve Bank of St. Louis.

<sup>8</sup> Ibidem.

well known, however, that these are sensitive to outliers and suffer from slow convergence (for an overview of these estimators' properties<sup>9</sup>).

A more robust alternative to these estimators was introduced by Cazals, Florens and Simar [2002]. It requires additional assumptions, namely that the sample observations at time  $t$  be *iid* random variables with pdf  $f_t(x_0, y_0)$  with support over  $P_t$  that this density be continuous in any direction into the interior of  $P_t$  and that  $D(x,y)$  be differentiable in both  $x$  and  $y$  in the interior of  $P_t$ . Here, the benchmark used to calculate the output oriented distance for a point  $(x_0, y_0)$  is not the production set as defined above. Rather, it would be the expected maximum output of some  $m$  firms chosen randomly, given that these firms use at most an input of a point  $x_0$ . This is the principle of the so-called order- $m$  estimator. For  $m \rightarrow \infty$ , the order- $m$  estimator would result in the same benchmark as the standard FDH production set, so both estimators would be the same. For the finite values of  $m$ , however, the order- $m$  benchmark would be at best the same as the FDH benchmark and hence the inefficiency estimated by an order- $m$  estimator cannot be inferior to that derived from the FDH.

The order- $m$  estimation of an output oriented score is straightforward: for a particular observation, all sample observations that dominate the observation in the input are selected. From this subsample,  $m$ -size samples are drawn with replacement. Note that this does not necessarily involve the observation itself. Then,  $\theta_{FDH}$  is calculated as described in (1) above. Because the observation itself is not necessarily part of the order- $m$  sample, scores greater and lower than unity may occur. This process is repeated  $B$  times and the average of all scores can be calculated, which we denote by  $\hat{\theta}_m$ .

### 3.2. Malmquist Index Decomposition

Wheelock and Wilson [2003] point out that the order- $m$  principle could be the most useful when applied to panel data in order to assess productivity change over time. A sequence of single-period efficiency scores can be used to decompose the overall productivity change into technological progress - the shift of the frontier - and changes in individual efficiency over time for each observation. The latter is the ratio of two single-period efficiency scores (see  $\Delta$  efficiency in (2) below), whereas the shift of the segment of the frontier relevant to a particular observation can be measured with the ratio of two different assessments of the same input-output bundle (in our case,  $IO^1$ , the period 1 bundle, see  $\Delta$  technology in (2) below). This assessment is usually expressed in terms of distance functions  $D^t(IO^s)$  where  $s$  and  $t$  may be any of the two periods 0 or 1

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<sup>9</sup> See: Simar L., Wilson P.W., [2000].

Note that it may not be possible to calculate the distance  $D^0(IO^1)$  for every observation, since some input-output combinations observed in period 1 may have not been feasible in the baseline period.

The Malmquist-index with base-period 0,  $MI^0$  is defined as:

$$MI^0 = \frac{D^0(IO^1)}{D^0(IO^0)} = \underbrace{\frac{D^0(IO^1)}{D^1(IO^1)}}_{\Delta \text{ productivity}} \cdot \underbrace{\frac{D^1(IO^1)}{D^0(IO^0)}}_{\Delta \text{ efficiency}}, \quad (2)$$

where  $D^0(IO^0) = \theta_0^{-1}$ ,  $D^1(IO^1) = \theta_1^{-1}$  and  $D^0(IO^1) = \theta_{01}^{-1}$  - period 1 performance is evaluated with the baseline technology. Therefore, values exceeding unity imply progressing productivity, technology or efficiency, while the values below unity imply regress. Following Wheelock and Wilson [2003], we generate pseudo observations  $\tilde{y}_i = y_i \hat{\theta}_i^m$ . They are used as the benchmarks for our calculations of the Malmquist index and its components. However, unlike Wheelock and Wilson [2003], we neither give the full decomposition in technical and scale efficiency nor bootstrap these indices.

#### 4. RESULTS

Let us present first in Tables below the annual average efficiency scores of the districts for the hospitals and for the polyclinics, respectively, which were calculated separately with an output oriented order- $m$  model. Even though there are many more observations than three times the number of the variables – which the literature commonly suggests as a minimum number of observations allowing well-differentiated results to be obtained<sup>10</sup> – the hospitals in the districts seem efficient with few exceptions. This may be due to the legacy of the Semashko system care system, i.e. a planned system that left little room for efficiency differences between hospitals. The overall average is below unity except for the initial period (see Table 1, the bottom row).

The polyclinic are somewhat; the only year when the average score is below unity is the final year of our observation (see Table 1, the bottom row). The average inefficiency is only around 4 % in the years 1997-2000.

<sup>10</sup> See: Cooper W.W., Seiford L.M., Tone K., [2000], *Data Envelopment Analysis*, Boston: Kluwer, p.252.

**Tab. 1: Efficiency Scores of Hospitals and Polyclinics for Districts and Years<sup>11</sup>**

	HOSPITALS						POLYCLINICS					
	1997	1998	1999	2000	2001	TOT.	1997	1998	1999	2000	2001	TOT.
CHERKASY	.955	.969	.994	1.020	.992	.986	1.009	1.061	1.069	1.058	1.020	1.043
	.049	.032	.089	.0866	.0707	.071	.1690	.1969	.179	.169	.139	.170
	19	19	19	19	19	95	19	19	19	19	19	95
CRIMEA	.941	.988	.969	.959	1.000	.972	.935	.941	.915	.921	.862	.915
	.103	.167	.103	.128	.165	.132	.302	.317	.1959	.248	.169	.244
	10	10	10	9	10	49	10	10	10	9	10	49
DNIPROPETROVSK	1.025	1.021	1.019	1.017	.991	1.01	1.113	1.074	1.070	1.060	1.009	1.065
	.084	.068	.099	.093	.048	.0795	.1751	.1588	.1857	.160	.115	.160
	18	19	18	19	19	93	18	19	18	19	19	93
KHERSON	1.098	.986	1.034	1.027	1.021	1.035	1.174	1.081	1.141	1.196	1.155	1.151
	.211	.191	.156	.128	.132	.167	.689	.446	.532	.692	.442	.562
	17	14	16	16	16	79	17	14	16	16	16	79
KIEV	1.044	.963	.982	.958	.960	.983	.927	.984	.957	.926	.933	.947
	.152	.093	.097	.086	.074	.108	.1483	.207	.187	.175	.182	.179
	19	19	20	15	16	89	19	19	20	15	16	89
KIROVOGRAD	1.00	.992	.980	.986	.980	.988	1.040	1.053	1.047	1.033	1.001	1.035
	.063	.061	.056	.041	.031	.052	.199	.271	.250	.225	.162	.221
	17	18	17	16	16	84	17	18	17	16	16	84
LUHANSK	.994	.968	.956	.979	.978	.975	1.219	1.181	1.236	1.200	1.098	1.189
	.082	.081	.064	.066	.091	.076	.286	.256	.560	.292	.213	.342
	14	14	15	15	13	71	14	14	15	15	13	71
ODESSA	1.025	1.00	.998	.994	1.02	1.01	.962	.967	.966	.982	.951	.966
	.133	.082	.102	.096	.123	.105	.055	.095	.085	.087	.0628	.077
	12	13	13	13	12	63	12	13	13	13	12	63
VOLYN	.978	.975	.984	.986	.981	.981	.9480	1.002	1.012	.997	1.001	.993
	.0325	.030	.028	.032	.026	.029	.196	.220	.202	.210	.171	.195
	11	12	13	14	13	63	11	12	13	14	13	63
TRANSKARPHIA	.950	.948	.911	.918	.890	.925	1.009	1.075	.963	1.109	.939	1.019
	.086	.102	.111	.086	.092	.095	.231	.399	.1390	.306	.186	.269
	10	11	9	8	9	47	10	11	9	8	9	47
ZAPORIZHZHYA	.967	1.013	1.003	.989	1.029	1.002	.972	.993	.976	.955	.910	.956
	.0485	.098	.093	.055	.142	.095	.1852	.154	.179	.134	.094	.143
	7	7	8	11	11	44	7	7	8	11	11	44
ZHYTOMIR: MEAN	1.010	.999	.995	.987	.994	.997	1.050	1.086	.965	.994	.951	1.014
	.129	.116	.124	.074	.042	.1027	.229	.324	.131	.173	.057	.214
	17	19	16	15	14	81	17	19	16	15	14	81
TOTAL	1.006	.985	.989	.990	.988	.991	1.039	1.047	1.035	1.041	.995	1.032
	.119	.0987	.099	.086	.093	.100	.296	.267	.288	.290	.204	.272
	171	175	174	170	168	858	171	175	174	170	168	858

Source: developed by the authors.

Productivity changes in time can be traced for the entire sample using the Malmquist-index figures listed in Table 2. The geometric means of indices averaged over districts and years for the hospitals and polyclinics are listed here. In most instances, both hospitals and polyclinics show progress. When averaged over all districts, the Malmquist index ranges between 1% and 4%, except for the two final periods, when the productivity of the polyclinics seems to leap forward by more than 12, whereas the hospitals' productivity remains at the usual level.

<sup>11</sup> Three rows for each oblast and Total are the (arithmetic) means, the standard deviations and the number of observations for the efficiency scores of the hospitals and polyclinics by year and oblast.

**Tab. 2: Malmquist Index and Decomposition**

OBLAST		1997		1998		1999		2000	
		HOSP	POLY	HOSP	POLY	HOSP	POLY	HOSP	POLY
CHERKASY	MALMQUIST	.885	.947	1.000	.996	.957	.988	1.024	1.092
	TECH. PROG.	1.152	1.005	.795	1.042	1.059	1.063	1.024	1.067
	CATCHING-UP	.768	.943	1.258	.956	.904	.929	1.001	1.023
CRIMEA	MALMQUIST	1.050	.992	.990	1.032	.960	1.001	1.084	1.087
	TECH. PROG.	1.005	1.016	.896	1.058	1.051	1.121	1.043	1.018
	CATCHING-UP	1.044	.977	1.105	.976	.913	.893	1.039	1.068
DNIPROPETROVSK	MALMQUIST	.964	1.040	1.017	1.079	1.016	.993	1.014	1.093
	TECH. PROG.	1.072	1.045	.842	1.049	1.072	1.019	1.031	1.034
	CATCHING-UP	.899	.996	1.208	1.029	.948	.974	.984	1.056
KHERSON	MALMQUIST	1.137	1.021	.892	1.002	1.014	.973	.320	1.155
	TECH. PROG.	1.099	.991	.791	1.012	1.068	1.133	.339	1.048
	CATCHING-UP	1.034	1.031	1.142	.991	.949	.859	.943	1.103
KIEV	MALMQUIST	1.072	.961	1.058	1.070	1.013	1.018	1.004	1.085
	TECH. PROG.	1.072	1.029	.865	1.048	1.047	1.031	1.010	1.038
	CATCHING-UP	.999	.934	1.224	1.020	.967	.987	.994	1.046
KIROVOGRAD	MALMQUIST	.964	.997	1.025	1.131	1.087	1.046	.359	1.104
	TECH. PROG.	1.013	1.042	.924	1.050	1.059	1.043	.345	1.060
	CATCHING-UP	.952	.956	1.109	1.091	1.026	1.003	1.040	1.042
LUHANSK	MALMQUIST	1.030	1.062	1.134	1.088	1.020	1.012	1.053	1.120
	TECH. PROG.	.980	1.029	.904	1.054	1.009	.979	1.066	1.005
	CATCHING-UP	1.051	1.032	1.254	1.032	1.011	1.034	.988	1.115
ODESSA	MALMQUIST	1.007	1.055	1.044	1.035	1.008	.986	1.030	1.084
	TECH. PROG.	1.041	1.039	.917	1.046	1.044	1.019	1.009	1.035
	CATCHING-UP	.968	1.015	1.138	.990	.965	.968	1.021	1.047
VOLYN	MALMQUIST	1.101	1.022	1.002	.991	1.009	1.030	1.051	.951
	TECH. PROG.	1.105	1.077	.900	1.040	1.012	.993	1.034	1.021
	CATCHING-UP	.997	.949	1.113	.952	.996	1.037	1.016	.932
TRANSKARPATHIA	MALMQUIST	.989	1.014	1.022	.920	1.016	.842	1.124	1.120
	TECH. PROG.	1.333	1.032	.692	1.081	1.047	1.037	1.023	1.021
	CATCHING-UP	.742	.982	1.478	.852	.970	.812	1.098	1.097
ZAPORIZHZHYA	MALMQUIST	.882	.953	.932	.950	1.101	.993	.231	1.228
	TECH. PROG.	.987	.990	.851	1.022	1.083	1.065	.257	1.117
	CATCHING-UP	.894	.962	1.095	.929	1.017	.932	.900	1.100
ZHYTOMIR	MALMQUIST	1.049	1.082	.958	1.016	1.010	1.043	1.094	1.202
	TECH. PROG.	1.110	1.024	.902	.974	.991	1.072	1.042	1.055
	CATCHING-UP	.945	1.056	1.062	1.043	1.020	.972	1.050	1.140
TOTAL	MALMQUIST	1.036	1.020	1.026	1.044	1.023	1.011	1.027	1.122
	TECH. PROG.	.960	1.027	.858	1.039	1.044	1.045	1.025	1.044
	CATCHING-UP	.934	.985	1.179	.996	.971	.957	1.002	1.059

Source: developed by the authors.

## 5. CONCLUSION

We have analyzed the efficiency of 193 different community hospitals and polyclinics in the rural areas of Ukraine between 1997 and 2001. This period was characterized by per capita spending on health care increasing in terms of domestic currency, but sharply declining when converted into the US dollars. Since the health care resources are rather limited, it would be of interest to see if any substantial differences with respect to the health care providers' efficiency can be detected. Most of the analyzed hospitals analyzed were found to be efficient, but the majority of the polyclinics were not. However, this remarkable uniformity of the results should not be interpreted as an indication of a fully efficient system, because some reason for this could be the legacy of the for-

merly planned health care sector. International benchmarking could be used to see, whether the Ukrainian health care sector is efficient and to what degree.

An interesting aspect of our results is that the only period where productivity improved considerably were the years 2000 and 2001. In 1999, the Supreme Court of Ukraine ruled that Ukrainian citizens were entitled to free health care and in 2000 a health care reform plan was commissioned. The increase in polyclinics' productivity may have been brought about by a combination of these two factors, but it is more likely that the true cause was the ruling of the Supreme Court. To corroborate our results we would need to match them with the data on the regional economic development and migration trends and to use data from later periods to test the ongoing efficiency changes.

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