УДК 338.2

***Tamara Podvysotska,*** *PhD in Economics,*
*National University "Kyiv-Mohyla Academy"*

# ECONOMETRIC METHODS OF HEALTHCARE SYSTEM EFFICIENCY ESTIMATION

*Our investigation is motivated by the fact that Ukraine and most other CEE and CIS countries launched reforms of their health-care system. The demand for these reforms was caused by high ratio of health-care expenditures (as percent of GDP) as well as by low health output. For example, in Ukraine health-care expenditures, as a share of GDP, are comparable to the EU level, while life expectancy at birth is by 10 years lower than in EU, mortality from tuberculosis is 20 times higher, and child mortality is 2,5 times higher. Therefore the goal of this investigation is to estimate and analyze efficiency of health-care systems using econometric methods and identify relevant policy instruments to improve efficiency of health-care reform.*

***Keywords:*** *econometric methods, efficiency estimation, healthcare reform.*

***Bibliog.*** *9.* ***Table:*** *1.*

***Подвисоцька Тамара,*** *к.е.н., Національний університет*
*«Києво-Могилянська академія»*

## Економетричні методи оцінки ефективності систем охорони здоров'я

*Дослідження мотивовано тим, що в Україні та більшості інших країн Центральної і Східної Європи та СНД відбувається реформування систем охорони здоров'я. Необхідність реформ викликана високим рівнем витрат на охорону здоров'я (відсоток від ВВП), а також низькими результатами показників здоров'я. Наприклад, в Україні рівень витрат на охорону здоров'я (частка від ВВП) порівнюваний з рівнем ЄС, у той час як очікувана тривалість життя при народженні на 10 років менша, ніж в ЄС, смертність від туберкульозу в 20 разів вища, дитяча смертність у 2,5 разів вище від середнього по ЄС. Тому метою даного дослідження є оцінка та аналіз ефективності системи охорони здоров'я із застосуванням економетричних методів моделювання та виявлення відповідних інструментів політики для підвищення ефективності реформи охорони здоров'я.*

***Ключові слова:*** *економетричні методи, оцінка ефективності, реформа сектору охорони здоров'я.*

***Подвысоцкая Тамара,*** *к.э.н., Национальный университет*
*«Киево-Могилянская академия»*

## Эконометрические методы оценки эффективности систем здравоохранения

*Исследование мотивировано тем, что в Украине и большинстве других стран Центральной и Восточной Европы и СНГ происходит реформирование систем здравоохранения. Необходимость реформ вызвана высоким уровнем расходов на здравоохранение (процент от ВВП), а также низким результатом основных показателей здоровья. Например, в Украине уровень расходов на здравоохранение (доля от ВВП) сопоставим с уровнем ЕС, в то время как ожидаемая продолжительность жизни при рождении на 10 лет меньше, чем в ЕС, смертность от туберкулеза в 20 раз выше, а детская смертность в 2,5 раз выше среднего по ЕС значения. Поэтому, целью данного исследования является оценка и анализ эффективности системы здравоохранения на основе использования методов эконометрического моделирования и выявления соответствующих инструментов политики для повышения эффективности реформы здравоохранения.*

***Ключевые слова:*** *эконометрические методы, оценка эффективности, реформа сектора здравоохранения.*

### Introduction

Ukraine and several other countries in the region recently initialized reforms of their health-care system. The need for reform is obvious, given high ratio of health-care expenditures (as ratio of GDP) accompanied by relatively low health output. For example, in Ukraine life expectancy at birth

is by 10 years lower than in EU, mortality from tuberculosis is 20 times higher, than in EU, and child mortality is 2,5 times higher (Program of Economic Reforms for 2010-2014 in Ukraine). Therefore of top priority task is determination effective policy instruments to use for health-care system reform, as well as tools for health-care reform outcome measurement. In our paper we aim to provide relevant outcomes for both issues.

Measuring efficiency in health care is not a simple task, as health outcomes are not directly related to health expenditure (Nemec, J., Chubarova, T., 2008) There have been several attempts to evaluate the efficiency of healthcare systems, focusing on various aspects and using different methods. The last one was done by WHO in 2001, focusing on main performance dimensions – equitable access (fairness), health status of inhabitants and costs, but Ukraine was not in the focus. Now when after 20 years of independence Ukraine started its reforms, assessing the outcomes of health reforms is very important, both in terms of evaluation of current situation and for adjusting further steps of reform.

**Objectives:**

– Estimate the efficiency of health-care systems in countries of CEE, CIS and compare them against the results for other European nations;

– Identify important policy-relevant instruments to increase efficiency of health-care systems;

– Estimate outcomes of the projected health-care reform in Ukraine.

**Practical contribution of research**

Evaluation of CEE and CIS health-care efficiency against other European countries could uncover additional peculiarities and specific features of the region, which could be relevant for policymakers.

Besides, we will analyze the relation between efficiency of health-care systems and state of controllable health-care policy variables, such as density of hospitals, surgeons, percentage of private health expenses, introduction of mandatory health insurance etc.

Empirical investigation of such issues would be of interest to Ukrainian policy-makers as well as policy-makers from other CIS and CEE countries.

**Hypotheses**

We developed initial set of hypothesis which we are going to test in our investigation:

– Efficiency of health-care systems in CEE and CIS is somewhat lower than in Western European countries, due to inefficient use of financial resources;

– Switching from general taxation to health insurance improves/deteriorates efficiency of health-care system;

– Relation between number of doctors and number of hospitals and health-care efficiency is non-linear;

As our investigation proceeds, we will add additional hypothesis into our analysis.

**Literature review**

Evans David, Tandon Ajay, Murray Christopher et al. (2000) were among the first to analyze efficiency of health-care system in the way comparable across countries and periods. They adapted stochastic "error components" frontier model, firstly introduced by Aigner et al. (1977) and Meeusen and van den Broeck (1977) for determining economic efficiency of health-care systems across 191 countries. Authors used disability-adjusted life expectancy (DALE) as the output of health-care system; health-care expenditures per capita was used as controllable input into health-care system, education (years of schooling) was used as controllable variable outside health-care system. Although this paper started comparable efficiency-analysis of health-care systems, it is difficult to infer policy-relevant conclusions to support reforms from their approach.

Tandon et al. (2001) introduced composite index as a measure of health-care system output. Their index included the following components (weights in parenthesis): health as measured by DALE – disability-adjusted life expectancy (25%), health inequality (25%), responsiveness level (12.5%), responsiveness-distribution (12.5%), fair-financing (25%). This paper is basically an extension of the previous one, as it replaces a single-variable output (DALE) with a composite index. The problem about lack of inference for policy-makers remains.

Kok Renske and Koolman Xander (2003) analyze process utility, as opposed to (health) outcome utility. Main argument in favor of process utility is that a large share of overall health care expenditures is used to satisfy patients' wishes, even though it may have no direct health outcomes. The au-

thors use WHO Multi-country Survey Study on Health and Responsiveness 2000-2001 (data on 67 countries available), and apply hierarchically ordered probit (HOPIT) model to estimate the responsiveness score for the countries in the dataset. The paper concentrates on responsiveness of health-care system, which is a vital health-care output, although it is based on data which is not available on regular basis, and hence cannot be used to analyze dynamics of a health-care system efficiency and control outcomes of health-care reforms.

McGlynn Elizabeth et al. (2008) is a comprehensive overview of micro-level outputs and inputs relating to health-care system elements (hospitals, physicians, surgeons etc.) Specific and vigorous approaches presented in this paper could be applied specifically to Ukraine and other CIS countries in case relevant micro-level data is available.

Our investigation is aimed to contribute policy-relevant analysis on macro-level (and, probably, on micro-level). as it concentrates on the dependence of economic efficiency and controllable health-care policy variables.

**Methodology**

**Data**

*Types of variables*

For our investigation, four types of variables are required. The first three types of variables are needed, following Evans et al., 2000, to estimate the frontier function: first are outcome indicators that represent output of the health system; second are health-system inputs used to produce the outputs; third are controllable non-health-system (or external to health care system) determinants of health.

Also we add the fourth type of variables into our investigation – policy variables, which relate to the health-care system and could explain efficiency differentials among countries and across time-periods.

Table 1

**Suggested indicators by group of variables**

| Outcomes | Inputs | External determinants | Policy variables |
|---|---|---|---|
| – Disability-adjusted life expectancy<br>– Standardized death rate<br>– Infant mortality rate<br>– Child mortality rate<br>– Maternal mortality rate<br>– Incidence of tuberculosis<br>– Composite index | – Total health expenditure per capita<br>– Public health expenditure per capita<br>– Private health expenditure per capita<br>– Expenditures by item (salaries, medicine, capital expenditures) | – Education<br>– Ecology<br>– Political stability | – Model of financing (insurance-based VS general taxation)<br>– Ratio of public to private expenditures<br>– Ratio of out-of-pocket payments<br>– Number of doctors per 100000 population<br>– Number of hospital beds per 100000 population<br>– Average hospital stay period |

*Source: compiled by the author.*

*Outcomes.* We plan to estimate separate equation for each of the outcomes (the list of outputs from Nemec and Chubarova, 2007), as well as for composite index (equally-weighted or weights based on expert estimations), constructed from several outcomes.

*Inputs*. According to Evans et al, 2000, health expenditure per capita has an advantage, as it allows us to interpret efficiency more broadly – as both technical and allocative efficiency, which are jointly referred to as 'economic efficiency'.

*External to health system variables*. Education – proxied by average years of schooling; ecology – by volume of $CO^2$ emissions; political stability – by Index of political instability.

*Policy variables.* Will be used to explain efficiency differentials. Most are readily available from selected data-sources.

*Sources of data*

Main sources of data are the European 'Health for All' (HFA) database of WHO and Trans-MONEE dataset of United Nations Children's Fund (UNICEF).

'Health for All' database 2009, prepared by World Health Organization, includes data on 50 European countries over period of 40 years (years 1970 to 2009). Database includes both output and

input health-care variables, as basic main socio-economic and demographic indicators. Database is ready to use for the efficiency analysis outlined in this proposal.

TransMONEE data-base includes data on CEE and CIS countries, covers broader range of socio-economic and demographic data for the region.

There are options on micro –level data-sets:

Demographic and Health Survey 2007 (Ukraine) – a nationally representative survey of 6841 working-age women and 3178 working-age men covering various health, fertility, demographic and other socio-economic issues.

Medstat official operating data on Ukrainian hospitals – covers data on more than 250 hospitals for time-span above 10 years. Data is not readily available, requires commercial contract with the responsible agency.

**Theoretical Model**

We design analysis based on SFA – stochastic frontier analysis (also known as "error component" model), as related to health-care system by Evans et al. (2000):

$$Y_{it} = \alpha + X_{it}'\beta + v_{it} - u_i, \quad (1)$$

Where $X_{it}$ is a vector of inputs and $v_{it}$ is the error term with mean zero. The term $u_i \geq 0$ is a random variable representing country-specific technical efficiency, and is constrained to be always non-negative. Technical efficiency is defined as ratio of expected value of observed output to the expected value of output when $u_i$=0:

$$TE_i = \frac{E(Y_{it}|u_{it}, X_{it})}{E(Y_{it}|u_{it} = 0, X_{it})}, \quad (2)$$

The denominator represents the frontier since technical inefficiency term takes the value of zero. It is usually assumed, given that the joint term *(v – u)* is observed, that non-negative *u*'s come from half-normal distribution (alternatively – truncated normal, exponential or gamma).

Equation (1) can be rewritten as:

$$Y_{it} = \alpha_i + X_{it}'\beta + v_{it}, \quad (3)$$

where the intercept $\alpha_i=(\alpha-u_i)$ is country-specific, its estimates can be found using fixed-effects. In order to provide that all estimated $u_i$*'s* are positive, the country with the maximum $\alpha_i$ is assumed to be the reference and is deemed fully efficient. In other terms:

$$\hat{\alpha} = \max\left(\widehat{\alpha_i}\right), \quad (4)$$

$$\widehat{u_i} = \hat{\alpha} - \widehat{\alpha_i}, \quad (5)$$

Estimation

Macro-Level Estimation

We plan to apply two-stage analysis in our paper in order to estimate efficiency of health-care systems of different countries with focus on Central and Eastern Europe (CEE) and Commonwealth of Independent States (CIS) countries (the two steps are detailed below):

*Step 1*: estimate of stochastic frontier analysis model, calculate efficiencies. Proposed estimation model (developed from Evans et al., 2000):

$$H_{it} = \alpha_i + \bar{\gamma}\bar{D} + \bar{\beta}_1 F_{it}\bar{D} + \bar{\beta}_2 E_{it}\bar{D} + \bar{\beta}_3\left[\left(F_{it}\right)^2\bar{D} + \bar{\beta}_4\left[\left(E_{it}\right)^2\bar{D} + \bar{\beta}_5 F_{it}E_{it}\bar{D} + v_{it}\right.\right.\right., \quad (6)$$

Where Hit – is an output of health-care system (e.g. disability-adjusted life expectancy – DALE), F1 – input into health-care system proxied by health-care expenditures per capita, E2 – controllable variable outside health care system, effecting health outcome (e.g. education). D – a vector of dummies for CIS and CEE countries. $\alpha_i$ – variable that is a combination of true intercept and inefficiency term, as in (5).

The equation is a translog model, which is a second-order Taylor-series approximation of an unknown functional form; can be used to estimate both Cob-Douglas and Constant Elasticity of Substitution production functions.

After estimation, we will obtain efficiencies for each observation in the sample, using formulas (4) and (5).

*Step 2*: regress efficiencies, obtained with step 1, on policy-relevant variables. Proposed estimation equation (fixed-effects model):

$$e_{it} = F(X_{it}; Y_{it}, v_{it}), \quad (7)$$

Where, $e_{it}$ is efficiency of health-care system of country $i$ in period $t$; $X_{it}$ – here vector of health-care policy relevant variables; $Y_{it}$ – vector of other factors which are determinants of health outside the health-care system, such as for example education.

**Conclusion**

It is hoped that outcomes would help to test hypotheses presented above, and thus provide factual evidence for policy-makers as for usefulness of certain planned elements of health-care reform.

We expect that the significance and signs of the estimated coefficients will be consistent in most cases with those observed in other EU and CEE countries. It is expected, however, that some specific features of the CIS and CEE health care systems adjustment will also be reflected in this study, and thus we expect to contribute to the debate about the difference of the CEE and the CIS countries and to the careful healthcare policy design in Ukraine.

**Bibliography**

1. Aigner D, Lovell K, Schmidt P. (1977). *Formulation and Estimation of Stochastic Frontier Production Function Models*. Journal of Econometrics. 1977; 6: 21-37.
2. Evans David, Tandon Ajay, Murray Christopher et al. (2000). *The Comparative Efficiency of National Health Systems in Producing Health: an Analysis of 191 countries*. Geneva, Switzerland. WHO, 2000.
3. Kok Renske and Koolman Xander (2003). *Health Care System Process Utility Compared: A Hierarchical Ordered Probit Regression Analysis*. Erasmus University Medical Center, Rotterdam.
4. Lekhan Valeria, Rudiy Volodymyr, Nolte Ellen. (2004). *Health Care Systems in Transition: Ukraine*. Copenhagen. WHO Regional Office for Europe.
5. Meeusen W, van den Broeck J. *Technical Efficiency and Dimension of the Firm: Some Results on the Use of Frontier Production Functions*. Empirical Economics 1977; 2(2): 109-122.
6. McGlynn Elizabeth et al. (2008). *Identifying, Categorizing, and Evaluating Health Care Efficiency Measures*. AHRQ Publication No. 08-0030. RAND Corporation under contract to the Agency for Healthcare Research and Quality (AHRQ).
7. Nemec Juraj and Chubarova Tatiana (2007). *Health Policies in CEE region: Selected Constraints*. Matej Bel University Banska Bystrica, Slovakia, Academy of Sciences, Moscow. Working paper.
8. Tandon Ajay et al. (2001). *Measuring Overall Health System Performance for 191 Countries*. WHO.
9. Ukrainian Center for Social Reforms (UCSR), State Statistics Committee (SSC) [Ukraine], Ministry of Health (MOH) [Ukraine], and Macro International Inc. (2008). *Ukraine Demographic and Health Survey 2007*. Calverton, Maryland, USA: UCSR and Macro International.
10. Програма економічних реформ на 2010 – 2014 роки: Заможне суспільство, конкурентоспроможна економіка, ефективна держава (2010). Комітет з економічних реформ при Президентові України.– Київ.

*Стаття надійшла до редакції 14. 04. 2014 р.*