PalArch's Journal of Archaeology of Egypt / Egyptology

A NEXUS BETWEEN COST EFFICIENCY AND COST PRODUCTIVITY: A CASE STUDY OF HEALTH SYSTEMS OF DEVELOPED COUNTRIES

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Balqees Naser Almessabi: A Nexus between Cost Efficiency and Cost Productivity: A Case Study of Health Systems of Developed Countries -- Palarch's Journal of Archaeology of Egypt/Egyptology, ISSN 1567-214x

Keywords: Cost Efficiency, DEA, Cost Malmquist Index, Truncated Regression

ABSTRACT
The aim of the paper is to investigate cost efficiency and cost productivity growth of the nationalhealth systems from developed countries. The study employed an input oriented Data Envelopment Analysis (DEA) to measure the cost efficiency of the health systems using data on infant mortality rate, under five mortality rate and life expectancy at birth as health outcomes for the period 2011-2017 in developed countries. In the second part of the study cost Malmquist Total Factor Productivity index based on data envelopment analysis is used to assess health cost productivity changes over the same period for each country. Factors affecting the cost efficiency and cost productivity is also determined by using bootstrap truncated regression. The empirical results show that the health systems of developed countries are cost efficient with score 0.804. However, there is decline in cost productivity of the health system of these countries with 3.9 percent rate. The result of truncated regression show the significant effect of all the environmental factors.The results are useful for policy-makers in designing long-term health reform plan aimed to improve the performance of the health systems.

I. INTRODUCTION

Health is obviously among the most valuable assets people can have. Health is the capability to live anactive, breathing and full life. It is the upshot of a multifaceted interactionbetween human genetic, the environment people live in, the society people are part of and their lifestyles (Papanicolas and Smith, 2013). Thus, health systems are not at thesource of health, but they play anessential role to preserve and improve the health. Therefore, it is so important to make sure that health systems perform at their best. For this, it is needed tounderstand how they work: this is the aim of health systems performanceassessment. Knowing how health systems work is always requisite. However, it is even more imperative in these times of economic chaos and financialrestraints. Healthcare costs has grown progressively in most developed countries, and governments are becoming increasingly concerned in achieving higher levels of efficiency, matching financial sustainability with high quality delivery of healthcare.

The comparison of health system performance is indeed becoming graduallypredominant, driven by growing demand for transparency and accountability. It can be one of the most influential drivers of health systems improvement by inducingpolicy-makers. However, if the comparison is partial or depend on inadequate analysis, it can give rise to seriously misleading signals, resulting in inappropriate policy responses. It is therefore essential that – if the full potential of comparison is to be realized – policymakers and analysts need to be made aware of the associated opportunities and pitfalls. This study offers an important comparison of health systems of developed countries. This study not only evaluated the technical, allocative and cost efficiency but cost productivity is also calculated with their determinants. The findings of this study arealso determine the nexus between cost efficiency and cost productivity of health system. The study offers a rich source of material for policymakers, their analytic advisors, academics and students of health systems.

Literature Review

Measuring the efficiency and productivity of health systems is the first step in elaborating and implementing new health policies. Furthermore, regional or international comparison of efficiency is a key lever forchange in health policy and in the provision of public services. According to Tandon et al. (2003),measuring efficiency in the health system over time could be also useful in assessing how reformsundertaken have impact upon the technical and allocative efficiency of the system. This is one reasonto measure efficiency and productivity of developed countries health systems.Secondly, measuring and comparing efficiency represents a way to assess the rational distribution ofhuman and economic resources.Due to the health data provided by World Health Organization (WHO), there are many studies regarding the efficiency of health systems focusing on developedeconomies. Hitiris and Possnett (1992), Babazono and Hilman (1994), Elola et al. (1995), DeRosario(1999), Or (2000a; 2000b), Berger and Messer (2002), Retzlaff-Roberts et al. (2004), Afonso and St.Aubyn (2006), Raguseo and Vlček (2007), Asiskovitch (2010), and Tchouaket et al. (2012), amongothers, have studied the efficiency of health systems in developed economies. Evans et al. (2000), Selfand Grabowski (2003), and Rajkumar and Swaroop (2008) extended their cross-section analysis to awider sample of both developed and developing countries. However, no study is found related to cost efficiency and cost productivity with their determinants in the literature.

An increasing number of studies have used DEA and Stochastic Frontier Analysis (SFA) in order to measure and compare efficiency across countries: Hollingsworth and Wildman (2003),Retzlaff-Roberts et al. (2004), Afonso and St. Aubyn (2006), Joumard et al. (2010), Hadad et al.(2011), and Sinimole (2012). Retzlaff-Roberts et al. (2004) used the DEA approach in order to assessthe technical efficiency of the utilization of health resources of OECD countries. They found that 13 of27 OECD countries were on the efficiency frontier and concluded that a country's health outcomes arenot necessarily indicative of how efficiently it uses its health resources. Afonso and St. Aubyn (2006)undertook an analysis of health system efficiency in 21 OECD countries. The study found thatcountries could increase their output by 40 percent using the same resources. Joumard et al. (2010)measured the efficiency of health care spending in 29 OECD countries. They found that technicallyinefficient countries could improve their life expectancy at birth by more than two years on average,maintaining health care spending constant.

In the previous years, a few studies have been conducted in order to measure and compare the efficiency of health care systems from developing countries. Kirigia et al. (2007), Bhalotra (2007),Mirmirani et al. (2008), Anyanwu and Erhijakpor (2009), and Gani (2009) have studied the efficiencyof health systems in developing economies from different area of the world.

Kirigia et al. (2007) assessed the technical efficiency of National Health Systems of 53 African continent countries using a DEA approach and evaluated the changes in health productivityover time. The production function used two outputs (male and female life expectancies) and twoinputs (per capital total health expenditure and adult literacy). They found that more than 90% of thecountries analyzed run inefficiently during the period 1999-2003. Based on Malmquist Total FactorProductivity (MTFP) they reported that all the national systems registered improvements in Total Factor Productivity due to technical progress.The differences in the efficiency of health care systems between two different region have been documented by Verhoeven et al. (2007), Jafarov and Gunnarsson(2008), Mirmirani et al. (2008), and Grigoli (2012). Verhoeven et al. (2007) found that CEE countriesin comparison to the OECD member states achieve low health outcomes with high real resourcecombinations. Jafarov and Gunnarsson (2008) studied the efficiency of government spending onhealth care and education in Croatia by using Data Envelopment Analysis (DEA). Mirmirani et al.(2008) assessed the health care efficiency in eight transition economies from CEE and a virtual unit(OECD countries, in average) for the period 1997-2001 and found that the most efficient systems arein Albania and Armenia. On the other hand, the least efficient systems for the period 1997-2001 wereRussia and Belarus, followed by Latvia and Romania. Grigoli (2012) also found that Slovak Republicis inefficient in converting the low levels of health spending into health outcomes.

This paper contributes to the extant literature through the following: first, this study used current data to estimate the cost efficiency and cost productivity of the health system. Second, this study first time evaluate the cost productivity of the health systems by using DEA models. Third, Cost Malamquist Productivity Index first time applied in the evaluation of the cost productivity of health system in this study. Fourth, this study first time used the bootstrap truncated regression to find out the determinants of cost productivity.

1.3 Methodology

In the literature there are four different classes of technique to measure efficiency of health care systems, each of them having own advantages and limitations: parametric techniques (regressionbased approaches); non-parametric techniques; deterministic methods and stochastic methods. In order to investigate cost efficiency and cost productivity change of the national health systems from developed countries, an input-oriented DEA and a DEA-based cost Malmquist index calculation have beenemployed in this paper.

Data envelopment analysis (DEA) has been introduced by Charnes et al. in 1978 and extended by Banker et al. (1984). Despite its limitations (see Spinks & Hollingsworth (2009) and Jacobs (2006)) , DEA has become very popular in the analysis ofproductivity efficiency in many areas: schools, hospitals, bank branches, production plants, etc. DEAhas been extensively applied in evaluating the health production efficiency at the micro level (such ashospital efficiency) and at the macro level of a country or a region.

DEA represents a linear non-parametric method used to measure efficiency of a homogenous set of Decision Making Units (DMUs). The efficiency score in the presence of multiple input andoutput factors can be computed as (Sinmole, 2012):

Efficiency = weighted sum of outputs / weighted sum of inputs.

The most widely used DEA models are CCR and BCC. The CCR model, developed byCharnes, Cooper and Rhodes (1978), had an input orientation and assumed that production is constant return to scale (CRS). The BCC model, elaborated by Banker, Charnes and Cooper (1984), assumes that production is variable return to scale (VRS). In this study, the BCC model with input orientation is used to estimate the cost efficiency. According to Farrell, cost efficiency is the product of technical efficiency and allocative efficiency. Technical efficiency represents the ability of a firm (or an entity) to obtain maximum feasible output from a given amountof inputs, or, alternatively, to use the minimum resources to produce a given level of output. A DMU is considered technically efficient if it lies on the efficient frontier. DMUs below the frontier are considered the inefficient units.While,the allocative efficiency represent the optimal allocation of resources in the production process. The value of efficiency score ($z \leq 1$) obtained represents the efficiency score for each DMU. A score of 1 will indicate an efficient DMU situated onthe frontier, while a score less than 1 implies that the DMU is inefficient.

Cost efficiency is calculated by solving the following linear program:

$$Min_{\lambda,zCE} \qquad Z_{CE}$$

s.t.

$$\lambda.Y \geq y_0$$

$$\lambda.C \leq Z_{CE}$$

$$\lambda_i \geq 0$$

$$\lambda.i = 1$$

Where

Y= It is matrix of dimension n × m of outputs

λ= It is a matrix of dimension 1×n of intensity variables.

C= It is a matrix of dimension n×1 of costs.

CE= it is a scalar demonstrating a country's cost level

i= it is a column vector of 1s.

The decomposition into allocative and technical components can be accomplished by first solving the following linear program, which gives the input oriented technical inefficiency component:

$Min_{z,u} u$

Subject

$z.Y \geq y_o$

$z.X \leq x$

$z_i \geq 0$

$$\sum_{i=1}^{n} zi = 1$$

Now it is simple to calculate the allocative efficiency by AE = CE/TE

In order to assess the changes in health productivity over the period 2011-2017, the study employed cost Malmquist Total Factor Productivity (MTFP) index, introduced byManiadakis and Thanassoulis (2000, 2004).Early estimations of dynamic technical productivity ignored input prices and hence, allocative efficiency. The allocative efficiency has to do with how a technically efficient firm can further reduce aggregate cost of securing its outputs by selecting an optimal mix of inputs given their associated costs. Since allocative efficiency and its change can significantly affect dynamic productivity it should be factored into cost efficiency dynamics (Thanassoulis et al., 2015).the classical technical Malmquist productivity index of Fare et al., (1992, 1994) was proposed when inputs and output quantities, but not their prices, are available. Maniadakis and Thanassoulis (2000, 2004) extended the technical Malmquist index to cost Malmquist productivity index (CMPI) using nonparametric DEA models and decomposed it into cost (overall) efficiency change and cost technical change. The cost (overall) efficiency change can further be decomposed into technical efficiency change (TEC) and allocative efficiency change (AEC), both capturing cost whilst the cost technical change can be broken down into the standard technical change (TC) and price effect (TC). The CMPI is better defined in terms of cost rather than inputs distance functions or input efficiency scores and is useful when managers minimize costs give input price data.The overall the decomposition of the cost Malmquist productivity index is as follows:

$CM = \Delta PTE \times \Delta SE \times \Delta T \times \Delta AE \times \Delta PE$

where

ΔPTE = pure technical efficiency change;

ΔCSE = cost scale efficiency change

ΔT = technologicalchange;

ΔAE = allocative efficiency change;

ΔPE = price effect change

Values of the above five components greater than unity suggest deterioration, while values less than 1 suggest the improvement. Computing and decomposing the cost Malmquist productivity index CM requires the computation of the minimum cost function under both VRS and CRS technologies. For the kth decision making unit (DMU) $C_v^t(y^t, w^t)$ is computed from the following linear programming problems.

$$\min_{x,\gamma} w_{k_n}^{t} x_n = (y^{t+1}, w^{t+1})$$

sub.

$$\sum_{j=1}^{J} \gamma_j y_{j_m}^{t} \geq y_{k_m}^{t+1}$$

$$m = 1.2, \ldots M;$$

$$\sum_{j=1}^{J} \gamma_j x_{j_n}^{t} \geq x_{kn}$$

$$n = 1.2, \ldots N$$

$$\sum_{j=1}^{J} \gamma_j \geq 1, \gamma_j \geq 0, x_n \geq 0$$

Other cost functions, $C_v^{t+1}(y^{t+1}, w^{t+1}); C_v^{t+1}(y^{t}, w^{t+1}); C_c^{t+1}(y^{t+1}, w^{t+1})$ and $C_c^{t+1}(y^{t}, w^{t+1})$ similarly obtained with and without the constraint $\sum_{j=1}^{J} \gamma_j = 1$. This method is an excellent contribution, but it did not deal with the exogenousenvironmental variables and noises.

In the second stage, the computed DEA efficiency and CMPI scores section is regressed against some environmental factors. The literature indicates that some of the factors that impact health system efficiency. A variety of regression techniques have been applied. Following specification has been formed.

$$Y_J = \alpha + Z_J \delta + \varepsilon_J \ldots\ldots\ldots J = 1, \ldots\ldots n$$

In the above equation α is the intercept and ε_J is the error term and z_J is a row vector of country specific variables with J supposed to relate to country inefficiency scores and CMPI (Y) via the vector of parameters δ (same to all J) needing our estimation. Following Asbu( ), the VRS DEA efficiency scores are transformed into inefficiency scores, left-censored at zero using the formula:

Inefficiency score = (1/Efficiency Score)-1

Tobit model has been used widely in the DEA literature for the estimation of model, however Simar and Wilson (2007) pointed out that such technique has been inappropriate. They suggested another technique which depends upon truncated regression with bootstrap and it has been found satisfactory in its performance during Monte Carlo experiments. So, in present study this technique has been used. It may be noted that the distribution of ε_J has been restricted with the condition $\varepsilon_J \geq 1 - \alpha z_J \delta$ (as both sides of the equation are restricted by unity), Simar and Wilson (2007) advancements have been used and assumed that distribution is truncated normal with a zero mean (before truncation), unknown variance and a (left) truncation point determined by this very condition. LikewiseYj, has been replaced by its DEA estimate $\hat{Y}_j$.

Data and Variables

One of the most important issues in conducting a cost efficiency study using DEA is the choice of the appropriate health production input and output variables. The most frequently usedoutputs (or health status) variables are life expectancy at birth, infant mortality and the under-5 (child)mortality rate (the probability of dying between birth and age five years expressed per 1,000 livebirths). In addition, some studies are using other health outcomes such as QALY (Quality-AdjustedLife Year), DALY (Disability-Adjusted Life Year), HYE (Healthy-Years Equivalent), HALE (Health-Adjusted Life Expectancy), SDR (standardized death rates), maternal mortality rate and incidence oftuberculosis. For example, Elola et al. (1995) employed as dependent variables infant mortality andlife expectancy and premature mortality by sex. Or (2000a, 2000b) used in his studies potential yearsof life lost (PYLL). Self and Grabowski (2003) and Evans et al. (2000) selected DALE (Disability-Adjusted Life Expectancy) as the most representative dependent variables.

The main categories of input that determined the population health status as resulted from the most important previous studies (Joumard et al., 2008 and OECD, 2010) are: health care resources measured in monetary terms or in physical terms; lifestyle factors; socio-economic factors.

In this study, the selection of input and output variables based on three restrictions. First, selected variables can be influenced easily and directly through a policy reform: numberof physicians per thousand population, number of beds per thousand population, number of nurses & midwives per thousand and total health expenditure percentage of GDP (as input prices). These four inputvariables represent two important resources for health sector: human resources and financial resources.Secondly, as in the most previous analyses at the system level, study used three outputs: infant deaths per1,000 live births and life expectancy at birth in years, and under 5 mortality rate. Infant mortality represents an outcome of ahealth system and, in the same time, an indicator of inequality in access to resources. Life expectancyat birth reflects the global result of the health system of a country. Thirdly, the reason for this choice is given by the fact that the data for these countries areprobably the most complete and comparable and are available for a long period of time (2011-2017).

In the second part of the study the estimated efficiency scores and CMI were analyzed by regressing them against a set of environmental factors. These included the per capita GNP, immunization, literacy rate, out of pocket health expenditures, population, unemployment.The models for second stage analyses are constructed as:

$$Y_{i.t} = C + pcGNP_{i.t} + IMU_{i.t} + LR_{i.t} + OOP_{i.t} + POP_{i.t} + UR_{i.t} + e_{i.t}$$

This analysis uses annual dataregarding health system inputs and outputs for 36 developed countries. The data related to the factors taken from World Health Organization (WHO).

1.4 Result

In the first stage, a DEA model estimated with the seven years of data jointly. Such pooling of the data over time is a frequent practice in DEA estimation and offers the advantage of a substantial increase in the sample size which is important for obtainingreliable estimates of efficiency (Zelenyukand Zheka, 2006).

1.4.1 Descriptive Statistics

Table 1 shows the descriptive results of the inputs, outputs and environmental factors in this study. Over the seven year period, there is variation in all the factors of the study.

Table 1: Descriptive Statistics of Inputs/Outputs and Environmental factors

Outputs and Inputs Factors		Mean	S. D.	Max	Min
Outputs	Life Expectancy at Birth	79.61	2.80	83.10	73.78
	Infant Mortality Rate	89.54	12.62	100.00	56.14
	Under 5 Mortality Rate	4.29	1.61	9.30	2.20
Inputs	Physician / 1000	3.25	0.87	6.20	2.04
	Beds / 1000	5.04	1.67	8.25	2.70
	Nurses & Midwives / 1000	8.72	3.90	16.05	3.45
Input Prices	Public Health Expenditures	6.76	1.57	9.43	3.43
Environmental Factors					
	Total No. of Population	28201645.83	55757472.93	309348193.00	318041.00
	Literacy Rate	99.38	0.64	99.95	97.87
	Out of Pocket Health Expenditures	19.46	9.06	45.37	5.27
	Per Capita GNP	35551.97	20499.97	88583.02	6700.70
	Unemployment Rate	21.29	9.89	46.20	7.70
	Immunization	95.06	4.55	99.00	76.00

1.4.2 Level of Cost Efficiency

When theseven years pooled data together using one production frontier, the study found that the national health systems of 36 countries are efficient (Table 2). The mean value of cost efficiency score (0.804) indicates that in the health systems of developed countries, 81 percent healthcare resources are cost minimizing inputs. It is due to efficient utilization (96 percent) and optimal allocation (84 percent) of given resources.

As can be observed in Table 2, the health system of 13 (36 percent) countries (Bulgaria, Croatia, Cyprus, Greece, Hungary, Ireland, Japan, Lithuania, New Zealand, Poland, Romania and Sweden) were allocative and costly efficient with score equal to one during the period 2011-2017. These countries are followed by Spain, France, United States, Denmark, Austrailia, Finland, Latvia, Italy, Netherlands and Portugal which aresituated on the efficient frontier (TE=1).While, ten out of thirty six countries have costly inefficient health system (CE<0.70). Among these, the health systems of Czech Republic and Austria are highly inefficient (CE<0.50). Similarly, health system of ten countries are in the range allocative inefficiency. On the other hand, health systems of all the developed countries are in the range of technically efficient as shown in Table 1.

Table 2: Technical, Allocative and Cost Efficiency Scores

DMUs	TE	AE	CE
Australia	1.000	0.844	0.844
Austria	0.791	0.603	0.477
Belgium	0.889	0.954	0.848
Bulgaria	1.000	1.000	1.000
Canada	0.971	0.849	0.824
Croatia	1.000	1.000	1.000
Cyprus	1.000	1.000	1.000
Czech Republic	0.768	0.622	0.478
Denmark	1.000	0.869	0.869

Estonia	0.914	0.922	0.843
Finland	1.000	0.726	0.726
France	1.000	0.930	0.930
Germany	0.799	0.941	0.752
Greece	1.000	1.000	1.000
Hungary	1.000	1.000	1.000
Iceland	0.981	0.568	0.557
Ireland	1.000	1.000	1.000
Italy	1.000	0.596	0.596
Japan	1.000	1.000	1.000
Latvia	1.000	0.716	0.716
Lithuania	1.000	1.000	1.000
Luxembourg	0.925	0.545	0.504
Malta	0.789	0.888	0.700
Netherlands	1.000	0.586	0.586
New Zealand	1.000	1.000	1.000
Norway	0.920	0.570	0.524
Poland	1.000	1.000	1.000
Portugal	1.000	0.526	0.526
Romania	1.000	1.000	1.000
Slovak Republic	0.977	0.647	0.632
Slovenia	0.815	0.617	0.503
Spain	1.000	0.984	0.984
Sweden	1.000	1.000	1.000
Switzerland	0.993	0.864	0.858
United Kingdom	0.963	0.775	0.747
United States	1.000	0.914	0.914
Average	0.958	0.835	0.804

Source: Author's Calculation

1.4.3 Cost Productivity

The Table 3 shows the average (GM) value of the CMPI scores. It is observed that health system of developed countries regress with the rate 3.9 percent during the study period. This regression is attributed by the regression of technical factor productivity change, classical Malmquist productivity index, efficiency change, and allocative efficiency change. Except2011-12, there is regression in the cost productivity of the healthcare system of developed countries in all the period of the study. In 2011-12, 19.6 percent growth is found in the cost productivity of the health system while higher level decline (7.6 percent) is found in the cost productivity of the healthcare system of developed countries in 2013-14.

Table 2: Summary of Annul Geometric Mean of Cost Malmquist Index

YEAR	EFFCH	TECHCH	PECH	SECH	TFPCH	AECH	PCH	CMI	GROWTH
2011-	0.993	0.992	0.990	1.003	0.985	0.921	0.556	0.804	19.6
2012-	1.024	1.007	1.019	1.005	1.032	1.172	0.823	1.035	-3.5
2013-	1.011	0.993	1.019	0.992	1.003	0.983	0.980	1.076	-7.6
2014-	0.998	1.008	0.993	1.004	1.006	0.962	1.006	1.015	-1.4

2015-	1.004	1.012	1.009	0.995	1.015	1.283	1.570	1.045	-4.5
2016-	0.985	1.038	0.982	1.003	1.022	0.862	1.094	1.064	-6.4
G.M.	1.002	1.008	1.002	1.000	1.010	1.020	0.958	1.039	-3.9

Source: Author's Calculation

As for as individual level of cost productivity is concerned (Table 3), there is decline in the cost productivity of the healthcare systems of 22 (62 percent) countries and remaining 14 (38 percent) get growth in their cost productivity during the period under consideration. Higher level decline (>40 percent) is found in the cost productivity of the healthcare system of Italy, Switzerland, and Cyprus. While, higher level (>40 percent) progression is found in the cost productivity of Denmark, Australia, and Romania.

Table 3: Cost Productivity of the Health System of Developed countries

DMUs	EFFCH	TECHCH	PECH	SECH	TFPCH	AECH	PCH	CMI
Australia	0.999	0.987	0.987	1.013	0.986	0.833	0.588	0.483
Austria	1.000	0.985	1.002	0.998	0.985	1.184	1.087	1.268
Belgium	0.970	1.073	0.969	1.001	1.041	1.099	1.132	1.295
Bulgaria	1.001	0.986	1.000	1.000	0.987	0.956	0.817	0.771
Canada	1.076	0.971	1.038	1.036	1.045	1.160	1.071	1.298
Croatia	0.995	0.982	1.005	0.990	0.977	1.171	1.102	1.261
Cyprus	1.001	1.027	1.000	1.001	1.028	1.230	1.159	1.466
Czech Republic	1.053	1.050	1.046	1.007	1.106	1.000	1.062	1.175
Denmark	0.986	1.030	1.000	0.986	1.016	0.826	0.603	0.506
Estonia	0.983	0.979	0.997	0.986	0.963	0.775	0.920	0.687
Finland	1.000	1.023	1.004	0.996	1.024	0.816	1.084	0.906
France	0.982	1.034	0.979	1.004	1.016	0.756	0.729	0.560
Germany	1.000	1.035	1.000	1.000	1.035	1.214	1.107	1.391
Greece	0.967	1.080	0.992	0.974	1.045	1.071	1.077	1.205
Hungary	0.987	1.039	0.988	0.999	1.025	1.005	0.631	0.650
Iceland	1.000	0.968	1.000	1.000	0.968	1.000	0.969	0.938
Ireland	0.982	0.991	0.983	0.999	0.973	1.451	0.716	1.011
Italy	1.000	0.996	1.000	1.000	0.996	1.521	1.162	1.760
Japan	1.047	0.978	1.043	1.004	1.024	0.852	1.167	1.018
Latvia	1.013	0.982	1.013	1.000	0.995	1.152	1.107	1.269
Lithuania	1.010	0.992	1.010	1.000	1.002	1.114	1.009	1.127
Luxembourg	1.022	0.971	1.026	0.997	0.992	0.946	0.987	0.926
Malta	1.043	0.970	1.042	1.001	1.012	1.000	1.147	1.160
Netherlands	1.002	1.004	1.000	1.002	1.006	1.118	1.018	1.145
New Zealand	1.000	0.982	1.000	1.000	0.982	1.012	1.033	1.026

Norway	1.000	0.992	1.000	1.000	0.992	1.000	1.004	0.996
Poland	1.027	0.999	1.026	1.001	1.026	0.877	1.106	0.995
Portugal	1.002	0.987	1.000	1.002	0.989	0.847	1.101	0.922
Romania	1.004	1.056	0.983	1.021	1.060	0.798	0.482	0.408
Slovak Repubc	0.970	1.055	0.974	0.996	1.023	0.800	0.931	0.762
Slovenia	0.978	1.011	1.000	0.978	0.989	1.094	0.755	0.817
Spain	1.000	1.024	0.993	1.007	1.024	1.074	1.044	1.148
Sweden	1.000	1.045	1.000	1.000	1.045	1.079	1.120	1.263
Switzerland	1.014	0.999	1.000	1.014	1.013	1.325	1.108	1.488
United Kingdom	0.979	1.033	0.975	1.004	1.011	1.000	1.047	1.058
United States	1.000	0.988	1.000	1.000	0.988	1.144	1.088	1.229
G.M.	1.002	1.008	1.002	1.000	1.010	1.036	0.980	1.039

Source: Author's Calculation

Components of Cost Malmquist Index

Cost Malmquist Index is the product of technical factor productivity index, allocative efficiency change and price change. The details of these components are explained as under.

Malmquist Productivity Index (MPI)

Similar to the cost productivity, technical productivity of the developed countries declined during the study period. However, the decline in technical productivity is very minimum (1 percent). This decline is associated with negative change in efficiency (0.2 percent) and technology (0.8 percent). At individual level, healthcare system of 21 (58. 33 percent) developed countries have regression in their technical productivity. Among which, healthcare system of Czech Republic and Romania have higher level of decline (>5 percent) in technical productivity. While, among 15 countries, the healthcare system of Iceland and Estonia have higher level of technical productivity (>5 percent). The change in technical productivity is determined by the efficiency change and technological change which are explain as under.

Efficiency change

The healthcare system of developed countries declined on efficiency frontier with the rate 0.2 percent in 2011-17. This decline is determined by the negative change in pure technical efficiency while scale efficiency change remain neutral during the study period. At individual level healthcare system of 14 countries have negative change in efficiency while 11 have positive change. The healthcare system of remaining 11 countries have no change in their efficiency during the study period.

Technological Change

It is observed in Table 2 that healthcare system of developed countries have negative change (0.8 percent) in innovation during the study period. Except in the periods, 2011-12 and 2013-14, there is decline in the innovation in the healthcare systems of developed countries. There is technological regress in the healthcare system of 16 (44.45 percent) developed countries. While, 20 (55.56 percent).

Allocative and Price Change

The last two extended components of CMPI are the allocative change and price change. Allocative change represent the regression or progression in the performance of the management of healthcare system. The overall decline is found in the management of the 36 developed countries during the study period. However there is growth in the allocative efficiency in all the study periods except 2012-13 and 2015-16. The healthcare system of 19 countries have regression in the performance of their management while 5 countries found with no change and 12 countries experienced improvement in the allocative efficiency. As for as price change is concerned, the positive change is found in the input prices during the period under consideration. Whereas, in first three couple of periods, health system of developed countries experienced positive change while in last three pair of consecutive period. At individual level, 25 countries' healthcare system have negative change in input prices while remaining 11 have positive input changes.

1.4.5 Determinants of Cost Efficiency and Cost Productivity

Results from Table 5 show that all of the determinants of cost efficiency and productivity are significant. The per capita GNP significantly and negatively (positively) affects costinefficiency (efficiency). An increase in per capita GNP means more cost efficiency in the healthcare system of developed countries. As for as cost productivity is concerned,per capita GNP significantly and positively affects CMPI. This means an increase in per capita GNP will increase the cost productivity growth of the healthcare system.

The table 5 also shows that the immunization is negatively (positively) related with inefficiency (efficiency) andstatistically significant. While the immunization positively (0.0003) contributed in the cost productivity of the healthcare system of developed countries. The coefficient of the literacy rate is negatively related to cost inefficiency score and statistically significant. This implies that a one percent increase in the literacy would drop the predicted value of inefficiency score. In case of cost productivity index, the coefficient of the literacy rate is positively related and statistically significant.

The coefficient of the out of pocket health expenditurepositively influence thecost inefficiency andnegatively influence their dynamic of cost productivity. It means increase in the private health expenditures in the healthcare system wouldincrease the cost inefficiency and decrease the cost productivity. The coefficient for population has also a negative sign that is consistent with our prior expectation and significant in case cost inefficiency. While in case of cost productivity of the healthcare system, it haspositive sign. The coefficient of the unemployment has positive effect on the cost inefficiency and negative effect on cost productivity of the healthcare system.

Table: Truncated Regression for the Cost inefficiency and Cost Productivity

	Cost Inefficiency			**Cost Malmquist Index**		
		C.I. (95%) Bootstrap			**C.I. (95%) Bootstrap**	
Variables	β	LB	UB	β	LB	UB
Intercept	2.401**	0.793	5.138	-1.942*	-3.241	0.038
Per Capita GNP	0.270***	0.141	4.574	-0.039*	-1.066	0.045
Immunization	-0.015*	-1.033	0.137	0.003*	0.000	0.217
Literacy Rate	-1.429**	-4.169	0.075	1.038**	0.092	3.751
Out of Pocket Health Expenditures	0.016**	0.008	2.261	-0.074**	-1.008	-0.042

Population	-0.627**	-3.914	0.406	1.528*	0.268	2.710
Unemployment	0. 081*	0.006	2.035	-0.417*	-1.035	0.058

CONCLUSION AND DISCUSSION

In this study, a nonparametric method used to analyze the healthcare system cost efficiency and cost productivity in developed countries.Using DEA models it was possible to decompose overall cost efficiencyinto allocative and technical components. The level of cost inefficiency was estimated to lie between 19 to 20%, which suggests that improving the overall efficiency of health system of developed countries could reduce thehealth system costs by reducing almost 20 percent input resources. Approximately, observed inefficiency was due to 4 percent technical and 16 percent allocative inefficiency. It means allocation resources are most cost increasing factor as compare to utilization of the resources. As for as cost productivity is concerned, there is 3.9 percent decline in the cost productivity of developed countries during the study period. This is associated with decline in technical productivity, level of innovation and allocative efficiency. It means healthcare system of developed countries are cost efficient but there is regressive cost productivity.

All the determinants of the cost inefficiency and cost productivity have statistically significant effect. For cost inefficiency, literacy rate has comparatively higher effect. While in case of cost productivity, literacy rate along with population has higher effect. In the light of these findings, developed countries can make their healthcare systems cost efficient and cost productive.