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Cost Productivity of Healthcare Systems in OIC's Member Countries: An Application of Cost Malmquist Total Productivity Index

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ARTICLE DETAILS	ABSTRACT
<p>History Revised format: 30 June 2019 Available Online: 31 July 2019</p> <hr/> <p>Keywords Total Factor Productivity, Cost Malmquist Productivity Index, Health Care, OIC's Member Countries</p> <hr/> <p>JEL Classification: O40, O47, C43, C49</p>	<p>Strengthening healthcare system increases the productivity of healthcare spending. To evaluate changes in cost productivity over a five year period (2011- 2015) in 55 OIC's member states. The cost Malmquist productivity index and bootstrap truncated regression are applied to estimate the dynamics of the cost productivity and its determinants in the healthcare system of OIC's member states. Life expectancy and under 5 child survival rate are used as outputs while doctors, nurses, mid wives and beds per thousand population are used as inputs. Public health expenditure is used as input price for measuring allocative efficiency change. The results of the study indicate that the cost productivity increases by 7.9% and the classical technical productivity grows by 8.9%. The increase in the cost productivity is mainly driven by an increase in allocative efficiency and technological change. All the determinants except population growth rate of cost productivity are found significant. Literacy rate and Per Capita GDP have come up the main driver of cost productivity growth. The study concludes that the impact of population growth on the overall shifts in the health production frontier is not significant.</p>

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1. Introduction

Worldwide comparison of the performance of healthcare system provides the enormous possibility for both within and cross-country learning. The evaluation of relative performance may provide policy-makers a benchmark that identifies in which areas the performance is above or below expectations. Furthermore, it provides them with an impetus to understand driving reported performance, as well as guidance for potential solutions.

Most of the healthcare systems have similar goals and face similar challenges, such as demographic change, limited resources, and rising costs. The developed and developing countries have used diverse strategies to address these challenges and in most the developing countries the existing structures and organizations find them in sufficient to cope with these challenges. Thus, the major advantage of international comparison is to provide information

regarding different experiences or even act as an experimental laboratory for others (1). Furthermore, these comparisons offer the possibility of exploring new and different options; the potential for mutual learning and even policy transfer; and the opportunity to reconsider and reformulate national policy in the light of evidences.

2. Cost Malmquist Productivity Index (Cmpi)

The cost Malmquist productivity index was initially applied by (2) to estimate the cost productivity of 30 Greek hospitals over the period 1992-1993. The major advantage of this approach was to determine the allocative efficiency change and price effect which helped to ascertain the decomposable sources of cost productivity dynamics. Another application of CMPI was done by (3) who estimated the three-stage cost Malmquist Productivity index in the biotech and biopharmaceutical industry in Taiwan for the period 2004-2007. The study concludes that CMPI is a relatively comprehensive productivity measure for firms as it includes both cost and input minimization over time.

Using the combined approaches of (2, 4). The cost productivity change of 200 Lithuanian family farms for the period of 2004-2009 was computed by (5). Another study conducted by (6) estimated the trends of technical and allocative efficiency in Lithuanian family farms. These studies pointed out that higher technical productivity growth could have been a bit misleading to conclude the firm's overall performance. Therefore, the addition of cost productivity expands the outlook for the firm productivity. Despite the CMPI's ability to account for all factors of production, there are still other contextual variables or exogenous factors beyond management control that can affect the dynamic cost productivity. Therefore, a second-stage analysis is relevant in exploring their influences. Not many studies have considered the potential second-stage correlates of cost productivity change. The present study is an attempt to handle these issues.

3. Methods

The study uses cost Malmquist productivity index for measuring cost productivity change and efficiency change of the individual countries for the period 2011 - 2015. . For this purpose data for 55 OIC's countries (excluding Palestine) has been collected from World Bank data set and World indicators reports. Bootstrap truncated regression is also used to identify the determinants of cost productivity change over the study period.

The study uses three inputs: (i) a total number of physician per 1000 population (ii) total number of hospital beds per 1000 population (iii) total number of nurses and midwives per 1000 population and two outputs: (i) life expectancy at birth (ii) under 5 survival rate. The total public health expenditure has been used as input prices for estimating cost efficiency change and allocative efficiency change. While Per Capita GDP, out of pocket health expenditure, the prevalence of smoking, literacy rate, and population growth rate are used to identify the determinants of the cost productivity of the healthcare system of 55 OIC's countries. The details of variables used in this study are presented in Table 1.

Table 1: Inputs, outputs, and Environmental Factors

	VARIABLES	EXPLANATIONS
Outputs	LE	Average number of years that a person at birth can be expected to live, assuming that age-specific mortality levels remain constant
	U5SR	Under 5 survival rate
Inputs	Doc /1000	Number of doctors per thousand people
	N&W/1000	Number of nurses and midwives per thousand people
	BEDS /1000	Number of hospital beds per thousand people
	COST	Public Healthcare expenditures
Environmental	OOP	Out of pocket health expenditure as a % of total health expenditures
	LR	Adult Literacy Rate
	SP	Prevalence of smoking (% of population)
	POPG	Population Growth rate
	PCGDP	Per Capita GDP (\$)

Early estimations of dynamic technical productivity ignored the 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 output 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 (7,8,9) parametric stochastic frontier analysis (SFA) and decomposed total factor productivity change (TFP) into technical efficiency change, allocative efficiency change, technical change, price effect and economies of scale effect. But this technique was criticized by (10) and (2) as demanding and practically unrealistic. As noted, the classical technical Malmquist productivity index of (4) was proposed when inputs and output quantities were available but their prices were not available. (2) Extended the technical Malmquist index to 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 and the cost technical change can be broken down into the standard technical change (TC) and price effect. 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 given input price data.

In stage one, the method introduced by (11) is used and CMPI is decomposed under the assumption of the variable return to scale. The CMPI measures the change over time in cost efficiency. Parallel to the decomposition of production Malmquist productivity index, the CMPI may be decomposed into the effects due to the improvement in production technology, production efficiency, variation in input prices and production scale. The overall decomposition of the CMPI is as follows.

$$CMPI = \Delta PTE \times \Delta T \times \Delta AE \times \Delta PE \times \Delta CSE$$

Where

ΔPTE = pure technical efficiency change;

ΔT = technical change;

ΔAE = allocative efficiency change;

ΔPE = price effect change; and

ΔCSE = cost scale efficiency change.

Values of the above five components greater than unity suggest deterioration, while values less than 1 indicate an improvement. In the second stage, the computed CMPI scores section is regressed against some environmental factors. A variety of regression techniques have been applied. Following specification has been formed.

$$CMPI_j = \alpha + \sum Z_j \delta + \varepsilon_j \dots j = 1 \dots n$$

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 CMI score. In DEA literature Tobit model has been widely used for estimating the model. However, (12) pointed out that such technique is inappropriate. They suggested another technique that shows satisfactory performance during Monte Carlo experiments as it depends upon truncated regression with bootstrap. The present study uses it to estimate the following model.

$$CMPI_{i,t} = \beta_0 + \beta_1(OOP)_{i,t} + \beta_2(LR)_{i,t} + \beta_3(SP)_{i,t} + \beta_4(POP.G)_{i,t} + \beta_5(PCGDP)_{i,t} + e_{i,t}$$

4. Empirical Results

Table 2 presents on average the data of inputs, outputs and environmental factors per year for the five financial years considered under study. This indicates that there is growth in the number of hospital beds, doctors, nurses and midwives per thousand population and at the same time input cost is increased during the study period. Overall, between 2011 and 2015, the growth in life expectancy at birth and under 5 child survival rate are observed. A similar trend is observed in the environmental factors during the period under consideration.

Table 2: Descriptive Statistics of Inputs, Outputs and Environmental Factors (2011-15)

		Output		Inputs				Environmental Factors				
		LE	U5SR	PHY*	N&W*	BEDS*	COST	OOP	LR	S P	POPG	PCGDP
2011	MEAN	67.88	943.74	1.06	1.68	1.56	49.87	40.56	52.81	34.1	2.57	8.6
	MEDIAN	70.46	956.3	0.64	0.94	1.08	48.44	41.43	45.09	31.85	2.47	6.4
	S.D	9.02	957.8	1.12	1.62	1.38	18.85	18.71	23.42	16.93	1.65	6
	MAX	80.63	850.2	3.92	6.01	7.7	92.02	73.84	99.78	63.7	7.76	29.7
	MIN	49.64	992	0.02	0.04	0.27	19.19	7.63	0.86	9	-2.15	0.3
2012	MEAN	68.21	945.89	1.34	1.98	2.14	49.72	42.59	59.29	34.71	2.49	8.82
	MEDIAN	70.65	958.9	1.09	1.23	1.9	48.17	45.89	50.76	32.8	2.41	7
	S.D	8.88	959.39	1.18	1.73	1.5	19.72	18.84	22.72	14.89	1.63	6.01
	MAX	80.82	854.8	3.84	7.86	7.6	91.82	83.84	99.99	62	7.06	29.6
	MIN	50.34	992.1	0.04	0.07	0.4	2.03	6.56	5.86	11.3	-3.04	0.2
2013	MEAN	68.53	947.89	1.29	2.08	2.64	49.9	40.69	63.07	36.20	2.39	8.81
	MEDIAN	70.84	961.4	0.98	1.64	2.4	49.62	43.69	56.98	35.3	2.38	6.9
	S.D	8.74	960.87	1.14	1.9	1.5	20.02	17.9	22.26	14.15	1.47	6.03
	MAX	80.99	859.3	3.75	8.87	8.1	92.15	71.61	99.98	68.4	6.5	29.7
	MIN	50.96	992.2	0.03	0.17	0.9	14.63	7.17	30.34	14.4	-3.11	0.2
2014	MEAN	68.84	949.78	1.29	2.11	1.89	50.55	40.63	67.33	37.09	2.3	8.81
	MEDIAN	71.01	963.7	1.28	1.05	1.59	51.7	40.49	63.75	39.5	2.5	6.5
	S.D	8.63	962.23	1.04	1.97	1.57	20.22	18.9	23.37	14.37	1.24	5.97
	MAX	81.14	863.3	3.49	8.37	7.7	93.86	76.03	99.98	71.8	5.86	29.7
	MIN	51.51	992.3	0.03	0.19	0.23	16.99	6.53	26	15.9	-2.47	0.2
2015	MEAN	69.15	951.53	1.37	2.33	1.68	49.84	40.38	73.82	38.68	2.2	8.81
	MEDIAN	71.18	965.8	1.38	1.05	1.47	47.39	39.73	79.72	40.85	2.45	7.04
	S.D	8.53	963.5	1.09	2.42	1.37	18.87	19.19	24.06	15.29	1.06	5.89
	MAX	81.29	867.5	3.87	11.65	7.7	91.82	83.9	99.79	76.2	5.22	29.8
	MIN	51.99	992.4	0.04	0.08	0.18	17.63	5.78	19.1	16.4	-1.64	0.3

The results of the study show that for 55 countries the same number of vectors containing cost Malmquist indices for each period are obtained. The cost Malmquist indices were aggregated across the countries. In order to maintain the integrity of the Malmquist indices the geometric average has been employed. The aggregated data are presented in Table 3.

Table 3: The Geometric Mean of cost Malmquist indices for 2011–2015

YEAR	EFCH	TECHCH	PECH	SECH	ACH	PCH	MPI	CMPI
2011-2012	1.006	0.972	0.983	1.023	1.012	1.023	0.978	1.013
2012-2013	0.788	0.804	0.867	0.909	0.980	0.635	0.633	0.394
2013-2014	1.401	1.086	1.259	1.113	1.014	1.113	1.521	1.716
2014-2015	0.929	0.734	1.033	0.9	0.945	0.9	0.683	0.581
GM	1.008	0.888	1.026	0.982	0.987	0.898	0.895	0.794

Table 3 shows that during the study period, 7.94% growth is observed in the cost productivity of the 55 healthcare system of OIC's member countries which is associated with 9.87% allocative efficiency change, 8.98 price change and 8.95% classical technical productivity. During the period 2012-2013, 3.94% growth is observed in cost productivity while 5.81% growth is observed in 2014-2015.

The Malmquist index followed the same pattern of dynamics, albeit it exhibited an increase in the total factor productivity amounting to 8.95% during the study period. It is associated with 9.82% scale efficiency change and 8.88% technological change. During the whole study period except 2013-2014 classical productivity growth is observed. Higher productivity growth is observed during the period 2011-2012 i.e. 9.78%. Considering the three

components of the Malmquist productivity index, it can be observed that the pure technical efficiency change is positive with an exception for the period of 2013–2014 and 2014-2015. , whereas the scale efficiency change and the technology change exhibit some additional features. The scale efficiency change has caused a decrease in productivity during 2011– 2012 and 2013-2014 which may be due to changes in the health system structure. The technology change also indicates that the production frontier moves outwards during the study period except 2013–2014. Finally, the two cost productivity indices, namely, change in allocative efficiency and prices, indicate a decrease in cost productivity during the 2011-2012 and 2013-2014 period. These changes are caused by both managerial decisions and rising input prices.

The scores of Cost Malmquist Index of Individual County are presented in Table 4 in which it can be observed that 44% of all the countries' healthcare system have shown regression in cost productivity while 56% countries have experienced growth in their cost productivity. While, in case of classical technical productivity 80% countries have shown growth in productivity and only 20% have experienced decline in productivity during the study period.

The healthcare systems of 28 countries (51%) have experienced improvement in allocative efficiency change while 8 countries (15%) have shown constant allocative efficiency change. A decline in price change has been observed in 30 healthcare systems (55%) while 5 countries (9%) have shown no price change during the study period.

5. Regression Analysis Of Efficiency Determinants

In order to find the determinants of cost productivity the present study uses truncated regression technique of (12). In the model CMPI is dependent variable and Per Capita GDP, out of pocket health expenditure as a percentage of total health expenditure, percentage of prevalence of smoking among the population, literacy rate and population growth are independent variables. The level of education, unemployment rate and per capita GDP are factors out of the control of the healthcare systems, and out-of-pocket expenditures is regarded as factor under the control of healthcare systems The results are obtained after 1000 iterations and are presented in Table 5.

Table 5: Bootstrapped Truncated Regression (2011-2015)

Variable	Original	Bias	SE	Bias Corrected	pLL (95%)	pUL(95%)	Sig
C	1.4221	0.0631	1.274	1.359	-1.2714	3.1521	
PCGDP	0.028	0.0026	0.0427	0.0254	-0.0253	0.207	***
OOP	-0.0643	-0.014	0.0732	-0.0503	-0.2691	-0.0025	**
SP	-0.0797	-0.0159	0.0261	-0.0638	-0.1605	0.0302	**
LR	0.0355	0.0014	0.0271	0.0341	0.0015	0.0514	***
POPG	-0.0392	0.0068	0.1351	-0.046	-0.13076	0.2372	
***= significant at 0.01							
**= significant at 0.05							

The results show that the coefficient of Per Capita GDP is positive and statistical significant which indicates that an increase in PCGDP leads to an increase in cost productivity. Generally, higher economic growth encourages the government to invest more in healthcare services for improving its quality and cost productivity of healthcare system. Therefore, a higher economic growth improves cost productivity of healthcare system. Out of pocket health expenditure as a percentage of total health expenditures has negative impact on the dynamic cost productivity which indicates that an increase in out-pocket expenditure in total health spending leads to the wastage of resources in public sector which in turn increases the cost of healthcare system which reduces the cost productivity. The prevalence of smoking has negative impact on the cost productivity of healthcare systems of OIC's countries. Our results are in line with (13). The literacy rate has positive and statistically significant coefficient which indicates that an increase in education level leads to an increase in the cost productivity of the healthcare systems. It may be due to the reason that improvement in education level promotes awareness regarding the diseases and relevant preventive measures. It helps the people to improve their health status which enhances the efficiency of the healthcare system. The results also reveal that the population has an insignificant contribution in improving the cost productivity of healthcare systems.

6. Conclusions

The cost Malmquist index has been decomposed into technical, scale, and allocative efficiency changes which are used for the analysis of productivity dynamics in 55 OIC's member countries. The analysis indicates that the changes in allocative and scale efficiency with the technological improvement give a momentum to the growth in cost efficiency. The cost productivity increases by 7.9% associated with 9.87% allocative efficiency change, 8.9% price change, 9.82% scale efficiency change and 8.8% technological change. The increase in the total factor productivity is mainly driven by an increase in scale efficiency and technological change. The education and Per Capita GDP have positive relationship with the CMPI of the healthcare systems while this relationship turns up negative for smoking and out of pocket health expenditure. Keeping in view the above analysis it is suggested that in order to maximize the cost productivity of health care systems in 55 OIC's countries, the policy makers and health managers should pay proper attention to the factors such as the promotion of public education level, the appropriate use of healthcare providers according to the needs of the population, proper management of the resources of healthcare systems, the allocation of adequate budget to health sector and establishing suitable referral system for providing people easy and better access to health services according to their income and healthcare needs.

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Appendix

Table 4: Cost Malmquist Index Decomposition

OIC	EFFCH	TECHCH	PECH	SECH	AECH	PCH	MPI	CMPI
Afghanistan	0.907	0.848	0.918	0.988	1	1	0.769	0.769
Albania	1.017	1.119	1.015	1.002	1	1.007	1.138	1.146
Algeria	1.042	0.94	1.046	0.996	1.056	0.993	0.98	1.028
Azerbaijan	0.978	0.854	0.978	1	1.194	1.005	0.835	1.002
Bahrain	0.96	0.814	0.962	0.998	0.983	0.912	0.782	0.701
Bangladesh	1.072	0.854	1.009	1.062	1.002	1.385	0.915	1.269
Benin	1.009	0.914	1	1.009	1.12	1.066	0.922	1.101
Brunei	1.033	0.953	0.988	1.045	0.817	1.268	0.984	1.019
Burkina Faso	1.039	0.945	1	1.039	0.84	1.103	0.981	0.909
Cameroon	1	0.884	1	1	0.849	0.957	0.884	0.719
Chad	1.005	0.856	1.153	0.871	1	1.106	0.86	0.951
Comoros	1.078	0.899	1.173	0.919	1.012	1.272	0.968	1.247
Cote d'Ivoire	1.071	0.946	1.178	0.91	0.935	1.209	1.013	1.146
Djibouti	1.025	0.893	1.172	0.875	0.926	1.254	0.916	1.063
Egypt	1.018	0.87	1.148	0.887	0.892	1.302	0.885	1.028
Gabon	1	0.903	1	1	1.347	0.807	0.903	0.982
Gambia	1.013	0.886	1.011	1.003	0.951	0.767	0.898	0.655
Guinea	1.002	0.892	1	1.002	1.145	0.759	0.893	0.776
Guinea-Bissau	0.949	0.888	0.973	0.976	1.043	0.778	0.843	0.684
Guyana	0.943	0.866	0.963	0.979	0.929	0.955	0.817	0.725
Indonesia	1.221	0.829	1.15	1.062	1.064	1.098	1.012	1.183
Iran	1.16	0.931	1.11	1.045	0.865	1.275	1.08	1.191
Iraq	1.124	0.912	1.103	1.019	1.012	1.265	1.026	1.313
Jordan	1.207	0.948	1.146	1.053	1.024	1.247	1.144	1.461
Kazakhstan	1.176	0.952	1.142	1.029	0.939	1.279	1.12	1.345
Kuwait	0.911	0.905	1	0.911	0.88	1	0.825	0.726
Kyrgyz	0.928	0.959	1.005	0.923	0.967	1.066	0.889	0.917
Lebanon	0.918	0.955	1	0.918	1	1.063	0.877	0.932
Malaysia	0.921	0.957	1	0.921	1.074	0.975	0.881	0.923
Maldives	0.924	0.958	1.017	0.909	1.165	1.031	0.885	1.063
Mali	1.024	0.91	1	1.024	0.997	1.125	0.933	1.047
Mauritania	0.906	0.853	1	0.906	1	1.008	0.773	0.779
Morocco	0.917	0.869	1.021	0.898	0.989	1.128	0.796	0.888
Mozambique	0.884	0.765	1	0.884	0.938	1	0.676	0.634
Niger	0.879	0.822	0.976	0.901	0.884	1	0.723	0.639
Nigeria	1.185	0.817	1.084	1.093	1.162	1.427	0.967	1.604
Oman	1.199	0.826	1.117	1.073	1.084	1.316	0.991	1.414
Pakistan	1.192	0.805	1.135	1.051	1	1.192	0.959	1.143
Qatar	1.076	0.931	0.938	1.147	0.861	1.738	1.002	1.5
Saudi Arabia	1.067	0.933	0.928	1.15	0.995	1.771	0.995	1.753
Senegal	0.978	0.886	0.998	0.98	0.608	1.296	0.866	0.683
Sierra Leone	1.12	0.87	1.153	0.971	1	0.69	0.974	0.672
Somalia	1.087	0.943	1.165	0.934	1	0.64	1.025	0.656

South Sudan	1.024	0.829	1.113	0.92	0.944	0.933	0.849	0.748
Suriname	1.097	0.784	1.143	0.96	0.953	0.913	0.86	0.749
Syrian	1.039	0.979	1.038	1	0.904	0.857	1.016	0.787
Tajikistan	0.829	1.008	0.849	0.976	0.821	0.926	0.836	0.636
Togo	0.819	0.984	0.842	0.973	1.267	0.794	0.806	0.811
Tunisia	0.849	0.907	0.853	0.995	0.959	1	0.771	0.739
Turkey	1.015	0.922	1.014	1	1.119	1.002	0.936	1.05
Turkmenistan	1	0.742	1	1	1.072	0.779	0.742	0.62
Uganda	1	0.758	1.003	0.997	1.042	0.734	0.758	0.579
UAE	0.932	0.857	0.932	1	1.006	0.699	0.799	0.562
Uzbekistan	0.964	0.781	0.986	0.978	0.956	0.693	0.753	0.499
Yemen	0.96	0.891	0.992	0.968	0.847	0.833	0.855	0.603
GM	1.008	0.888	1.026	0.982	0.983	1.023	0.895	0.9
MEDICAN	1.009	0.892	1	0.996	1	1.005	0.889	0.917
S.D	0.098	0.069	0.086	0.064	0.119	0.240	0.107	0.290
MAX	1.221	1.119	1.178	1.15	1.347	1.771	1.144	1.753
MIN	0.819	0.742	0.842	0.871	0.608	0.64	0.676	0.499