Journal of Applied Research on Industrial Engineering
www.journal-aprie.com

Fight Against COVID-19: A Global Efficiency Evaluation based on Contagion Control and Medical Treatment

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PAPER INFO

Chronicle:
Received: 26 March 2020
Revised: 1 April 2020
Accepted: 3 April 2020

Keywords:
COVID-19, SARS-CoV-2, Outbreak Response Management, Efficiency Evaluation, Contagion, Medical Treatment, Data Envelopment Analysis

ABSTRACT

There have been several major global outbreaks during the past decades, with the latest being the worst. The COVID-19 pandemic has infected hundreds of thousands and killed thousands in the world affecting most countries in around the globe. Outbreak response management efficiency can have a major impact on the outcome of the pandemic. Therefore, in this paper, the performance of most seriously affected countries regarding contagion control and medical treatment of COVID-19 is evaluated using data envelopment analysis. The efficiency values are calculated based on the conditions of the countries and the number of confirmed cases in the first step in order to create a basis for analysis according to the contagion control. In the second step the performance evaluation is done considering the total number of confirmed cases, the death cases, and the recovered cases to evaluate the efficiency of medical treatment in the countries. The countries are also classified into four groups using area chart, and for each group, some suggestions and analyses are presented. The results show the performance of the countries regarding the contagion control and medical treatment.

1. Introduction

The world has witnessed several newly emerged diseases spreading in various regions of the globe. From Zika, Nipah, Ebola, and coronavirus, also known as CoV. A new pathogen of the latter type observed for the first time in December 2019 in Wuhan, China. This coronavirus and the disease caused by it were named the 2019-novel coronavirus (2019-nCoV) and coronavirus disease 2019 (COVID-19) by World Health Organization (WHO) while Coronavirus Study Group (CSG) of the International Committee the name SARS-CoV-2 for the new coronavirus on February 2020. The genome sequence of 2019-nCoV was soon obtained by the Chinese scientists rapidly on 7 January 2020 [1]. As of the end of March 2020, more than 570,000 cases of COVID-19 have been confirmed in the world including more than 26,000 deaths [2]. Some studies estimated the basic reproduction number (R0) of 2019-nCoV to be approximately 2.2 [3]. Different research showed that the R0 for this coronavirus may be even larger and can lie in the range from 1.4 to 6.5 [4]. Compared to its previously well-known coronaviruses,

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DOI: 10.22105/JARIE.2020.225087.1146

i.e. SARS and MERS, 2019-nCoV has infected an extremely larger population around the globe and has claimed many more lives [5].

The number of infected and death cases in a country in case of an outbreak, and the rate at which they increase depend highly on the preparedness and the conditions of that country. The efficiency evaluation of the countries can be done and is significant in many ways. An indicator of performance of countries in outbreak response management is the confirmed Case Fatality Rate (cCFR). Based on this indicator and confirmed Case Recovery Rate (cCRR), Jouzdani (2020) presented an early evaluation of the global situation. Although such indicators may provide insight for evaluation, they may fall back in projecting the impact of the situation under which a country is fighting with the disease [6].

In this paper, the efficiency of countries affected by 2019-nCoV are evaluated considering their population density and health system infrastructures using Data Envelopment Analysis (DEA). In the first step, the countries with better performance in contagion control are identified, and in the second step, the countries are evaluated based on the confirmed case fatality and confirmed case recovery. In order to consider the countries with significant confrontation with the disease, the countries in which at least one month is passed since the beginning of the epidemic are selected as the population under investigation. Along with the numerical results, an area chart is presented to classify the countries to four classes based on their efficiency in contagion control and medical treatment. For each of the four classes, corrective and preventive actions can be defined.

The exposition of the paper is as follows. In the next section, the research material is discussed. Section 3 presents the research methodology. In Section 4, the results of applying the model are presented and several analyses are conducted and finally, Section 5 concludes the paper.

2. Material and Method

In this section, the data and concepts for conducting this research are explained. In the first sub-section the data, and in the second, the concept of Data Envelopment Analysis are presented.

2.1. The Data

Data from the National Evaluation of Rural Primary Health Care Programs, conducted by the Health Services Research Center, University of North Carolina at Chapel Hill, is used in this research. This was a five year (1978-1983), multidisciplinary evaluation of different organizational approaches to rural primary health care delivery. The database included extensive reporting on program and provider characteristics, scope of services, provider stability and productivity, revenues and costs, and administrative and financial policies. Secondary in formation was abstracted from Bureau of Community Health Services (BCHS) Common Reporting Requirements, and Bureau of Health Professions (BHP) Area Resource Files, from the Department of Health and Human Services [7].

As an indicator of the overall public health of the countries, the average of 13 International Health Regulations Core Capacity Scores is utilized. The data represent the percentage of attributes of 13 core capacities collected at a specific point in time. The 13 core capacities are: 1) National legislation, policy, and financing, 2) Coordination and National Focal Point communications, 3) Surveillance 4) Response, 5) Preparedness, 6) Risk communication, 7) Human resources, 8) Laboratory, 9) Points of entry, 10) Zoonotic events, 11) Food safety, 12) Chemical events, and 13) Radio nuclear emergencies [8].

Contact frequency among people is known as one of the major factors affecting in the spread of diseases. A crucial factor that can increase the frequency of contact in a country is the population density which is a measurement of population per unit area. The data is provided by the United Nations Statistics Division gathered from national statistical offices, and uses the data to estimate the urbanization. Those estimates are presented in World Urbanization Prospects United Nations Statistics Division (2020)[9]. To evaluate the efficiency of the countries in contagion control and medical treatment, the total number of confirmed, death, and recovered cases of COVID-19 are used. The data are provided by the World Health Organization (2020)[3].

2.2. Data Envelopment Analysis

Data Envelopment Analysis (DEA) is one of the reliable non-parametric techniques to evaluate the efficiency of decision-making units [10]. Farrell (1957) proposed an efficiency measurement method with one input and one output [11]. Then Charnes et al. (1978) extended Farrell's viewpoint and proposed a model that could measure the efficiency of decision-making units (DMUs) with several common inputs and outputs [12].

These comparable existences are referred to as decision-making units that are used to convert inputs into outputs. In this method, no assumptions for determination of the production function is made, and it is solved through optimization models. A frontier function surrounding the internal and external factors is constructed using the information on the real inputs and outputs of DMUs. This boundary includes linear parts that not only determine the most efficient units but provide a basis for analysis of inefficient units. The advantage of data envelopment analysis is that the "efficiency frontier" can be generalized and employed as a model for similar organizations [13].

The mathematical form of basic DEA is a fractional model and finding its solution is quite completed; therefore, the revised version of DEA, called CCR which was introduced by Charnes et al. (1978). This model is the basic form to formulate other variants in DEA. In fact, this pattern includes a constant return on scale. According to this point that in many cases return to scale is variable, Banker et al, developed CCR and considered a different return to scale and therefore, introduced BCC which is shown as follow as a multiple input-oriented form [14]:

Min θ

Subject to:

$$\theta x_{ip} - \sum_{j=1}^{n} \lambda_j x_{ij} \geq 0, \quad i = 1 \text{ to } m$$

$$\sum_{j=1}^{n} \lambda_j \, y_{rj} \geq y_{rp}\,, \quad r = 1 \text{ to } s$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0 \quad \forall_j\,, \quad \theta \;\; free$$

In the above model m, s, and n are the number of inputs, outputs, and DMUs. x_{ij} and y_{rj} are the i^{th} input and r^{th} output values for the j^{th} DMU. λ_j is the weight of the j^{th} DMU, and θ is the efficiency value. A DMU with an efficiency value of 1 is considered efficient, otherwise it is inefficient [15].

3. Methodology

In this paper, DEA is used to analyze the performance of the countries regarding the 2019-nCoV outbreak. The study is conducted in two steps: in the first step, the DEA model is solved considering two inputs of the Country Population Density and the Average of 13 International Health Regulations Core Capacity Scores (IHRCCS), and one output of Confirmed Cases ***(Figure 1)***. In this step, the efficient DMUs are the countries with relatively high population density and a low health index (based on the Average of 13 IHRCCS that have had a lower number of confirmed cases during a certain time period in comparison with other countries. In other words, the efficient DMUs (countries) have shown a better performance in contagion control.

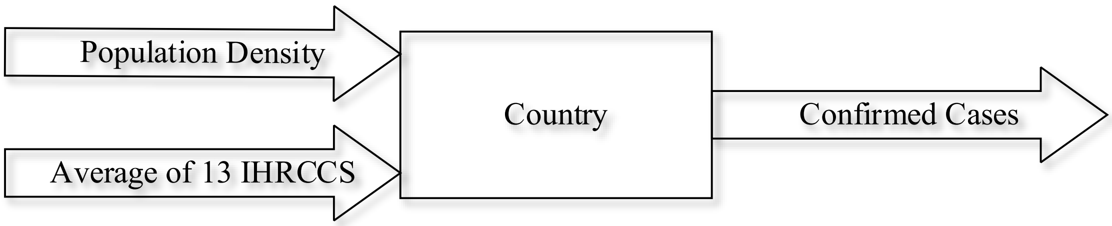

Figure 1. *The first step DEA model*

It should be noted that Country Population Density is an undesirable input and the number of Confirmed Cases is an undesirable output. A solution to this model gives the Contagion control Efficiency for each country. Because the return to scale is variable in this model, BCC is utilized.

In the second step, the DEA model has one input, which is the number of Confirmed Cases, and two outputs, which are the number of the Recovered Cases and the number of Death Cases ***(Figure 2)***. In this step, the efficient DMUs are the countries that have had a relatively larger number of Death Cases and a relatively lower number of Recovered Cases during a certain time period in comparison with other countries. In other words, the efficient DMUs (countries) in this step are the ones that have been inefficient in medical treatment for death prevention.

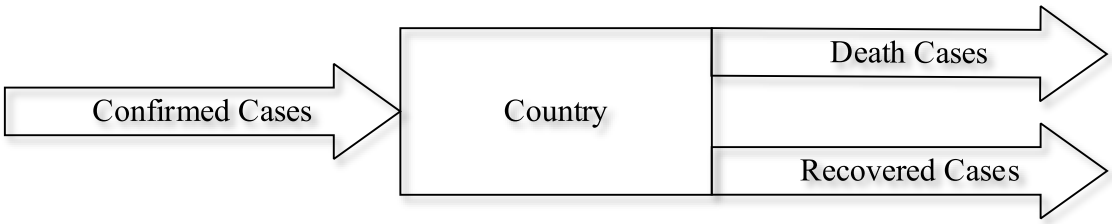

Figure 2. *The second step DEA model*

It should be noted that the number of Recovered Cases is an undesirable output in this model. Similar to the model in the previous step, since the return to scale is variable in this model, BCC is utilized. In addition, a solution to this model show the Medical Treatment Inefficiency for each country.

Having the efficiency numbers in the first and second steps, in addition to the conventional efficiency analysis for each country, it is possible to provide benchmarks for death prevention and medical treatment. In this study, the DMU (country), identified as efficient in the first step, has managed to control the contagion despite of poor geographical situation and healthy system infrastructure in comparison to other countries while the DMU (country), which is identified as efficient in the second step, has been inefficient in death prevention and recovery acceleration considering the total number of Confirmed Cases in comparison to other countries.

In order to have a better understanding of the performance of different countries and their classification, an area chart, as shown in ***Figure 3***, is used. The horizontal axis is the Contagion control Efficiency, and the vertical axis represents the Medical Treatment Inefficiency. The total mean efficiency values are used to divide the chart into four areas. The countries are positioned in this chart according to their calculated efficiency number obtained in first and the second step of DEA. ***Table 1*** provides the description for the DMU (country) positioned in each of the four areas of the chart.

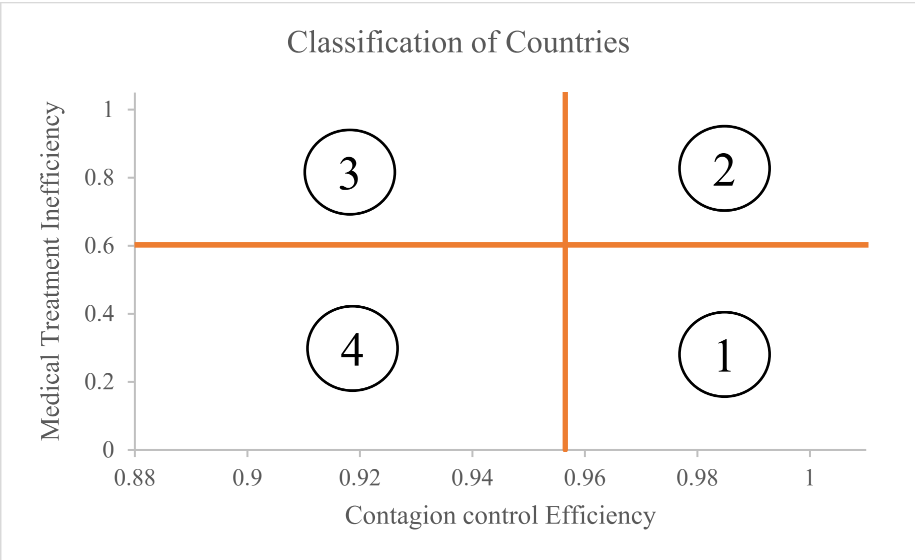

Figure 3. *An area chart for classification of countries based on their efficiencies*

Table 1. *Description of the areas of the chart*

Area	Contagion control efficiency	Medical treatment inefficiency	Description of the situation of the countries in the corresponding area in comparison to other countries	Note on the countries in the corresponding area
1	↑	↓	*Good performance both in contagion control and medical treatment*	*High performing benchmarks from which lessons can be learned*
2	↑	↑	*Good performance in contagion control but poor performance in medical treatment*	*Can be a benchmarks and lessons learned on medical treatment*
3	↓	↑	*Poor performance both in contagion control and medical treatment*	*In critical condition and need special global attention*
4	↓	↓	*Poor performance in contagion control but good performance in medical treatment*	*Can be a source of lessons learned on contagion control*

4. Result

In this paper, in order to provide the bed for an identical condition for all the countries in the DEA, the countries in which the 2019-nCoV outbreak has been emerged for at least a month are selected as the population under investigation. The countries in which on 25 March 2020 at least one month is passed after their first confirmed case of COVID-19 are presented in ***Table 2***. From the 29 countries in ***Table 2***, 7 countries with less than 10 confirmed cases are omitted from the analyses. The remained countries are presented in ***Table 4***.

For the performance evaluation in the first step Country Population Density and Average of 13 IHRCCS are considered as the inputs and the number of Confirmed Cases as the output. The solution is obtained considering variable return to scale using a BCC model. Since the number of Confirmed Cases is an undesirable output, it is considered as an input, and because Country Population Density is an undesirable input, it is considered as an output when solving the model. Therefore, the model is solved considering two inputs of the number of Confirmed Cases and the Average of 13 IHRCCS, and one output of Country Population Density. The BCC model is solved to obtain the results which are depicted in ***Table 3***.

In this step, the efficient countries are the ones that during the first 30 days since the first confirmed case of the COVID-19 have had less number of Confirmed Cases considering the Country Population Density and the Average of 13 IHRCCS. According to ***Table 3***, it is clear that these countries are Cambodia, Nepal, Singapore, and Sri Lanka. These are the countries that have had a good performance in contagion control in comparison to other countries. However, since the objective of this study is to classify the countries, the countries with less than 10 confirmed cases during the first 30 days since their first confirmed case are omitted in order to make the DMUs more comparable and make the classification more clear. Therefore, Belgium, Finland, India, Nepal, Philippines, Russia, Sri Lanka are omitted. These remaining countries are presented in ***Table 4***.

Table 2. *The data for the first step of DEA on the countries in which on 25 March 2020 at least one month is passed since the first 2019-nCoV confirmed case [3],[8],[9]*

No.	Country	Inputs		Output
		Country Population Density	Average of 13 IHRCCS	Confirmed Cases
1	*Australia*	*3.32*	*99.68*	*22*
2	*Belgium*	*382.75*	*82.90*	*23*
3	*Cambodia*	*94.71*	*80.65*	*1*
4	*Canada*	*4.15*	*100*	*10*
5	*China*	*153.31*	*100*	*75077*
6	*Egypt*	*102.80*	*96.40*	*109*
7	*Finland*	*18.23*	*96.00*	*2*
8	*France*	*119.21*	*89.41*	*12*
9	*Germany*	*240.37*	*96.54*	*17*
10	*India*	*464.15*	*95.28*	*3*
11	*Iran*	*51.58*	*76.23*	*18407*
12	*Iraq*	*92.61*	*88.88*	*233*
13	*Italy*	*205.56*	*90.00*	*1128*
14	*Japan*	*346.93*	*99.57*	*94*
15	*Republic of Korea, South*	*527.30*	*97.90*	*104*

16	*Lebanon*	*667.20*	*80.00*	*187*
17	*Malaysia*	*98.51*	*100*	*22*
18	*Nepal*	*203.26*	*22.42*	*1*
19	*Philippines*	*367.51*	*81.34*	*3*
20	*Russia*	*8.75*	*99.00*	*2*
21	*Singapore*	*8357.63*	*99.41*	*85*
22	*Spain*	*93.74*	*94.85*	*84*
23	*Sri Lanka*	*341.47*	*75.75*	*1*
24	*Sweden*	*24.61*	*92.71*	*12*
25	*Thailand*	*136.62*	*97.07*	*35*
26	*United Arab Emirates*	*118.31*	*96.78*	*13*
27	*United Kingdom*	*280.60*	*89.38*	*23*
28	*USA*	*36.19*	*76.20*	*13*
29	*Vietnam*	*313.93*	*95.21*	*16*

The results of efficiency calculations are presented in ***Table 5***, showing that Canada, France, Iran, Singapore, and USA are efficient in contagion control considering the Population Density, the Average of 13 IHRCCS, and the number of Confirmed Cases in comparison to other countries in the study.

In the second step, according to the proposed methodology, the DEA is performed considering a variable return to scale using a BCC model. In this step, the number of Confirmed Cases is an input, and the number of Death Cases and the number of Recovered Cases are the outputs. The information for 22 countries are presented in ***Table 6***, and the results are presented in ***Table** 7*.

The results of efficiency calculation indicate that Canada, China, France, Iran, Iraq, Italy, Lebanon, and Sweden have an efficiency value of 1 showing that these countries have had poor performance in medical treatment of COVID-19 patients in comparison to other countries in the study.

Table 3. *The results of the first step*

No.	**Country**	**1st Step Efficiency**	**No.**	**Country**	**1st Step Efficiency**
1	*Australia*	*0.22492*	16	*Lebanon*	*0.33500*
2	*Belgium*	*0.29089*	17	*Malaysia*	*0.22420*
3	*Cambodia*	***1.00000***	18	*Nepal*	***1.00000***
4	*Canada*	*0.22420*	19	*Philippines*	*0.64065*
5	*China*	*0.22420*	20	*Russia*	*0.50000*
6	*Egypt*	*0.23257*	21	*Singapore*	***1.00000***
7	*Finland*	*0.50000*	22	*Spain*	*0.23637*
8	*France*	*0.25075*	23	*Sri Lanka*	***1.00000***
9	*Germany*	*0.23587*	24	*Sweden*	*0.24183*
10	*India*	*0.77905*	25	*Thailand*	*0.23097*
11	*Iran*	*0.29411*	26	*United Arab Emirates*	*0.23166*
12	*Iraq*	*0.25225*	27	*United Kingdom*	*0.25901*
13	*Italy*	*0.24935*	28	*USA*	*0.29423*
14	*Japan*	*0.23879*	29	*Vietnam*	*0.24645*
15	*Republic of Korea, South*	*0.26026*			

Table 4. *The data for the first step of DEA on the countries with more than 10 cases in the first 30 days since their first confirmed case [3],[8],[9]*

No.	Country	Inputs		Output
		Country Population Density	Average of 13 IHRCCS	Confirmed Cases
1	*Australia*	*3.32*	*99.68*	*22*
2	*Belgium*	*382.75*	*82.90*	*23*
4	*Canada*	*4.15*	*100*	*10*
5	*China*	*153.31*	*100*	*75077*
6	*Egypt*	*102.80*	*96.40*	*109*
8	*France*	*119.21*	*89.41*	*12*
9	*Germany*	*240.37*	*96.54*	*17*
11	*Iran*	*51.58*	*76.23*	*18407*
12	*Iraq*	*92.61*	*88.88*	*233*
13	*Italy*	*205.56*	*90.00*	*1128*
14	*Japan*	*346.93*	*99.57*	*94*
15	*Republic of Korea, South*	*527.30*	*97.90*	*104*
16	*Lebanon*	*667.20*	*80.00*	*187*
17	*Malaysia*	*98.51*	*100*	*22*
21	*Singapore*	*8357.63*	*99.41*	*85*
22	*Spain*	*93.74*	*94.85*	*84*
24	*Sweden*	*24.61*	*92.71*	*12*
25	*Thailand*	*136.62*	*97.07*	*35*
26	*United Arab Emirates*	*118.31*	*96.78*	*13*
27	*United Kingdom*	*280.60*	*89.38*	*23*
28	*USA*	*36.19*	*76.20*	*13*
29	*Vietnam*	*313.93*	*95.21*	*16*

Table 5. *The results of the first step for the countries*

No.	Country	1st Step Efficiency	No.	Country	1st Step Efficiency
1	*Australia*	*0.76445*	15	*Republic of Korea, South*	*0.79234*
2	*Belgium*	*0.93084*	16	*Lebanon*	*0.97450*
4	*Canada*	***1.00000***	17	*Malaysia*	*0.76374*
5	*China*	*0.76514*	21	*Singapore*	***1.00000***
6	*Egypt*	*0.79238*	22	*Spain*	*0.80507*
8	*France*	***1.00000***	24	*Sweden*	*0.95579*
9	*Germany*	*0.83712*	25	*Thailand*	*0.78789*
11	*Iran*	***1.00000***	26	*United Arab Emirates*	*0.92319*
12	*Iraq*	*0.85910*	27	*United Kingdom*	*0.86017*
13	*Italy*	*0.85191*	28	*USA*	***1.00000***
14	*Japan*	*0.77400*	29	*Vietnam*	*0.89473*

Table 6. *The data on the countries for the second step of DEA [3]*

No.	Country	Input	Outputs	
		Confirmed Cases	Death Cases	Recovered Cases
1	*Australia*	*22*	*0*	*11*
2	*Belgium*	*23*	*0*	*1*
4	*Canada*	*10*	*0*	*3*
5	*China*	*75077*	*2238*	*18014*
6	*Egypt*	*109*	*2*	*27*
8	*France*	*12*	*1*	*4*
9	*Germany*	*17*	*0*	*14*
11	*Iran*	*18407*	*1284*	*5710*
12	*Iraq*	*233*	*20*	*57*
13	*Italy*	*1128*	*29*	*46*
14	*Japan*	*94*	*1*	*18*
15	*Republic of Korea, South*	*104*	*1*	*16*
16	*Lebanon*	*187*	*4*	*4*
17	*Malaysia*	*22*	*0*	*15*
21	*Singapore*	*85*	*0*	*37*
22	*Spain*	*84*	*0*	*2*
24	*Sweden*	*12*	*0*	*0*
25	*Thailand*	*35*	*0*	*15*
26	*United Arab Emirates*	*13*	*0*	*4*
27	*United Kingdom*	*23*	*0*	*8*
28	*USA*	*13*	*0*	*3*
29	Vietnam	16	0	14

Table 7. *The results of the second step for the countries*

No.	Country	2nd Step Efficiency	No.	Country	2nd Step Efficiency
1	*Australia*	*0.45455*	15	*Republic of Korea, South*	*0.19568*
2	*Belgium*	*0.50704*	16	*Lebanon*	***1.00000***
4	*Canada*	***1.00000***	17	*Malaysia*	*0.45455*
5	*China*	***1.00000***	21	*Singapore*	*0.11765*
6	*Egypt*	*0.24121*	22	*Spain*	*0.14063*
8	*France*	***1.00000***	24	*Sweden*	***1.00000***
9	*Germany*	*0.58824*	25	*Thailand*	*0.28571*
11	*Iran*	***1.00000***	26	*United Arab Emirates*	*0.76923*
12	*Iraq*	***1.00000***	27	*United Kingdom*	*0.43478*
13	*Italy*	***1.00000***	28	*USA*	*0.80000*
14	*Japan*	*0.18893*	29	*Vietnam*	*0.62500*

Table 8. *The efficiency values used to create the area chart*

No	Country	1st Step Efficiency	2nd Step Efficiency
1	*Australia*	*0.764*	*0.455*
2	*Belgium*	*0.931*	*0.507*
4	*Canada*	***1.000***	***1.000***
5	*China*	*0.765*	***1.000***
6	*Egypt*	*0.792*	*0.241*
8	*France*	***1.000***	***1.000***
9	*Germany*	*0.837*	*0.588*
11	*Iran*	***1.000***	***1.000***
12	*Iraq*	*0.859*	***1.000***
13	*Italy*	*0.852*	***1.000***
14	*Japan*	*0.774*	*0.189*
15	*Republic of Korea, South*	*0.792*	*0.196*
16	*Lebanon*	*0.974*	***1.000***
17	*Malaysia*	*0.764*	*0.455*
21	*Singapore*	***1.000***	*0.118*
22	*Spain*	*0.805*	*0.141*
24	*Sweden*	*0.956*	***1.000***
25	*Thailand*	*0.788*	*0.286*
26	*United Arab Emirates*	*0.923*	*0.769*
27	*United Kingdom*	*0.860*	*0.435*
28	*USA*	***1.000***	*0.800*
29	*Vietnam*	*0.895*	*0.625*
Average		*0.879*	*0.627*

In order to classify the countries, the efficiency values in the first and the second steps are used as presented in ***Table 8***. The average efficiency for the first step is 0.879, and that of the second step is 0.627. These values are used to create the four areas depicted in ***Figure 4***.

From the chart, it can be seen that Singapore, Belgium, and Vietnam are in area 1 showing that these countries have been acted efficiently both in contagion control and medical treatment of the patients, and can be benchmarks. Iran, France, Canada, the United States, Sweden, the United Arab Emirates, and Lebanon are in area 2. These countries have had controlled the contagion efficiently; however, their performance regarding medical treatment has been poor. These are the countries that can be looked upon for medical treatment of COVID-19.

In the other hand, China, Italy, and Iraq are the countries in area 3 where there are the countries with most critical situation with poor performance in both contagion control and medical treatment. In these countries, rapid response is needed to ameliorate the situation. However, it should be noted that the position of China may be due to the reason that it is the first country to be hit be 2019-nCoV, and no prior knowledge, experience, and preparation could not exist for this country. Germany, Malaysia, South Korea, Australia, Japan, Egypt, Spain, and England are in area 4. Although these countries have had a poor efficiency in contagion control, they have been successful in providing the patients with medical treatment. These countries can be benchmarks for medical treatment of COVID-19 because they have succeeded in controlling the deaths even though 2019-nCoV is spread in their territory.

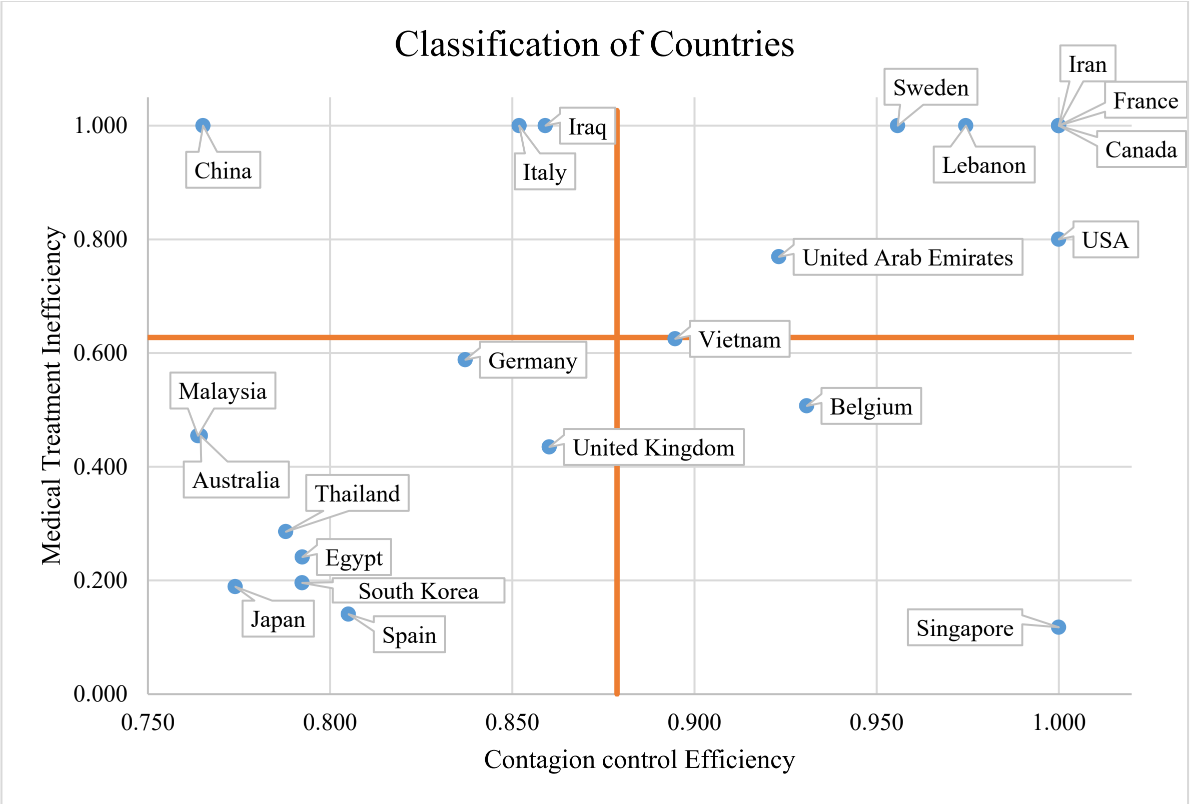

Figure 4. *The area chart used for classification of the countries*

5. Conclusion

In this paper, the efficiency of countries regarding the COVID-19 is studied using DEA. The countries in which on 25 March 2020 at least one month is passed after their first confirmed case of COVID-19 and have had at least 10 confirmed cases compose the population of the study. The study is conducted in two steps. In the first step, the efficiency values of the countries are calculated considering their performance in contagion control of the disease. In the second step, they are compared based on the performance in medical treatment of the patients that could fruit in decreasing the number of death cases and increasing the number of recovered cases. In addition to these efficiency evaluations, the countries are classified into four classes based on their performance in contagion control and medical treatment.

This study is limited in several ways. It should be noted that the results are obtained based on the data gathered during the aforementioned period; therefore, the generalization of the results to other time periods should be done carefully. The selection of the indicators affects the outcomes of the model. Therefore, a different set of indicators may lead to a different collection of results and analyses.

The results indicated that Singapore, Vietnam, and Belgium are the countries with the highest efficiency in both aspects. More specifically, Singapore with the highest efficiency among the countries even with one of the highest population densities in the Southeast Asia, is far ahead of others. In Europe, Belgium is the most efficient while Italy is the least. In the Middle East, Iran has been the most efficient in contagion control, and although Egypt has been the least in this regard, it has been the most efficient in medical treatment.

This study provides some interesting insights for future research. Outbreak response management performance evaluation can be done for other countries in similar situations. A two-stage DEA model can be utilized to analyze the data. More comprehensive indicators can be incorporated into the model for more extended results. The analysis can be performed for different time periods so that the movement of the countries across the areas of the chart can be observed and interpreted for deeper analysis.

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