ASSESSING RESOURCE MANAGEMENT EFFICIENCY OF COUNTRIES ON PARALYMPIC GAMES USING DATA ENVELOPMENT ANALYSIS

by

Danylo Kresik

A thesis submitted in partial fulfillment of the requirements for the degree of

MA in Business and Financial Economics

Kyiv School of Economics

2024

Thesis Supervisor: ______________________ Professor Elena Besedina

Approved by

Head of the KSE Defense Committee, Professor [Type surname, name]

Date ____________________________________

Acknowledgments

I would like to express my gratitude to all administrative and academic staff of Kyiv School of Economics (KSE) for providing me with an education of the highest standard. The institution's focus on both academic excellence and Ukraine's future development are inspiring.

My thanks go to all the professors at KSE, and in particular to Professor Besedina, whose guidance and support have been invaluable throughout the process of completing my master's thesis.

I would also like to thank my family for their continuous love and encouragement. In particular, I am deeply grateful to my girlfriend Yeva, who backed me up during the most challenging moments of my academic journey.

Finally, I say my thanks to my groupmates. The shared experience of our studies and the collaborative atmosphere have made this journey memorable. I hope that this is only the beginning of even greater endeavors together.

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LIST OF ABBREVIATIONS

WHO. World Health Organization

NBC. National Broadcasting Company

CNBC. Consumer News and Business Channel

FIFA. Fédération Internationale de Football Association (International Federation of Association Football)

GDP. Gross Domestic Product

DEA. Data Envelopment Analysis

DMU. Decision-Making Unit

BCC. R. D. Banker, A. Charnes and W. W. Cooper

CCR. A.Charles, W. W. Cooper and E.Rhodes

WDI. World Development Indicators

API. Application Programming Interface

CHAPTER 1. INTRODUCTION

Nowadays the Olympic Games and Paralympic Games are among the largest sports events in scale. Each season of Games is awaited by millions of fans throughout the world. The Olympic Games have a rich history which goes back in time for more than 2,000 years. The Greeks were the first to measure time by the occurrence of the Olympic Games, held every four years. In 1894 the Olympic Games took the form in which they are now, it is the time when the International Olympic Committee was created - it was aimed to educate young people in a peaceful and friendly environment which has no borders between the nations.

At the same time, the Paralympic Games were created in a short period of time after World War II ended. The main premise for the Paralympic Games' occurrence was a huge number of people injured (both military servicemen and civilians) in the result of military actions. The Paralympic Games do not seem to be as popular among sport fans. According to data shared by NBCUniversal, a broadcast television network, the number of viewers at the 2024 Olympic Games was twice as many as the number of viewers at the 2024 Paralympic Games. Even though the 2024 Paralympic Games were record-breaking in terms of viewership, with 15.4 million viewers across NBC, Peacock, USA Network, CNBC, and Telemundo in the USA, they still lag far behind the nearly 31 million viewers of the Olympic Games (SportsPro, 2024).

Another topic for discussion is the fairness of the current ranking of medal results in the Paralympic Games. Athletes with different backgrounds and from varying conditions are compared to each other only during a particular event, such as a performance, fight, or race. This research proposes an alternative ranking system that takes into account the amount of support an athlete may receive from their government, as well as the potential for a country to have a champion among its athletes.

Additionally, the research evaluates the effectiveness of resource management by each country and provides recommendations for which sports policies should be prioritized. These findings may encourage governments to become more involved in the preparation for the Paralympic Games and help guide more effective distribution of funds by identifying which sports programs to focus on and which partnerships to pursue.

The negative side of this research is that it may not be applicable to particular governments as these activities are not economically justified. Robert A. Baade and Victor A. Matheson (2016) state that hosting games is not beneficial for most of the countries as those are unprofitable. For instance, four cities withdrew from bidding for the 2022 Winter Olympics as it was negatively treated by the citizens. While the Games can have a positive impact in terms of new job opportunities, investments in infrastructure, and a boost to the tourism industry, the economic benefits are not always guaranteed. At the same time, hosting this event opens additional cash streams for the particular country from tourists, sponsors, media and athletes.

The structure of this research looks the following way. The second chapter elaborates on the Paralympic and Olympic Games within last years, pointing out the trends some of the countries show. Also, related studies with application of DEA approach or regression analysis are overviewed within the chapter. The third chapter amplifies the understanding of the methodologies and its main models. It is followed by the fourth chapter with the description of the data collection process and its descriptive analysis. The fifth chapter shares the results. The concluding chapter brings out the insights and recommendations for participants of Paralympic Games.

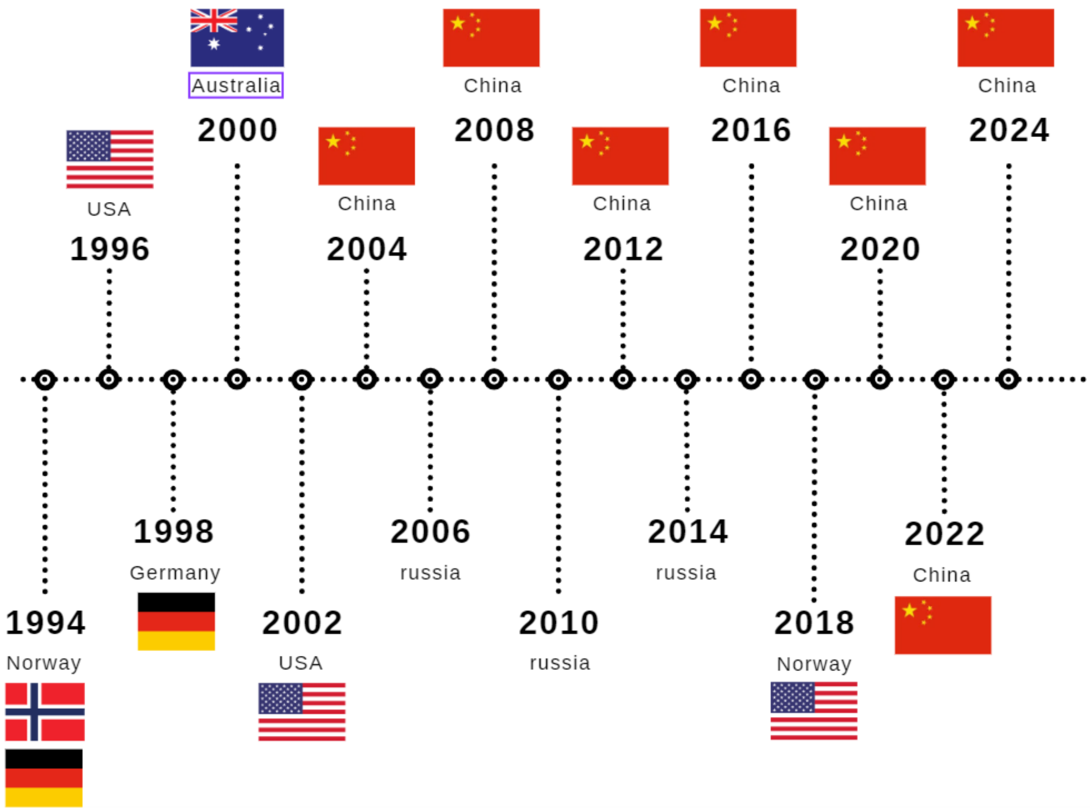
CHAPTER 2. INDUSTRY OVERVIEW AND RELATED STUDIES

In the modern world the sports industry is not limited by the activities which actually mean doing sports, it also has a huge, billion-dollars industry built on it. It includes both doing professional and amateur sports, recreational activities, promotions, advertisement, broadcasting and media, food products, etc. There is also a broad range of people involved in the sports industry, including athletes, coaches, and teams, as well as clothing manufacturers and fans.

Competitions are the basis all sports industry is created on. There is no sense in the sports industry without people who are either the best in the kind of sport they are doing or they are liked by fans. These competitions - tournaments, matches, games create a solid layer of economy mainly in developed countries. Any world-scale event like the Olympics, FIFA World Cup, Wimbledon Championships, Tour de France, and so on, has a valuable effect on the economy of the hosting country.

It was confirmed by Bernard and Busse (2004) that there is a positive correlation between the country's population, main economic indicators, like GDP per capita, and the number of medals received at the Games. But researchers have also paid attention to other factors that determine success in the Games. There are examples of countries with developed economies which have a comparatively similar level of population and GDP but showing totally different results in competitions. Main example, confirming these findings, is People's Republic of China which population reaches ⅕ of the world's population. As it is seen on Figure 1, China truly has had an apparent success during the last 2 decades in Summer Olympic Games in particular. But these determinants do not explain the reason China has reached such a success only now

Figure 1. TOP countries in the Paralympic Games from 1994 till 2024.

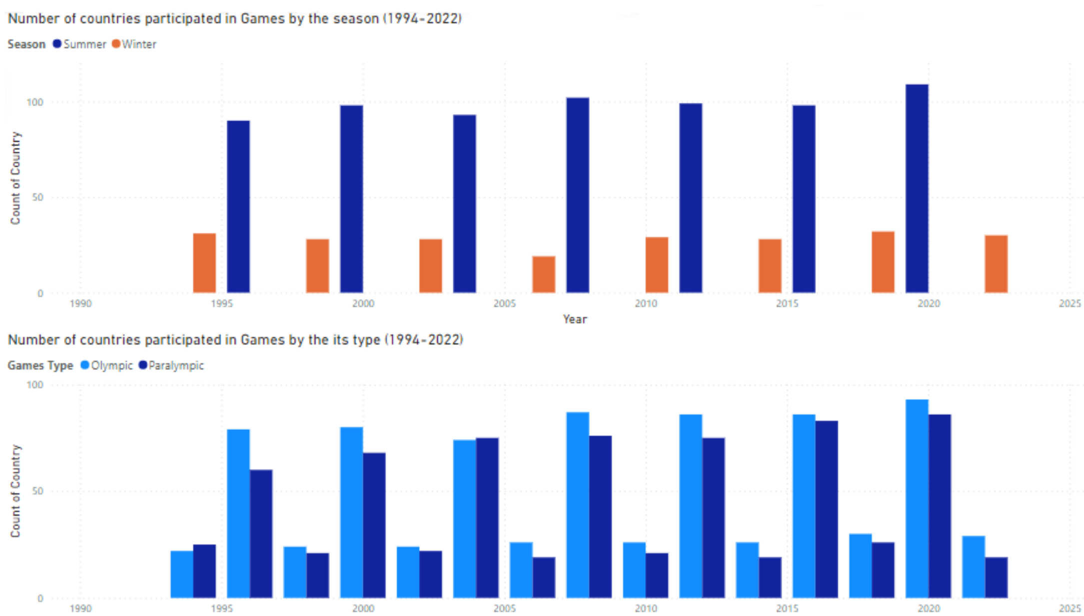


Source: Created by the author using data from the official website of the Paralympic Games.

It is important to mention that there is a growing trend of the number of countries involved in the Games. As it is seen from Figure 2, Summer Olympics and Paralympics have almost 3 times more national participants than the Winter Games, but, nevertheless, it is mainly growing from season to season, even despite the fact that some countries are not suitable for winter kind of sports because of the tropic climate and mainly warm weather conditions throughout the world.

As it was mentioned in the introduction, one of the aims of this research is to explore the difference between the Olympic and Paralympic Games which is mainly characterized by the number of people watching each type of Games. The Paralympic Games are much less popular than Olympic ones among fans. It could be explained by the low number of countries involved, as a result - less viewers supporting their fellow citizens, but, as it is seen from the lower graph on Figure 2, the number of countries involved in each type of Games is nearly similar.

Figure 2. Number of countries involved in the Olympics and Paralympics per season and games type.



Source: Created by the author using data from the official websites of Olympic and Paralympic Games.

Another kind of determinant which impacts a nation's success in the Games was researched by Noland & Stahler (2017). Main idea of this work is that the nature of sports development and government investments in sports may vary depending on the political system of the country. Democratic and authoritarian countries were taken into consideration. It was suggested that political systems with centralized operations in regard to sports development are more effective and it may bring positive results in a shorter period of time.

Tcha & Pershin (2003) mainly focused on the economic factors as independent variables. At the same time, the model used in the research incorporated the concept of revealed comparative advantage. That means that additional components of the analysis were explained through the specialization of each country, which is determined by geographical, historical and biological input parameters.

The different approach was used in De Bosscher et al. (2008). In this work success was considered in both absolute and relative terms. Researchers questioned the way results are mainly measured by the total number of medals. They proposed to add consideration of weight of the particular medal. In this way, gold, silver and bronze medals are treated differently in the estimation of success. With the application of such a methodology, researchers proved that the resulting success of countries may be re-assessed which leads to the different conclusions relative to previous research when total medals are used.

Another study which is closely related to the current work is Lui and Lui (2022). The researchers focused on consideration of socio-economic determinants which impact the result of the Paralympic Games. As it was mentioned earlier that the Paralympic Games were not yet a well-explored phenomenon as the Olympic Games. One of the determinants which had an influence on Paralympics results was average duration of schooling in a particular country. This factor is the one which was found to have significant impact on winning at the Paralympic games. It was also indicated that population effect still has a sufficient effect on successful results, even though the distribution of injured people and people with disabilities across countries is not random.

Revealing the topic of athletic performance measurement, I would like to mention the academic paper by Foster, James, and Haake (2010), which overviews the impact of the increasing global population on athletes' performance. It is noted that with the growing number of people, the probability of having someone who breaks a particular world record also increases. Evidence of this conclusion is the fact that the marathon world record has been broken 36 times since 1908 (and 42 times by the end of 2024). At the same time, through the application of an exponential decay model, the authors concluded that there is currently no strong correlation between population size and athletic performance, even though such a correlation was significant in earlier periods. This is important to mention in regard to the topic of my research, as population size is chosen as one of the major factors impacting the performance of national teams at the Paralympic Games.

The last but not the least academic paper to mention is Scandizzo & Pierleoni (2017). Materials of this research are important to cover mostly not because of the technical implementation of it, but mostly because of its wide overview of economic benefits brought by Olympics and Paralympics for the hosting country. The authors divide all impacts of games into intangible and tangible benefits, infrastructural positive and negative aspects, social, environmental and political effects. Presence of negative aspects brings authors to the conclusion that the perception of holding the games in the particular city by its citizens is integral. Another conclusion is that both ex-ante and ex-post studies do not properly cover the estimation of intangible impact of competitions. Effective evaluation which confirms the necessity of Olympics and Paralympics to be held depends on distinguishing between cost-benefits assessment and impact analysis.

CHAPTER 3. METHODOLOGY

The aim of the research is to study the factors that affect a country's performance at Paralympic Games. In particular, I hypothesize that countries with higher adult population, GDP per capita, government health expenditures, domestic private health expenditure per capita and great performance at the previous Paralympic Games demonstrate greater efficiency in converting these resources into better performance at the Paralympic Games.

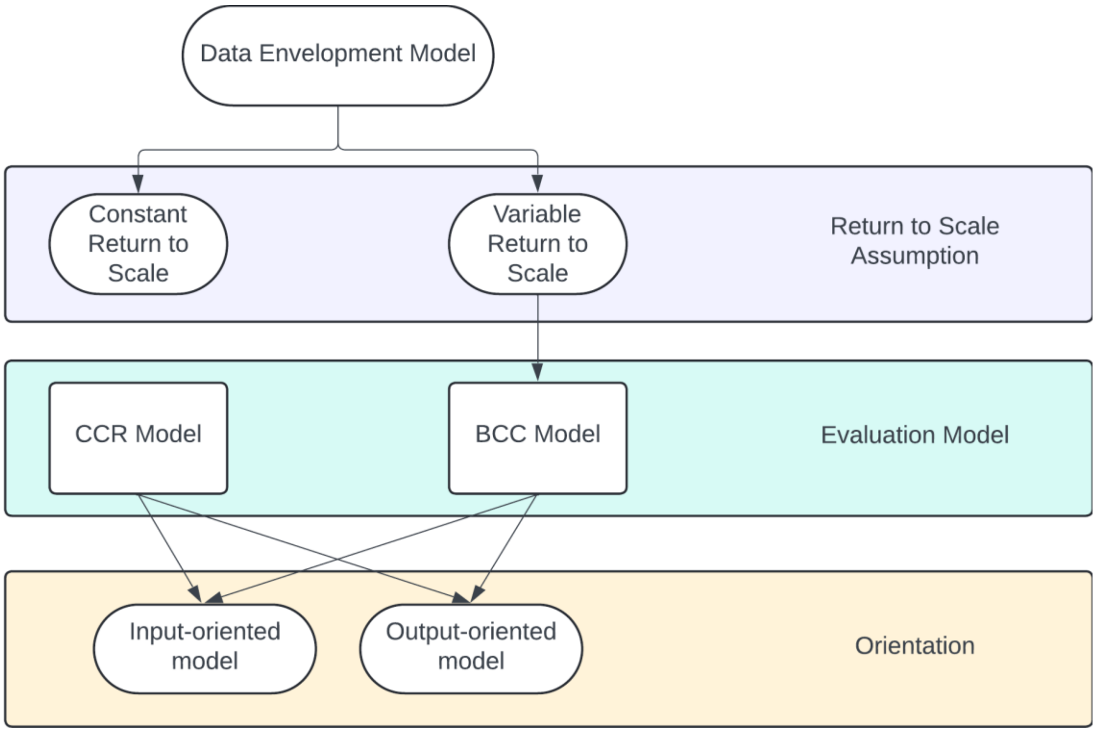
Differently from the previous studies that used regression analysis as the main methodology to forecast or to explain the results of national teams in the Olympics. For the same reason, there is a smaller number of academic studies dedicated to Paralympic Games. In this paper we are focusing on the efficiency of resource management by the countries. For this purpose I am using one of the major mathematical programming approaches to frontier analysis. First approach is usually characterized as parametric. Basics of this methodology was initially described in Lovell and Schmidt (1988) and advanced in Bauer (1990). The second approach (nonparametric) is also known as Data Envelopment Analysis (DEA). With application of engineering ratio approach it is used as the technique to estimate the parameters which characterize the measure of efficiency. DEA is a method of linear programming which examines the performance of specific units. These units are called Decision Making Units (DMUs) and this terminology can be applied to any entity which efficiency can be measured. For instance, hospitals, government agencies, investment funds, stores. In the current paper I am applying DEA approach with countries-participants of Paralympic Games 2024 as DMUs which have received at least one medal. It is applicable to different spheres of economies, operations management, manufacturing, healthcare, etc (Seaford & Thrall, 1990).

First mention of the DEA concept was introduced in 1978 by A.Charles, W. W. Cooper and E.Rhodes (CCR model). The efficiency measure was aimed either to maximize the ratio of weighted outputs to weighted inputs per each unit or to minimize the ratio of weighted inputs to weighted outputs per Decision Making Unit. The model can be divided into two types: output-oriented and input-oriented models. Output-oriented models are used in research that focuses on the production of outputs, while input-oriented models are applied to research aimed at decreasing the amount of inputs used in production. In this research, the input-oriented model will aim to minimize the following inputs: population, GDP per capita, health expenditures, and domestic private health expenditure per capita. Meanwhile, the output-oriented model will focus on increasing the number of medals won by national teams. Output-oriented model is applicable to the topic of this research as the deliverables of it are expected to help countries to improve their performance at the Paralympic Games.

Another DEA concept was introduced in 1984 by R. D. Banker, A. Charnes and W. W. Cooper (BCC model). The principal difference between BCC and CCR models is that the BCC model estimates efficiency with assumed variable return to scale when CCR models assess it with assumption of constant return to scale. Variable return to scale implies that changes in output are disproportionate to the changes in inputs. Based on the topic of the current research, there is no indication of proportional growth of output in response to the growth of inputs, so the BCC model is the one applicable to this paper.

The basic structure of the DEA model and its classifications can be seen in Figure 3.

Figure 3. Overview of the DEA models classification.



Source: Created by the author using data from W.W. Cooper, L.M. Seiford and J. Zhu, 2011.

An additional part of the Data Envelopment Analysis includes its output in the form of a reference set or group of DMUs, along with lambda (λ) values that indicate the weight of the dependency of one particular inefficient DMU on another efficient DMU. The benchmark DMU is inefficient and is compared to another efficient DMU, while the reference DMU is an efficient entity that the benchmark DMU is compared with. Each inefficient benchmark DMU is compared with at least one efficient reference within the model's performance (Park & Kim, 2018).

In order to construct the model in the form of mathematical notation, several variables have to be considered:

C - number of Decision Making Units;

j - index of countries   j = 1, 2, 3, … 81;

Pop_j - Adult population (15-64 years) of country j;

$GDPc_j$ - GDP per capita of country j;

HE_j - government health expenditures of country j;

$DHEc_j$ - domestic private health expenditure per capita of country j;

MR_j - weighted medal score of the country j at Paralympic Games 2020 in Tokyo;

WMS_j - weighted medal score of the country j at Paralympic Games 2024 in Paris;

0 - index of the countries being under assessment;

δ_0 - variable return to scale free variable;

λ_j - weight of the DMUs;

θ - efficiency score which indicates maximum WMS for DMU 0.

That results that the linear programming formulation of the model which measures efficiency of the countries-participants of the Paralympic Games 2024 looks the following way:

Maximize θ

Subject to the following constraints:

$$\sum_{j=1}^{C} \lambda_j \, WMS_j \geq \theta \, WMS_0 \quad (1)$$

$$\sum_{j=1}^{C} \lambda_j \, Pop_j \leq Pop_0 \quad (2)$$

$$\sum_{j=1}^{C} \lambda_j \, GDPc_j \leq GDPc_0 \quad (3)$$

$$\sum_{j=1}^{C} \lambda_j \, HE_j \leq HE_0 \quad (4)$$

$$\sum_{j=1}^{C} \lambda_j \, DHEc_j \leq DHEc_0 \quad (5)$$

$$\sum_{j=1}^{C} \lambda_j \, MR_j \leq MR_0 \quad (6)$$

$\sum_{j=1}^{C} \lambda_j = 1,\ \lambda_j \geq 0$ - convexity constraints (7)

The result of the model specified above would be efficiency scores per each Decision Making Unit. This index allows us to rank the countries-participants and find those which use their input resources efficiently and inefficiently.

I select five main inputs which are resulting in 1 output. First input is the adult population of countries-participants of the Paralympic Games 2020. This factor is found to be important for national teams to succeed in the Olympic Games (e.g. Lui, 2022). It is clear that a bigger population means a bigger possibility of preparing a sufficient number of athletes. With the growing number of participants/athletes within the single country, competition and quality of performance grows. Another input is GDP per capita - an indicator which shows the economic development of the country, standard of living and individual well-being which might also have a direct impact on the performance of the national team on Paralympics. The third input is the amount of government health expenditures (in absolute value taken as a share of GDP). The level of access to healthcare for people with disabilities, development of inclusive services funded from the budget have an effect not only on the performance of people with disabilities at Paralympics, but also on their presence there at all. The fourth input is the domestic private health expenditure per capita which also shows the accessibility of medical services in the country and the well-being of athletes with disabilities does depend on what shape they are in which, in its turn, depends on the quality of medical assistance they receive. The last but not the least input is the weighted medal score of the specific country on the Paralympics 2020 (which is the previous Summer Games). The logic behind this input is that its score shows the level of preparation a country has in terms of showing results at the Paralympics. Also, this input may characterize the additional motivation and experience athletes gained in previous Games.

CHAPTER 4. DATA

This research uses a dataset with information collected from various sources. The dataset covers the period from 2018 to 2024. Even though the subject of research is Paralympic Games 2024, the dataset includes data about the results of national teams at Paralympic Games 2020 as one of the inputs. The data on socio-economic indicators which are used as inputs is collected for the year of 2022 as it shows the true potential of resources which might be used at the summer Paralympic Games.

Paralympics Data: information on the number of gold, silver, bronze per each Games has been scraped from the Paralympic Committee website. It was complemented with information about the season and the year when the particular Games were taking place. The dataset was also added with the following DMUs: Republic of Moldova, Trinidad and Tobago, Luxembourg, Mauritius, Nepal.

Socio-economic Data: this information has multiple sources which were mainly reputable institutions like World Bank and World Health Organization. Data on population was segmented by the people aged from 15 to 64 in order to eliminate the non-correlation when people cannot be participants of the Games. World Development Indicators API was used within the embedded solution in R. To get the data on GDP per capita and government health expenditures WDI API was also utilized. Domestic private health expenditure per capita and great performance at the previous Paralympic Games were supplied through World Health Organization API.

The output variable (weighted medal score) was created as a composite measure by assigning weights to gold, silver and bronze medals in accordance with the coefficients proposed in Lins et al (2003) which, in its term, was adopted from Gomes et al. (2001). Within that research DEA BCC model was applied to find out the weights of each medal type with the decision-making units' preferences in the form of inputs. The outputs of this model resulted in the following formula of the weighted medal score:

$$Weighted\ Medal\ Score = 0.5814Gold\ +\ 0.2437Silver\ +\ 0.1749Bronze$$

It is necessary to mention that several adjustments were applied to the dataset. Countries (DMUs), like Venezuela and Hong Kong were omitted from the dataset because of the lack of data about socio-economic indicators necessary for the research. Lack of these DMUs does not have a significant impact on the results as the share of medals gained at Paralympics 2024 is not competitively outstanding. Socio-economic variables for Cuba and Chinese Taipei (Taiwan) have also been manually added due to the lack of information in original data sources. Also, the value of "Refugee Paralympic Team" in Country variable was removed as this team consists of representatives of multiple countries and they may reside in countries different from their countries of origin.

Table 1 presents descriptive statistics of the dataset. From the data provided, it may be highlighted that the mean weighted count for 2024 (6.46) is slightly higher than the 2020 count (6.12) suggesting a small improvement in the overall performance distribution of the countries. This may show that countries with smaller populations or lower GDPs per capita performed slightly better on a relative scale. Another observation is that the mean of government health expenses is higher than the median, which indicates that there are several countries with comparatively high spendings (countries with developed economies, like the US or Germany) that skews the distribution. This observation is also applicable to the variables gdp_per_capita and population.

Table 1. Descriptive statistics of the research dataset.

Variable	Min	Median	Mean	Max	Standard Deviation
gold_count	0	2	6	94	12.97
silver_count	0	3	6	76	11.55
bronze_count	0	3	7	50	10.20
Population, in thousands	395.59	12452.19	51809.9	978190.68	152834.83
gdp_per_capita	1272	16414	26799	128678	27378
government_health_expenses, in mln USD	794.48	21037.48	129641.10	4813026.92	543507.53
private_health_expenses	13.38	324.49	654.42	7131.24	1034.02
weighted_count_2020	0.00	2.28	6.12	79.36	11.47
weighted_count_2024	0.17	2.14	6.46	81.92	11.85

Source: own calculations based on the main research dataset.

Application of the Data Envelopment Analysis (DEA) model requires input and output values to be balanced. In constructing the BCC model, I have used the linear programming software with the make_deadata function in R. For the DEA model to function effectively, it is crucial to scale the inputs and outputs. In Table 2 we can see not normalized data of inputs and output for 10 DMUs from the dataset and the mean per each column.

Table 2. Values of inputs and output for TOP-10 countries according to their medal results at the Paralympic Games 2024.

country	population	gdp_per_capita	government_health_expenses	private_health_expenses	weighted_count_2020	weighted_count_2024
People's Republic of China	974720366	12614.06	958000914871	303.12	79.36	81.92
Great Britain	43301590	49463.86	418032497297	852.21	40.97	44.63
United States of America	217606073	82769.41	4813026922486	5573.82	35.71	35.89
Netherlands	11561484	64572.01	130327391379	1823.10	21.65	21.94
Brazil	146595887	10294.87	214991253974	466.88	22.91	27.52
Italy	37541549	39003.32	215828280151	801.21	19.75	23.21
Ukraine	25336440	5069.70	14318437459	177.10	30.13	25.21
France	41973641	44690.93	375615551884	1195.50	15.12	22.77
Australia	17217866	64820.91	182200128296	1740.50	24.52	19.51
Mean value	168428321	41477.67	813593486422	1437.05	32.24	33.62

Source: research dataset.

One common method of feature scaling is mean normalization (e.g. Sarkis, 2007). This is a simple manipulation performed per each DMU. In Equation 8, the calculation of the mean value for column *i* is presented. From the formula in equation 9 it is seen that the mean-normalized value is equal to the particular value of input/output *Ni* divided by the mean of the values from the respective column *i*. Taking one example from the table above, it results that the normalized value for DMU "People's Republic of China" for input "Population" is approximately 5.79.

$$\mu_x = \frac{1}{N} \sum_{i=1}^{N} x_i \quad (8)$$

$$VNorm_{Ni} = \frac{x_i}{\mu_x} \tag{9}$$

$$VNorm_{CP} = \frac{974720366}{168428321} \approx 5.79 \tag{10}$$

where i - particular input/output; N - the index of DMU (Country); μ_x - the mean value for column i ; x_i - the value of DMU N for the input/output i; $VNorm_{Ni}$ - the normalized value for DMU N for the particular input/output i ; CP - index identification of the value for DMU C (People's Republic of China) in column of input P (Population).

In table 3 the results of mean-normalization are outlined. Values in columns population, gdp_per_capita, government_health_expenses, private_health_expenses, weighted_count_2020, weighted_count_2024 correspond to the original values from the table above. Now it makes much more sense and simplifies the process of making the conclusions.

Table 3. Mean-normalized values of inputs and output on the example of TOP-10 countries according to their medal results at the Paralympic Games 2024.

country	population	gdp_per_capita	government_health_expenses	private_health_expenses	weighted_count_2020	weighted_count_2024
People's Republic of China	5.79	0.30	1.18	0.21	2.46	2.44
Great Britain	0.26	1.19	0.51	0.59	1.27	1.33
United States of America	1.29	2.00	5.92	3.88	1.11	1.07
Netherlands	0.07	1.56	0.16	1.27	0.67	0.65
Brazil	0.87	0.25	0.26	0.32	0.71	0.82
Italy	0.22	0.94	0.27	0.56	0.61	0.69
Ukraine	0.15	0.12	0.02	0.12	0.93	0.75
France	0.25	1.08	0.46	0.83	0.47	0.68
Australia	0.10	1.56	0.22	1.21	0.76	0.58
Mean value	1.00	1.00	1.00	1.00	1.00	1.00

Source: research dataset.

CHAPTER 5. RESULTS

This chapter reveals the results of DEA approach application to estimate the efficiency of resource management by the countries-participants of the Paralympic Games 2024. In particular, this research is based on the output-oriented BCC model approach - the subtype of frontier analysis.

For the purposes of building the model the dataset described in Chapter 4 was used. The model was aimed to propose an alternative ranking for Paralympic Games taking into account possibilities of the countries which directly impact the performance of athletes. As a result of using the model, there are two parts of its outcomes: 1) efficiency scores for each DMU (country), and 2) a reference set of DMUs along with their corresponding lambda values.

5.1 Efficiency scores

Per each decision-making unit, the model results in an efficiency score ranging from 0 to 1, where 0 indicates that the country does not effectively use its given resources, while 1 means that the country is operating at maximum efficiency, utilizing its resources optimally. In table 4 the rank of TOP 10 countries on Paralympic Games 2024 is listed. The whole dataset with efficiency scores can be found in APPENDIX A. 26 countries out of 82 are denoted as "effective" and its score is equal to 1. In order to make sure that a single position in ranking is placed only with one country, weighted medal result (weighted_count_2024) is taken into consideration. China and Great Britain hold the first and the second position in the Alternative Ranking respectively - this matches their ranks in the Traditional Ranking. Brazil, Ukraine and France are performing as third, fourth and fifth based on their capabilities. Even though the Netherlands "loses" its positions in alternative ranking, this country is still treated as effective. Ukraine and Uzbekistan show the lowest socio-economic indicators among TOP 10 countries in the alternative ranking, having comparatively high results on the previous Paralympic Games. That means that Ukraine and Uzbekistan constantly perform on a high level.

At the same time, the USA, Australia and Japan show a negative trend in converting their resources, going down from 3rd, 9th and 10th positions to 48th, 66th and 73th positions in alternative ranking. Government and domestic private health expenses are high. In particular, the US has the coefficient of government_health_expenses equal to 38.13 compared to 8.39 in China which goes next in descending order.

Table 4. Efficiency scores of TOP 10 DMUs according to traditional and alternative ranking of the countries' medal results.

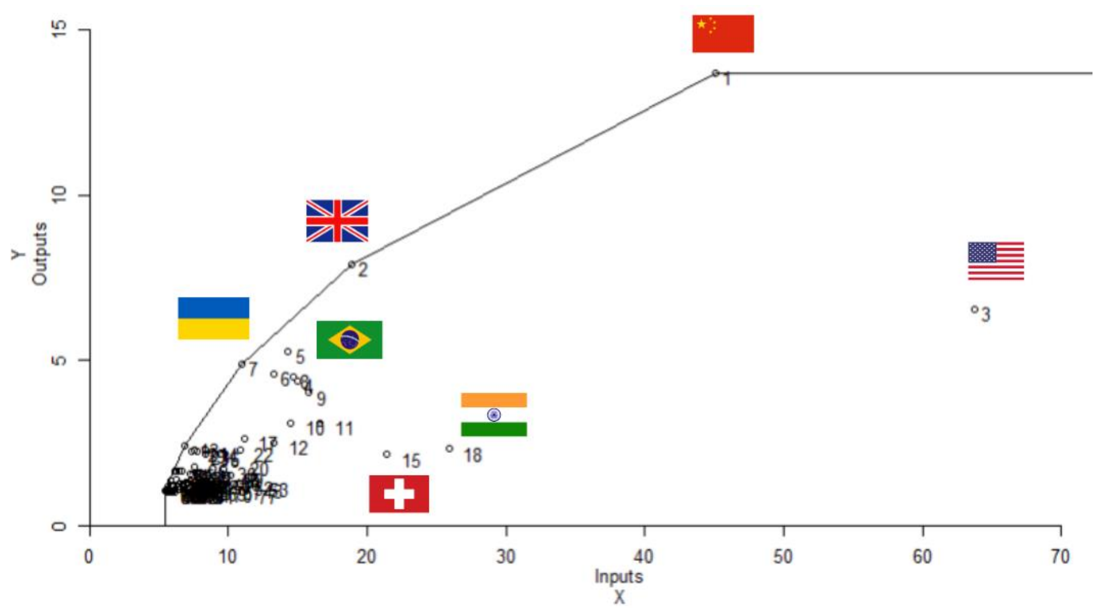
Sorted by Traditional Ranking				Sorted by Alternative Ranking			
Alternative Ranking	Traditional Ranking	Country	Efficiency Score	Alternative Ranking	Traditional Ranking	Country	Efficiency Score
1	1	People's Republic of China	1	1	1	People's Republic of China	1
2	2	Great Britain	1	2	2	Great Britain	1
48	3	United States of America	0.87728	3	5	Brazil	1
6	4	Netherlands	1	4	7	Ukraine	1
3	5	Brazil	1	5	8	France	1
28	6	Italy	0.98511	6	4	Netherlands	1
4	7	Ukraine	1	7	13	Uzbekistan	1
5	8	France	1	8	18	India	1
66	9	Australia	0.76871	9	23	Turkiye	1
73	10	Japan	0.65838	10	15	Switzerland	1

Source: research dataset.

Among countries with efficiency scores equal to 1 there are also Cuba, Tunisia, Georgia, Portugal, Latvia. Ethiopia, Mongolia, Namibia, Republic of Moldova, Kenya, Sri Lanka, Trinidad and Tobago, Luxembourg, Montenegro, Mauritius and Nepal.

An output-oriented DEA model is applied when there is a need to solve a maximization problem. It is used to determine the scalar theta for a particular decision-making unit, subject to the given inputs. In Figure 4 the way countries-leaders are placed in respect to the efficiency frontier is reflected. Important notice is that several efficient countries are not placed directly in the frontier line because it is limited with two-dimensional space when there are 5 inputs listed. It greatly reflects how not efficiently the US uses its resources in the form of healthcare expenses to achieve results on the Paralympic Games 2024. This country is expected to outperform China and to take the first place with available resources.

Figure 4. Two-dimensional efficiency frontier of the model.



Source: Created by the author using data from Chapter 4.

From another side of the efficiency table, there are countries which perform the worst, according to the analysis. In Table 5 we can see TOP 10 DMUs in descending order of the efficiency score.

Table 5. Efficiency scores of bottom 10 DMUs according to alternative ranking of the countries' medal results.

Alternative Ranking	Traditional Ranking	Country	Efficiency Score
82	30	Mexico	0.39
81	70	Sweden	0.47
80	67	Austria	0.53
79	44	South Africa	0.60
78	50	New Zealand	0.61
77	58	Chile	0.63
76	11	Germany	0.64
75	40	Malaysia	0.66
74	53	Ireland	0.66
73	10	Japan	0.66

Source: research dataset.

It can be summarized that Mexico and Sweden used less than half of their resources to succeed at Paralympics 2024 - 39% and 47% respectively. As it was mentioned above, Japan and Germany are among leaders, according to the traditional ranking, but it does not reflect that the capabilities of these national teams can bring better results.

5.2 Reference set of DMUs

In Table 6 we can observe the reference groups formed per each reference DMU. The whole table can be found in APPENDIX B. Some of the reference countries with extremely low lambda values were omitted from Table 6.

Table 6. Reference set of DMUs and corresponding lambda values.

Reference DMU	Benchmark DMU and lambda values	N benchmark countries
Georgia	Costa Rica (0.942), Slovakia (0.924), Finland (0.891), Serbia (0.888), Norway (0.884), Czechia (0.851), Denmark (0.848), Sweden (0.847), Greece (0.842), Austria (0.838), Israel (0.817), Hungary (0.811), Singapore (0.799), Chile (0.778), Lithuania (0.713), Ireland (0.711), Belgium (0.696), Malaysia (0.604), Ecuador (0.599), Bulgaria (0.572), Kuwait (0.57), Croatia (0.541), Romania (0.535), Slovenia (0.474), Peru (0.418), Argentina (0.374), Kazakhstan (0.337), Iraq (0.231), Bosnia and Herzegovina (0.223), New Zealand (0.212), Vietnam (0.149), Jordan (0.145), Morocco (0.134), Saudi Arabia (0.126), Chinese Taipei (0.107)	35
Turkiye	Mexico (0.824), Argentina (0.425), Thailand (0.424), Japan (0.403), Republic of Korea (0.394), South Africa (0.372), Colombia (0.368), Malaysia (0.297), Indonesia (0.283), Egypt (0.176), Chile (0.158), Algeria (0.136), Germany (0.131), Italy (0.13), Canada (0.118)	15
Republic of Moldova	Bosnia and Herzegovina (0.743), Saudi Arabia (0.638), Chinese Taipei (0.617), Croatia (0.441), Kuwait (0.425), Romania (0.418), Vietnam (0.356), Iraq (0.33), Peru (0.291), Bulgaria (0.23)	11
Uzbekistan	Islamic Republic of Iran (0.907), Poland (0.803), Colombia (0.619), Thailand (0.568), Spain (0.535), Morocco (0.5), Algeria (0.429), Italy (0.361), South Africa (0.211), Jordan (0.207), Greece (0.109), Malaysia (0.1)	11
Ethiopia	Pakistan (0.984), Nigeria (0.934), Egypt (0.755), Indonesia (0.518), Iraq (0.265), Peru (0.259), Vietnam (0.233), South Africa (0.15), Algeria (0.117)	9

Source: DEA model output.

From the data above, it can be seen that there are several countries that have become the reference points for the other inefficient countries. Georgia is relied upon by 35 countries in the estimation process. Costa Rica, Slovakia, Finland, Serbia, Norway, Czechia, Denmark, Sweden, Greece, Austria, Israel, Hungary - a group of countries which show a similar technique in resource management. Mexico is closely related to Turkiye in terms of resource management. The highest lambda value among all references belong to the pair of Ethiopia and Pakistan which states that more than 98% of Pakistan's performance at Paralympics relies on Ethiopia's performance.

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

Within this research, I have applied the frontier analysis technique, particularly the data envelopment approach to estimate the efficiency of resource management by countries-participants of Paralympic Games 2024. The main model applied is characterized as a BCC (with variable return to scale assumption) output-oriented model. That means that the main aim was to maximize the output - medal score of the particular country - with the given inputs in the form of population, GDP per capita, government health expenses, domestic private health expenses and the results shown at the previous Paralympic Games 2020 in Tokyo. The main idea was to get the alternative ranking of countries as a result of its performance in competitions. Based on this alternative ranking, we have come up with insights that give a clearness of high performers among the participants and those national teams which are expected to show better results with the given inputs.

Efficiency frontier and efficiency scores are the outputs of the DEA model which has shown that China and Great Britain are absolute leaders at converting their resources into medal scores at Paralympic Games 2024. Alternative ranking is based on fair measures that assess the hard work of athletes and national teams. The BCC output-oriented model takes into consideration the resources that countries can use during preparations for the Paralympic Games. For instance, athletes from Mauritius and Nepal face more challenges in accessing high-level training conditions and participating in competitions. Sometimes, national teams cannot even be represented at world-level competitions due to a lack of funding or insufficient participants in a particular sport. At the same time, some countries which are included into TOP-10 countries of traditional ranking, like the USA, Italy, Australia and Japan should reconsider the distribution of their resources if they are willing to perform better at Paralympic Games. The resources they dispose allow them to significantly improve the results.

Analysis of the reference set of DMUs has given us the understanding of 5 main groups of inefficient countries whose performance partially depends on the performance of 5 efficient countries. That means that countries from those groups are recommended to adapt best practices relative to their country. Among efficient countries are: Georgia which has the largest number of countries correlated with its performance, Turkiye, Uzbekistan and Moldova. Inefficient countries have the reference DMU which approximately has the same weighted amount of imputed resources, but an efficient country shows better performance. That means that Costa Rica, Slovakia, Finland, Serbia, Norway, Czechia or Denmark may benefit from "borrowing" policy techniques Georgia has in regards to Paralympics Games preparation. Research of similarity between countries in those groups requires an additional attention as empirically most of benchmark DMUs look to have similar geographical location and the stage of economic development. For instance, in the "Ethiopia group" there are countries with developing economies located in Africa, Latin America or Eastern Asia.

To summarize, frontier analysis and DEA approach in particular is well suited for the resolution of efficiency problems. This is not limited to business metrics, organizations or governments, it also can be applied to sports, environment or education to find the "weak" point and help policymakers, managers and other stakeholders to eliminate ineffective processes.

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APPENDIX A

Alternative Ranking	Traditional Ranking	Country	population	gdp_per_capita	government_health_expenses	private_health_expenses	weighted_count_2020	weighted_count_2024	Efficiency Score
1	1	People's Republic of China	19.81	1.47	8.39	1.46	13.97	13.69	1
2	2	Great Britain	1.84	2.85	4.22	2.30	7.69	7.91	1
3	5	Brazil	3.83	1.38	2.66	1.71	4.74	5.26	1
4	7	Ukraine	1.49	1.19	1.11	1.27	5.92	4.90	1
5	8	France	1.81	2.67	3.90	2.83	3.47	4.53	1
6	4	Netherlands	1.22	3.41	2.01	3.79	4.54	4.40	1
7	13	Uzbekistan	1.44	1.11	1.06	1.17	2.13	2.43	1
8	18	India	19.88	1.09	1.90	1.07	1.97	2.32	1
9	23	Turkiye	2.12	1.49	1.39	1.15	1.61	2.24	1
10	15	Switzerland	1.11	4.72	1.81	11.90	1.91	2.16	1
11	24	Cuba	1.15	1.36	1.11	1.16	1.45	1.68	1
12	27	Tunisia	1.16	1.15	1.03	1.16	1.64	1.64	1
13	49	Georgia	1.05	1.31	1.02	1.42	1.12	1.35	1
14	41	Portugal	1.13	2.02	1.25	2.48	1.06	1.33	1

15	34	Latvia	1.02	1.84	1.03	1.88	1.18	1.31		1
16	42	Ethiopia	2.43	1.05	1.04	1.02	1.10	1.22		1
17	55	Mongolia	1.04	1.22	1.01	1.28	1.10	1.20		1
18	60	Namibia	1.03	1.16	1.01	1.28	1.07	1.12		1
19	72	Republic of Moldova	1.03	1.25	1.01	1.20	1.00	1.06		1
20	73	Kenya	1.64	1.07	1.04	1.05	1.03	1.04		1
21	74	Sri Lanka	1.28	1.14	1.03	1.10	1.12	1.04		1
22	75	Trinidad and Tobago	1.02	1.75	1.01	2.09	1.00	1.04		1
23	77	Luxembourg	1.01	5.80	1.04	2.27	1.00	1.03		1
24	78	Montenegro	1.01	1.46	1.01	1.63	1.03	1.03		1
25	79	Mauritius	1.02	1.43	1.01	1.47	1.00	1.03		1
26	80	Nepal	1.37	1.05	1.02	1.08	1.00	1.03		1
27	66	Chinese Taipei	1.45	2.22	1.36	1.58	1.03	1.17		0.99989
28	6	Italy	1.72	2.46	2.66	2.22	4.23	4.59		0.98511
29	21	Thailand	1.97	1.27	1.20	1.18	1.90	2.31		0.98425
30	56	Iraq	1.52	1.21	1.10	1.19	1.10	1.21		0.96357
31	37	Kazakhstan	1.24	1.48	1.08	1.25	1.24	1.40		0.95360
32	19	Colombia	1.71	1.26	1.25	1.23	1.96	2.27		0.94735

33	68	Bosnia and Herzegovina	1.04	1.32	1.02	1.32	1.03	1.08	0.94264
34	12	Canada	1.51	2.99	3.04	3.75	2.04	2.51	0.94174
35	62	Slovenia	1.03	2.22	1.05	2.10	1.07	1.12	0.94029
36	64	Saudi Arabia	1.47	2.20	1.49	1.53	1.03	1.09	0.93348
37	32	Greece	1.13	1.87	1.17	2.23	1.41	1.57	0.93247
38	20	Belgium	1.14	3.04	1.55	3.05	1.73	1.86	0.91929
39	57	Croatia	1.05	1.82	1.05	1.32	1.23	1.18	0.91037
40	61	Romania	1.24	1.69	1.18	1.31	1.07	1.12	0.90409
41	59	Kuwait	1.07	2.26	1.07	1.33	1.07	1.12	0.90033
42	45	Ecuador	1.23	1.25	1.08	1.29	1.15	1.23	0.89989
43	82	Vietnam	2.31	1.16	1.15	1.16	1.04	1.03	0.89717
44	39	Egypt	2.38	1.13	1.14	1.16	1.26	1.34	0.89161
45	36	Denmark	1.07	3.55	1.34	2.58	1.35	1.43	0.88745
46	22	Republic of Korea	1.71	2.24	2.23	2.74	1.93	2.30	0.88594
47	31	Morocco	1.48	1.14	1.06	1.17	1.63	1.66	0.87921
48	3	United States of America	5.20	4.09	38.13	9.52	6.83	6.56	0.87728
49	28	Azerbaijan	1.14	1.27	1.03	1.31	2.48	1.57	0.86999
50	26	Hungary	1.12	1.83	1.12	1.52	1.98	1.78	0.86701

51	48	Indonesia	4.69	1.18	1.39	1.09	1.42	1.53	0.86424
52	71	Cyprus	1.02	2.36	1.02	1.82	1.12	1.06	0.86128
53	35	Argentina	1.58	1.53	1.48	1.85	1.31	1.51	0.85856
54	38	Nigeria	3.44	1.06	1.11	1.11	1.56	1.35	0.85206
55	25	Algeria	1.56	1.20	1.11	1.14	1.65	1.68	0.84919
56	65	Peru	1.44	1.30	1.13	1.24	1.10	1.09	0.84125
57	52	Norway	1.07	4.28	1.38	2.90	1.25	1.28	0.83428
58	47	Costa Rica	1.07	1.63	1.05	1.46	1.13	1.18	0.83405
59	63	Bulgaria	1.08	1.59	1.07	1.58	1.08	1.09	0.82635
60	81	Pakistan	3.81	1.05	1.08	1.03	1.10	1.03	0.81323
61	33	Slovakia	1.07	1.91	1.08	1.50	1.67	1.35	0.81023
62	16	Poland	1.46	1.82	1.40	1.49	2.22	2.19	0.80983
63	43	Singapore	1.09	4.16	1.22	3.86	1.19	1.22	0.80540
64	14	Islamic Republic of Iran	2.21	1.17	1.18	1.18	2.61	2.29	0.77740
65	76	Lithuania	1.04	2.04	1.05	1.95	1.09	1.03	0.77520
66	9	Australia	1.33	3.42	2.41	3.66	5.01	4.02	0.76871
67	54	Serbia	1.08	1.46	1.06	1.53	1.34	1.26	0.76323
68	29	Israel	1.11	2.96	1.31	3.11	1.68	1.54	0.76160

69	46	Jordan	1.14	1.17	1.03	1.26	1.41	1.21	0.73588
70	51	Czechia	1.13	2.18	1.25	1.57	1.40	1.32	0.72087
71	17	Spain	1.62	2.25	2.34	2.16	2.80	2.64	0.70366
72	69	Finland	1.07	2.97	1.23	2.37	1.24	1.12	0.66959
73	10	Japan	2.41	2.26	4.51	1.83	3.49	3.10	0.65838
74	53	Ireland	1.07	4.88	1.29	3.23	1.49	1.26	0.65749
75	40	Malaysia	1.48	1.42	1.14	1.35	1.36	1.28	0.65741
76	11	Germany	2.02	3.03	5.52	2.86	3.23	3.11	0.63894
77	58	Chile	1.26	1.64	1.24	2.17	1.34	1.23	0.62990
78	50	New Zealand	1.07	2.80	1.20	2.38	1.78	1.35	0.61228
79	44	South Africa	1.82	1.22	1.24	1.32	1.48	1.29	0.60170
80	67	Austria	1.12	3.09	1.48	3.01	1.38	1.14	0.52590
81	70	Sweden	1.13	3.07	1.51	2.28	1.35	1.09	0.47448
82	30	Mexico	2.68	1.51	1.84	1.48	2.12	1.71	0.39492

APPENDIX B

Main DMU	Lambda DMU	Value
Pakistan	Ethiopia	0.983339
Costa Rica	Georgia	0.941119155
Nigeria	Ethiopia	0.933416622
Slovakia	Georgia	0.923709125
Islamic Republic of Iran	Uzbekistan	0.906987288
Finland	Georgia	0.890810255
Serbia	Georgia	0.887928046
Norway	Georgia	0.883150405
Germany	France	0.869234881
Czechia	Georgia	0.85026706
Denmark	Georgia	0.847561562
Sweden	Georgia	0.846463779
Azerbaijan	Mongolia	0.845434821
Greece	Georgia	0.841838274
Austria	Georgia	0.837766476
Mexico	Turkiye	0.823624254
Israel	Georgia	0.816535785
Hungary	Georgia	0.810331323
Poland	Uzbekistan	0.802421577
Australia	Netherlands	0.801379139
Singapore	Georgia	0.798722377

Chile	Georgia	0.777382023
Egypt	Ethiopia	0.75476807
Bosnia and Herzegovina	Republic of Moldova	0.742950682
Lithuania	Georgia	0.712612593
Ireland	Georgia	0.710027884
Belgium	Georgia	0.695537672
Cyprus	Latvia	0.64122618
Saudi Arabia	Republic of Moldova	0.637223718
Colombia	Uzbekistan	0.618896497
Chinese Taipei	Republic of Moldova	0.616540419
New Zealand	Latvia	0.609866182
Malaysia	Georgia	0.603589939
Ecuador	Georgia	0.598231028
Bulgaria	Georgia	0.571821588
Kuwait	Georgia	0.569731414
Thailand	Uzbekistan	0.567659992
Croatia	Georgia	0.540997033
Romania	Georgia	0.534952925
Spain	Uzbekistan	0.534164885
Indonesia	Ethiopia	0.517614167
Canada	Portugal	0.500436379

Morocco	Uzbekistan	0.499879142
United States of America	France	0.48255413
Slovenia	Georgia	0.473224669
Jordan	Namibia	0.459172281
Croatia	Republic of Moldova	0.440997294
Spain	France	0.430003158
Algeria	Uzbekistan	0.428009857
Kuwait	Republic of Moldova	0.424352739
Argentina	Turkiye	0.424156688
Thailand	Turkiye	0.423360442
Romania	Republic of Moldova	0.417754477
Peru	Georgia	0.417242237
Japan	Turkiye	0.402157657
Republic of Korea	Turkiye	0.393703664
Canada	France	0.382438203
Argentina	Georgia	0.373269422
South Africa	Turkiye	0.371015281
Colombia	Turkiye	0.367916795
Italy	Uzbekistan	0.360993371
Vietnam	Republic of Moldova	0.355470046

Italy	Great Britain	0.350801359
Kazakhstan	Georgia	0.336843506
Kazakhstan	Cuba	0.336614045
Republic of Korea	Portugal	0.33382946
Iraq	Republic of Moldova	0.329998816
United States of America	Great Britain	0.329619196
Slovenia	Montenegro	0.321934352
Malaysia	Turkiye	0.296964974
Cyprus	Montenegro	0.291183934
Peru	Republic of Moldova	0.290022532
Ecuador	Nepal	0.282856185
Indonesia	Turkiye	0.282200072
Chinese Taipei	Portugal	0.276546813
Republic of Korea	France	0.272466876
South Africa	Nepal	0.26873957
Iraq	Ethiopia	0.26412775
Vietnam	Nepal	0.263644201
Peru	Ethiopia	0.258822207
Japan	France	0.251807274
Saudi Arabia	Portugal	0.236888905
Japan	Brazil	0.234866155

Vietnam	Ethiopia	0.232234961
Iraq	Georgia	0.230469033
Bulgaria	Republic of Moldova	0.229947317
Morocco	Nepal	0.227641096
Bosnia and Herzegovina	Georgia	0.222880012
New Zealand	Georgia	0.211402869
South Africa	Uzbekistan	0.210258619
Jordan	Uzbekistan	0.206103324
Argentina	Portugal	0.20257389
Bulgaria	Portugal	0.198231095
Slovenia	Luxembourg	0.189743258
Jordan	Tunisia	0.189081071
Kazakhstan	Republic of Moldova	0.188555686
United States of America	People's Republic of China	0.187826673
Egypt	Turkiye	0.175520888
New Zealand	Netherlands	0.171571809
Algeria	Cuba	0.170630925
Australia	Great Britain	0.167509971
Singapore	Portugal	0.166860763
Italy	France	0.159054075

Chile	Turkiye	0.15705228
Azerbaijan	Ukraine	0.154565179
Ireland	Switzerland	0.154012679
South Africa	Ethiopia	0.149986529
Lithuania	Luxembourg	0.149968315
Vietnam	Georgia	0.148650792
Jordan	Georgia	0.144299783
Mexico	Brazil	0.142065973
Indonesia	India	0.13817805
Algeria	Turkiye	0.135452887
Hungary	Ukraine	0.13480555
Morocco	Georgia	0.133667908
Germany	Turkiye	0.130765119
Italy	Turkiye	0.129151194
Saudi Arabia	Georgia	0.125887376
Belgium	Switzerland	0.123865292
Israel	Netherlands	0.122088935
Poland	France	0.120006276
Canada	Turkiye	0.117125419
Lithuania	Trinidad and Tobago	0.11621307
Algeria	Ethiopia	0.116187018
Japan	Great Britain	0.111168914

Greece	Uzbekistan	0.10861577
Chinese Taipei	Georgia	0.106912768
Iraq	Nepal	0.102273432
Denmark	Switzerland	0.101338681
Sweden	France	0.099988043
Belgium	France	0.099965245
Malaysia	Uzbekistan	0.099445087
Norway	Switzerland	0.094223985
Finland	Switzerland	0.087437577
Austria	France	0.084635457
Belgium	Netherlands	0.080631791
Algeria	Nepal	0.079424146
Ecuador	Turkiye	0.077667703
Austria	Switzerland	0.077598068
Islamic Republic of Iran	Ukraine	0.076261471
Kazakhstan	Turkiye	0.075766523
Czechia	France	0.074439734
Iraq	Turkiye	0.073130969
Morocco	Ethiopia	0.072718299
Ireland	Netherlands	0.071175299
Czechia	Uzbekistan	0.070880312
Algeria	Republic of Moldova	0.070295167

Serbia	Uzbekistan	0.069556944
Poland	Georgia	0.066736424
Egypt	Uzbekistan	0.065426462
Ireland	Latvia	0.064784139
Kazakhstan	Ethiopia	0.062220239
Indonesia	Uzbekistan	0.062007711
Morocco	Turkiye	0.060991784
Israel	France	0.059510073
Nigeria	Ukraine	0.057071918
Chile	France	0.056542552
Sweden	Portugal	0.053548178
Cyprus	Luxembourg	0.050806201
Hungary	Netherlands	0.047307724
Romania	Ethiopia	0.047292598
Serbia	Netherlands	0.040408133
Costa Rica	Portugal	0.039903664
Slovakia	Netherlands	0.038708865
Slovakia	Ukraine	0.037582009
Singapore	France	0.03441686
Mexico	France	0.034309773
Bosnia and Herzegovina	Portugal	0.034169307
Peru	Turkiye	0.033913023
Greece	France	0.033275226

Denmark	Netherlands	0.031552434
Norway	France	0.02262561
Ecuador	Uzbekistan	0.022124919
Lithuania	Montenegro	0.021206022
Denmark	France	0.019547323
Ecuador	Cuba	0.019120166
Finland	France	0.018657212
Spain	Turkiye	0.018250616
Croatia	Ukraine	0.018005673
Spain	Great Britain	0.017581341
Cyprus	Georgia	0.016783685
Australia	Switzerland	0.016772795
Greece	Great Britain	0.016270731
Islamic Republic of Iran	People's Republic of China	0.015507628
Slovenia	Latvia	0.015097721
Costa Rica	Turkiye	0.014363168
Australia	France	0.014338095
Pakistan	Georgia	0.013249494
Poland	Turkiye	0.010835723
Nigeria	People's Republic of China	0.009511459

Chile	Uzbekistan	0.009023145
Hungary	Great Britain	0.007555403
New Zealand	Ukraine	0.00715914
Colombia	Brazil	0.006608707
Colombia	France	0.006578001
Kuwait	Portugal	0.005915847
Thailand	Ethiopia	0.005149029
Morocco	Republic of Moldova	0.005101772
Costa Rica	France	0.004614013
Czechia	Great Britain	0.004412895
Egypt	India	0.00428458
Thailand	India	0.003830537
Pakistan	Nepal	0.003411506
Finland	Netherlands	0.003094956
Serbia	Ukraine	0.002106877
Israel	Switzerland	0.001865206
Jordan	Ukraine	0.001343541
Islamic Republic of Iran	Brazil	0.001243613

APPENDIX C

Reference DMU	Benchmark DMU	Number of benchmark countries

Georgia	Costa Rica (0.942), Slovakia (0.924), Finland (0.891), Serbia (0.888), Norway (0.884), Czechia (0.851), Denmark (0.848), Sweden (0.847), Greece (0.842), Austria (0.838), Israel (0.817), Hungary (0.811), Singapore (0.799), Chile (0.778), Lithuania (0.713), Ireland (0.711), Belgium (0.696), Malaysia (0.604), Ecuador (0.599), Bulgaria (0.572), Kuwait (0.57), Croatia (0.541), Romania (0.535), Slovenia (0.474), Peru (0.418), Argentina (0.374), Kazakhstan (0.337), Iraq (0.231), Bosnia and Herzegovina (0.223), New Zealand (0.212), Vietnam (0.149), Jordan (0.145), Morocco (0.134), Saudi Arabia (0.126), Chinese Taipei (0.107), Poland (0.067), Cyprus (0.017), Pakistan (0.014)	35
Turkiye	Mexico (0.824), Argentina (0.425), Thailand (0.424), Japan (0.403), Republic of Korea (0.394), South Africa (0.372), Colombia (0.368), Malaysia (0.297), Indonesia (0.283), Egypt (0.176), Chile (0.158), Algeria (0.136), Germany (0.131), Italy (0.13), Canada (0.118), Ecuador (0.078), Kazakhstan (0.076), Iraq (0.074), Morocco (0.061), Peru (0.034), Spain (0.019), Costa Rica (0.015), Poland (0.011)	15
Republic of Moldova	Bosnia and Herzegovina (0.743), Saudi Arabia (0.638), Chinese Taipei (0.617), Croatia (0.441), Kuwait (0.425), Romania (0.418), Vietnam (0.356), Iraq (0.33), Peru (0.291), Bulgaria (0.23), Kazakhstan (0.189), Algeria (0.071), Morocco (0.006)	11
Uzbekistan	Islamic Republic of Iran (0.907), Poland (0.803), Colombia (0.619), Thailand (0.568), Spain (0.535), Morocco (0.5), Algeria (0.429), Italy (0.361), South Africa (0.211), Jordan (0.207), Greece (0.109), Malaysia (0.1), Czechia (0.071), Serbia (0.07), Egypt (0.066), Indonesia (0.063), Ecuador (0.023), Chile (0.01)	11
Ethiopia	Pakistan (0.984), Nigeria (0.934), Egypt (0.755), Indonesia (0.518), Iraq (0.265), Peru (0.259), Vietnam (0.233), South Africa (0.15), Algeria (0.117), Morocco (0.073), Kazakhstan (0.063), Romania (0.048), Thailand (0.006)	9

France	Germany (0.87), United States of America (0.483), Spain (0.431), Canada (0.383), Republic of Korea (0.273), Japan (0.252), Italy (0.16), Poland (0.121), Sweden (0.1), Belgium (0.1), Austria (0.085), Czechia (0.075), Israel (0.06), Chile (0.057), Singapore (0.035), Mexico (0.035), Greece (0.034), Norway (0.023), Denmark (0.02), Finland (0.019), Australia (0.015), Colombia (0.007), Costa Rica (0.005)	8
Portugal	Canada (0.501), Republic of Korea (0.334), Chinese Taipei (0.277), Saudi Arabia (0.237), Argentina (0.203), Bulgaria (0.199), Singapore (0.167), Sweden (0.054), Costa Rica (0.04), Bosnia and Herzegovina (0.035), Kuwait (0.006)	7
Nepal	Ecuador (0.283), South Africa (0.269), Vietnam (0.264), Morocco (0.228), Iraq (0.103), Algeria (0.08), Pakistan (0.004)	5
Great Britain	Italy (0.351), United States of America (0.33), Australia (0.168), Japan (0.112), Spain (0.018), Greece (0.017), Hungary (0.008), Czechia (0.005)	4
Netherlands	Australia (0.802), New Zealand (0.172), Israel (0.123), Belgium (0.081), Ireland (0.072), Hungary (0.048), Serbia (0.041), Slovakia (0.039), Denmark (0.032), Finland (0.004)	3
Switzerland	Ireland (0.155), Belgium (0.124), Denmark (0.102), Norway (0.095), Finland (0.088), Austria (0.078), Australia (0.017), Israel (0.002)	3
Brazil	Japan (0.235), Mexico (0.143), Colombia (0.007), Islamic Republic of Iran (0.002)	2
Cuba	Kazakhstan (0.337), Algeria (0.171), Ecuador (0.02)	2
Latvia	Cyprus (0.642), New Zealand (0.61), Ireland (0.065), Slovenia (0.016)	2
Luxembourg	Slovenia (0.19), Lithuania (0.15), Cyprus (0.051)	2
Montenegro	Slovenia (0.322), Cyprus (0.292), Lithuania (0.022)	2
Ukraine	Azerbaijan (0.155), Hungary (0.135), Islamic Republic of Iran (0.077), Nigeria (0.058), Slovakia (0.038), Croatia (0.019), New Zealand (0.008), Serbia (0.003), Jordan (0.002)	2

India	Indonesia (0.139), Egypt (0.005), Thailand (0.004)	1
Mongolia	Azerbaijan (0.846)	1
Namibia	Jordan (0.46)	1
People's Republic of China	United States of America (0.188), Islamic Republic of Iran (0.016), Nigeria (0.01)	1
Trinidad and Tobago	Lithuania (0.117)	1
Tunisia	Jordan (0.19)	1

APPENDIX D

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