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Abstract

We assess the public spending efficiency of 20 Latin American countries over the period of 2000-2019, computing Data Envelopment Analysis efficiency scores. For the Public Sector Performance composite indicator, we use the annual data of socio-economic indicators, and for the input measure we consider Total Public Spending as a percentage of GDP, by spending category. The results show that public spending during the period under study increased, but that overall governments were not efficient, as on average they could have used 27% less spending to achieve the same levels of performance. On the other hand, governments could have increased their performance by 18% whilst maintaining the same level of spending. The most-efficient countries were Chile, Guatemala, Panama, and Paraguay, with the least efficient being Bolivia, Venezuela, Nicaragua, Suriname, and Brazil.

JEL-Codes: H110, C130, C140, H500.

Keywords: government efficiency, Data Envelopment Analysis, government spending, Latin America.

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1. INTRODUCTION

The role of fiscal policy broadly covers the accomplishment of the three Musgravian functions: allocation of resources, distribution of income, and the stabilisation of the economy. As governments endeavour to accomplish these roles, it is important to analyse the quality of government spending and how effective has been the use of public resources, especially in a region that mostly depends on revenues from commodities, which is non-permanent income. Accordingly, this paper analyses government expenditure and its efficiency for 20 Latin American countries between 2000 and 2019. This cross-country analysis enables drawing relative comparisons for the region as a whole and highlights which countries used their economic resources better and performed well within the same region.

The reality in Latin America is that government spending increased over the last two decades, and at a relatively greater speed since 2010. With the onset of the global financial and economic crisis, most of the region's countries implemented expansionary fiscal policies that were intended to increase aggregate demand. Spending on subsidies, transfers, and certain social programmes was accordingly increased, which, although it helped mitigate the impact of the crisis on the most vulnerable sectors, in some cases it led to a permanent rise in government spending. Consequently, public spending as percentage of GDP in the 20 countries comprising our analysis increased by 7% of GDP from 2000 (19.3%) to 2020 (26.3%). In addition, the average spending in the Latin American countries under study in the areas of health, education, and social protection increased from representing 1.5%, 3.2% and 3.4% of GDP in 2000, to representing 2.8%, 4.3% and 5.6% of GDP in 2020, respectively.

Our contribution to the literature lies in the study's focus on the analysis of public sector efficiency in Latin American countries, especially with regards the provision of both public sector performance indicators and (output and input) efficiency scores ensuing from the implementation of the Data Envelopment Analysis. As mentioned in Afonso et al. (2020), less evidence is available for Asia, Africa, or Latin America regarding public sector efficiency. Hence, our paper provides a public sector performance and efficiency analysis for a time span of 20 years covering 20 countries, with our dataset including many socio-economic areas, which thus make it possible to analyse individual categories of spending areas.

The remainder of the paper is organised as follows. Section 2 provides the literature review, while Section 3 describes the methodology applied to compute the performance indicators and the Data Envelopment Analysis methodology. Section 4 reports the empirical analysis and Section 5 concludes.

2. LITERATURE

Using efficiency analysis, along the lines of the seminal work of Farrell (1957), the related literature expands the use of methods such as Free Disposal Hull (FDH), Data Envelopment Analysis (DEA), and composite performance indicators to study the efficiency of government spending – notably across countries.

For example, Afonso and St. Aubyn (2004) computed the efficiency of public spending specifically for the education and health sectors for a sample of OECD countries. These same authors compared both non-parametric methods: Free Disposal Hull (FDH) analysis and Data Envelopment Analysis (DEA) and for both methodologies, they found that in the education sector (input and output), Finland, Japan, Korea and Sweden were the most efficient countries, whereby their students achieved the best results with fewer resources, whereas Belgium (input) and Portugal (output) were the least efficient. The average input efficiency score in their study education was 0.89, which means that on average, countries could have used 11% less resources to achieve the same output.

Afonso et al. (2005) carried out one of the first efficiency analyses, using public sector performance (PSP) composite indicators and public sector efficiency (PSE) indicators for 23 OECD industrialised countries for the period of 1990 and 2000. For the countries analysed, the division into small, medium, and large governments corresponded to spending below 40% of GDP, between 40% and 50% of GDP, and above 50% of GDP respectively. The analysis was divided into four expenditure categories, namely education, health, public infrastructure, and administration. These were called the “Opportunity Indicators”, and were the “Musgravian” indicators that reflected allocation, distribution, and stabilisation. The results showed that, on balance, small governments report better economic performance (PSP) than large governments or medium sized governments. The FDH analysis results showed that Japan, United States, and Luxembourg were placed on the “production possibility frontier”, in that large governments, on average, are able to use 35% less spending to achieve the same PSP. Furthermore, the EU15 countries were identified as being relatively less efficient when compared with both the United States and the average of the other OECD countries in the sample.

Afonso et al. (2010) also studied public sector performance and efficiency for the period of 2001-2003 for 22 countries, including the 12 new EU members at that time, as well as emerging markets, such as Brazil, Chile, Mexico and others. The authors found important differences across the countries, with Brazil being one of the worst countries in terms of PSP. Even though most of the emerging economies performed less-well than the old, industrialised countries, the economies of the recently-industrialised Asian countries performed well. Regarding the

efficiency scores, the Asian countries achieved higher scores with lower public spending. By analysing the DEA results, Thailand, Cyprus, Ireland, and Korea were found to be on the production frontier, with Chile next on the list. Finally, the Tobit analysis showed that per capita GDP, public sector competence, educational levels, and the security of property rights all appeared to contribute to the prevention of inefficiencies in the public sector.

There are few studies that address public efficiency in Latin America. Clements et al. (2007) calculated the efficiency of spending on infrastructure (rails, roads, electricity, water, and telecommunications) in seven Latin American countries (Argentina, Bolivia, Brazil, Chile, Colombia, Mexico, and Peru) during the 1990s and the early 2000s, using the Free Disposal Hull Analysis technique. The results showed that Chile and Mexico demonstrated higher levels of efficiency.

Afonso et al. (2013) analysed 23 countries, using the Public Sector performance (PSP), Public Sector Efficiency (PSE) indicators and Data Envelopment Analysis (DEA) efficiency scores for the period of 2001-2010. They divided the countries according to their public spending as a percentage of GDP, namely: below 25% of GDP; between 26% and 30% of GDP; and above 30% of GDP. Their results showed again that the larger the size of the government, the less efficient it is. The results of PSP placed Chile, Trinidad and Tobago, Panama, and Costa Rica as the best performers. For education, Costa Rica, Trinidad and Tobago, and Guyana were ranked in first place in that order. In terms of health, Costa Rica and Chile topped the list, while Chile was ranked first for the provision of public infrastructure. Next, the overall PSE score placed Guatemala, Chile, and Peru at the top of the group, followed by the Dominican Republic, Ecuador, and El Salvador. It is also important to remark that Trinidad & Tobago and Panama do not feature at the top of the list of PSE scores. In the DEA Chile, Guatemala and Perú were placed on the efficiency frontier, with, on average, countries being able to achieve the same level of outcome by using 40% less spending or they could increase their performance by 19% with the same level of inputs.

Ribeiro (2008) also analyses 17 countries of Latin America from 1998 to 2002. Following the same process, the author computed the PSP indicator for five areas: health, education, public administration, equality, and economic performance. Finally, the author computed DEA analysis to gain efficiency scores and analysis the non-discretionary variables, but using the bootstrap methodology. The countries with the best PSP scores were Chile for health, administration, and economic performance, Costa Rica for education and health, and Uruguay for equality, and the lowest scores in the region were for Guatemala, Paraguay and Bolivia. According to the DEA analysis, the countries located at the production frontier are Costa Rica,

the Dominican Republic, and Guatemala. On the contrary, Bolivia, Brazil and Honduras were the more inefficient countries.

Finally, one of the latest studies of efficiency in Latin America is that of Izquierdo et al. (2018), in which the analysis compares countries of Latin America versus OECD countries. The methodology used was DEA for the sectors of health, security, and public administration, employing indicators such as public salaries, transfers and subsidies, and public purchases. These authors estimated on average about 4.4% of inefficiency for GDP, which represents about 16% of public spending. Regarding security, their results showed an average 70% of efficiency, which equates to 30% of crime not being prevented. The results of Izquierdo et al.'s research are diverse across countries, and the authors detected a correlation between better institutions and greater efficiency. In addition, in the health sector, Chile was the only Latin-American country to be placed at the production frontier, while Barbados, Costa Rica, Cuba, and Uruguay also received good efficiency scores. On the other hand, Bolivia, Ecuador, Guatemala, Guyana, Panama and Suriname all registered low efficiency scores for health.

The recent literature has also investigated the relationship between the tax system and spending efficiency, the idea being that it is not only changes in revenues that affect the level of public spending. For instance, Afonso et al. (2020) assessed whether structural tax reforms positively or negatively affect public spending efficiency for OECD economies during the period of 2007-2016. They calculated the composite indicators of government performance and then the input efficiency scores for 2016-2017 using DEA technique for 3 different models. The results, showing an average efficiency score of around 0.6-0.7, and therefore spending was 30%-40% lower, on average. Furthermore, Chile, Korea, and Switzerland were located at the efficiency frontier. Later on, the same authors used a panel analysis to assess the impact of tax reforms on the computed DEA input efficiency scores, reporting that those countries that increased their tax rates experienced lower spending efficiency. When the authors controlled for endogeneity, they achieved two specific results: i) increasing tax rate reforms worsens public sector efficiency, and ii) increasing tax base reforms improves efficiency. Regarding the control variables, the authors found that population, primary balance, and number of internet users all positively affect public sector efficiency.

Following up on this topic, Afonso et al. (2021) evaluated the relevance of taxation for public spending efficiency from 2003 to 2017 for the OECD countries. Having calculating DEA efficiency scores and measuring the impact of tax structures, the main conclusions were that inputs could be theoretically lower by approximately 32%–34%, and that expenditure efficiency is negatively associated with taxation.

3. METHODOLOGY

3.1. Public Sector Performance

The total number of countries in Latin America and the Caribbean is 42, but data is not available for all of them, especially the Caribbean countries. The sources used to collect the information for the social and economic indicators are mainly the World Bank, the International Monetary Fund (IMF), and the Economic Commission for Latin America and the Caribbean (ECLAC). From the 42 countries, we analyse 20 countries from both Central (10) and South (10) America for the period of 1990 to 2019.

Following the methodology of Afonso et al. (2005), we first compute a Public Sector Performance (PSP) composite indicator, which includes seven socio-economic areas of government activity, which are referred to as the PSP sub-indicators (including the Musgravian functions of the State, distribution, economic performance/allocation, and stabilisation).

Administration: is proxied by the Governance indicators of the World Bank, which reflect the perceptions of the quality of public services, capacity to regulate and implement policies and rules of society, freedom of expression, as well as the active participation of society in government. The four indicators used are available for all the countries during the whole period of 1996-2019. The original data ranges from -2.5 (bad) to 2.5 (good) and they were then rescaled from 0 to 5 for the calculation.

Education: is measured by the average years of secondary school enrolment and the quality of the education system over the period of 1990-2019 for the first indicator, and for only 2008-2018 for the second indicator, without information for Belize, Guatemala, and Suriname. The countries with less data available for the whole the period are Guyana, Nicaragua, Paraguay, Honduras, Suriname, Bolivia, and Brazil.

Health: comprises three indicators, two of which have complete data for the whole series since 1990, albeit Maternal Mortality only has information for all countries since 2000, with data missing before that date for Honduras, Nicaragua, Panama, Suriname, Bolivia, Paraguay, and Peru. These three indicators were: i) Mortality rate, under-5 years old (per 1,000 live births): changed to $(1,000 - \text{Value})/1,000$; ii) Adolescent fertility rate (births per 1,000 women aged 15-19): Changed to $(1,000 - \text{Value})/1,000$; and iii) Maternal mortality ratio (modelled estimate, per 100,000 live births): Changed to $(100,000 - \text{Value})/100,000$.

Infrastructure: is measured by the indicator “Quality of Infrastructure” from the World Economic Forum, with information only being available for the period of 2008-2018, except for Belize, Guyana, and Suriname.

Distribution: includes the Gini Index, although data is missing for several countries during the period, with more fully-available data only being available since 2000. Countries such as Belize, Guatemala, Guyana, Nicaragua, and Suriname lack information. For calculations, the data were changed to the 100-Gini Value.

Economic performance: consists of three indicators: i) unemployment rate; ii) GDP per capita; and iii) GDP growth. The values are a five-year average, as they are macro indicators that change in the long term. Data is available for all countries.

Stability: is composed of a five-year average of the coefficient of the variation of growth and the inflation rate. All countries possess information for the whole period. The coefficient of variation of Growth is Standard Deviation (five-year average)/Five-year average, which is changed to $1/x$ and Inflation is the five-year average (used as $1/x$).

For further details on the indicators, see Appendix Table A.1. After all the transformations had been carried out, each indicator was normalised by its sample mean and the resultant values were used to construct the performance composite indicators.

Each PSP sub-indicator is the average of its indicators for each country for every year, with the total PSP being the average of the seven PSP sub-indicators (with equal weights assigned). The first four categories of administration, education, health, and infrastructure are considered to be “Opportunity Indicators”, which refer to the government as being the provider of both public services and equal opportunities to the society. The following three categories are distribution, economic performance, and stability, which are called the “Musgravian Indicators”, and they represent the ability of the government to promote the functions of distribution, allocation, and stabilisation.

The PSP was computed for the period of 1990-2019, subject to the limitation of the data described above. It is important to mention that the PSP values over time are measured relative to those of other countries, which means that over time the PSP values could increase or decrease, not just because of the evolution of the indicators, but also as a result of the behaviour of the other countries.

3.2. Data Envelopment Analysis (DEA)

As mentioned by Afonso et al. (2007), this strand of analysis has its roots in the seminal work of Farrell (1957), in which the author provided a measure of productive efficiency which considers inputs and outputs, and went on to obtain a production function with constant returns to scale. Recent papers have used non-parametric approaches for measuring relative expenditure efficiency across countries and this thesis follows the description of DEA

constructed by Afonso et al. (2007), and thus the measurement of public sector efficiency follows a function for each country i from a total of 20, calculated by:

$$Y_i(t) = f(X_i(t)) \quad (1)$$

where Y_i = Composite indicator representing the output, and X_i = Government Spending representing input. Accordingly, country i will be efficient if $Y_i > f(X_i)$, which implies that the output is the best that can be obtained for the respective input level.

By using DEA, it is possible to compute a theoretical efficiency frontier, where the inefficiency of country i is measured by computing the distance to the theoretical frontier. The linear programming problem involved supposes k inputs and m outputs for the 20 countries under analysis. For the i -th country, y_i is the column vector of the outputs and x_i is the column vector of the inputs. X can be defined as the $(k \times n)$ input matrix, and Y as the $(m \times n)$ output matrix.

The DEA model is then specified for a given i -th country, and, as an illustration, adopting an input-oriented approach, the efficiency scores are computed by means of the following linear programming problem:

$$\begin{aligned} & \min_{\theta, \lambda} \theta \\ \text{s. t. } & -y_i + Y\lambda \geq 0 \\ & \theta x_i - X\lambda \geq 0 \\ & I1'\lambda = 1 \\ & \lambda \geq 0 \end{aligned} \quad (2)$$

where y_i is a vector of outputs, x_i is a vector of inputs, λ is a vector of constants, $I1'$ is a vector of ones, X is the input matrix, and Y is the output matrix. The efficiency scores of θ , range from 0 to 1, such that countries performing on the frontier are awarded a score of 1. More specifically, if $\theta < 1$, the country is within the production frontier (i.e., it is inefficient), and if $\theta = 1$, then the country is situated on the frontier (i.e., it is efficient).

DEA can provide two sets of results, both of which are input- and output-oriented. Input efficiency scores represent the proportional reduction in inputs, while the output constant holds firm and the output-oriented scores measure the proportional increase in outputs while the inputs remain constant.

4. EMPIRICAL ANALYSIS

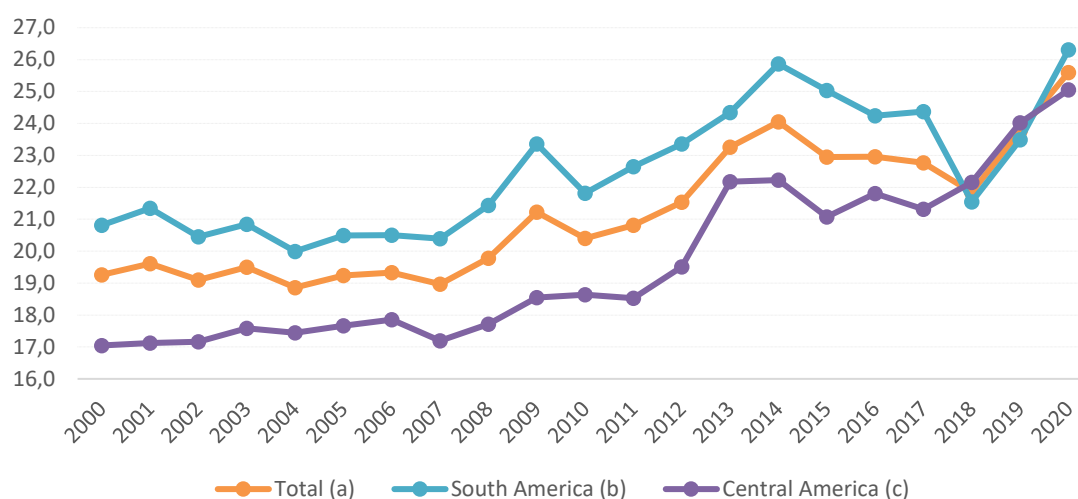
4.1. *Government Spending Data*

Due to the limited availability of data for government spending, our analysis only focusses on the period of 2000 onwards. Over the last two decades government spending in Latin America has shown an upward trend, as presented in Figure 1. On average, it represented 19.3% of GDP in 2000 and increased to 25.6% of GDP in 2020, with a growth rate of 32.9%. The results also show that the government spending in South America is greater than the level in Central America. When comparing the two regions, average spending in 2000 was 20.8% in South America, and 17.0% in Central America, which increased to 26.3% and 25.1% of GDP in 2020 respectively¹. However, the growth rate of the percentage of government spending between 2000 and 2020 was larger for Central America (46.9%) than South America (26.4%). Figure 1 displays the evolution of this indicator, where government spending reached a peak during the years of the global economic crisis in 2008-2009, which was mostly due to the expansive fiscal policies adopted by governments to increase aggregate demand and mitigate the impact of the crisis on the private sector and on households.

During the years following the crisis, the increase of public spending continued at a good pace, reaching its next peak in 2014. The average growth rate between 2010 and 2014 was 2.6%, while between 2000 and 2009 it was 1.1%, with values showing a slight reduction from 2015 up until 2018, after which it increased again, attaining the highest value of total government spending in 2020, which can be explained by the measures and policies taken by governments to face the economic, social and health crisis caused by Covid-19. It was during 2020 that governments increased spending to completely unexpected rates, with many countries registering values over 17% (El Salvador, Guatemala, Argentina, Brazil, Paraguay, and Peru).

¹ Currently no data is available for Panama (2018, 2019, and 2020), Bolivia (2019 and 2020) and Venezuela (2015 to 2020)

Figure 1: Average Government Spending (% GDP)



Source: Economic Commission for Latin America and the Caribbean (ECLAC)

- (a) Belize (since 2012), Costa Rica, El Salvador, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Suriname (since 2013), Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, and Venezuela.
- (b) Belize (since 2012), Costa Rica, El Salvador, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Suriname (since 2013).
- (c) Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, and Venezuela.

*Corresponds to Central Government Spending for all countries, except Peru, where General Government Spending is used.

This increase of public spending during the period under study was largely due to the commodities prices boom, which started at the beginning of the 2000s and lasted for about a decade, which gave rise to an increase in public revenues. Furthermore, even though these price increases stopped during the months immediately following the economic crisis of 2008-2009, the strong level of Chinese demand soon resumed and prices increased again (Ocampo, 2017).

It is important to mention that Latin American countries mostly rely on commodities exports, and therefore government revenues depend on taxes levied on commodity sectors and profits from state-owned enterprises in sectors such as oil and minerals. Latin America is highly natural resource dependent, with countries such as Bolivia, Colombia, Ecuador, and Venezuela depending mainly on Fuels, whereas Brazil, Chile, Peru are dependent on Minerals and Argentina, Paraguay, Uruguay, Guatemala, Honduras, and Nicaragua depend on Agriculture. According to the analysis of Ocampo (2017), the commodity boom between 2003 and 2013 was stronger for oil and metals than it was for agricultural goods.

4.2. Public Sector Performance Results

Table I shows the results of the standardised PSP for 1990, 2000, 2010, and also 2019 for the 20 countries under analysis. These results represent outcome indicators, without considering

the amount of spending incurred. Panama registered the highest total PSP in 1990 and 2000 (2.23 and 1.43 respectively) compared with Guyana (0.42) in 1990, and both Venezuela and Ecuador in 2000 (which registered almost the same value of 0.74), which recorded the lowest PSP during the same years. Then in 2010 the first place was passed on to Chile, which registered the highest score (1.24) between the countries and maintained this position for many years, up until 2013, whereas the worst place was occupied by Nicaragua which recorded 0.78. Next, the best and worst ranked performers changed back to Panama (1.36) and Venezuela (-0.5) in 2019.

Table I: Public Sector Performance Indicator by type

Country	1990			2000			2010			2019		
	Musg.	Opp.	Total	Musg.	Opp.	Total	Musg.	Opp.	Total	Musg.	Opp.	Total
Belize	2.02	0.99	1.67	1.68	1.04	1.30	0.94	0.97	0.96	1.72	0.95	1.25
Costa Rica	1.25	0.89	1.11	1.14	1.06	1.10	0.92	1.17	1.06	1.27	1.30	1.28
El Salvador	0.67	0.99	0.78	1.02	0.91	0.96	0.89	1.08	1.00	1.81	0.90	1.36
Guatemala	1.15	0.97	1.09	1.45	0.75	1.10	1.03	0.95	0.98	1.61	0.79	1.12
Guyana	0.13	1.00	0.42	0.76	1.10	0.96	0.68	1.01	0.88	1.28	0.98	1.13
Honduras	1.00	0.98	0.99	0.90	0.90	0.90	0.87	0.93	0.90	1.18	0.83	1.01
Mexico	0.91	0.99	0.95	0.96	1.03	1.00	0.96	1.03	1.00	1.05	1.05	1.05
Nicaragua	0.06	0.80	0.43	1.22	0.86	1.00	0.61	0.86	0.78	0.64	0.84	0.74
Panama	3.45	1.02	2.23	1.83	1.03	1.43	1.17	1.05	1.10	1.72	1.01	1.36
Suriname	0.41	1.00	0.71	0.82	1.00	0.91	1.35	0.96	1.11	0.38	0.96	0.72
Argentina	0.47	1.13	0.80	0.75	1.16	0.95	0.96	0.99	0.98	0.59	1.07	0.83
Bolivia	0.41	0.96	0.59	1.06	1.00	1.03	1.43	0.87	1.05	1.33	0.91	1.12
Brazil	0.91	1.00	0.93	0.75	1.04	0.89	0.94	1.05	1.01	0.50	1.06	0.78
Chile	1.15	1.16	1.16	1.16	1.25	1.21	1.09	1.32	1.24	1.01	1.24	1.14
Colombia	1.69	1.01	1.46	0.66	0.97	0.81	0.95	1.05	1.00	0.96	1.07	1.01
Ecuador	0.66	1.01	0.83	0.61	0.88	0.74	1.00	0.89	0.94	0.90	0.99	0.95
Paraguay	1.21	0.77	1.03	0.66	0.85	0.77	0.89	0.79	0.83	1.01	0.92	0.97
Peru	0.26	1.08	0.67	0.92	1.04	0.98	1.23	0.96	1.08	1.17	1.10	1.14
Uruguay	0.84	1.22	1.03	0.78	1.24	1.01	1.22	1.20	1.21	0.85	1.25	1.05
Venezuela	0.68	0.98	0.83	0.53	0.89	0.74	0.89	0.82	0.85	-1.61	0.61	-0.50
Avg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Max.			2.23	1.83	1.25	1.43	1.43	1.32	1.24	1.81	1.30	1.36
Min.			0.42	0.53	0.75	0.74	0.61	0.79	0.78	-1.61	0.61	-0.50

Source: Authors calculations. It is important to notice that PSP in 1990 includes only Education, Health, Economic, and Stability, because of data availability. Since 2000, PSP includes more less all sub indicators. Infrastructure is only since 2008 until 2018 and Administration only since 1996.

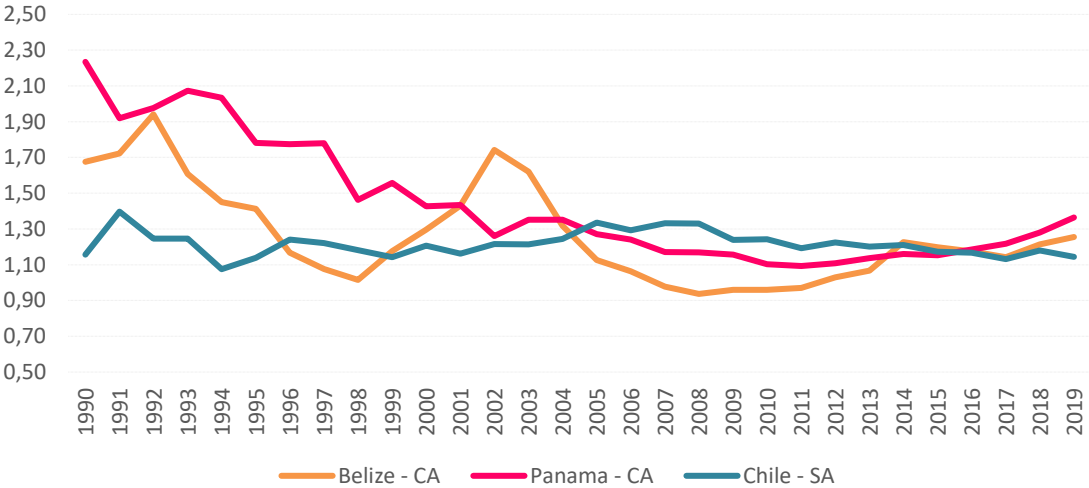
Analysing by type of indicator, i.e., whether it is Musgravian or Opportunity PSP, the results show that best or worst scores do not represent the same countries as in the cases of Total PSP. For example, if only Musgravian PSP (economic indicators) are checked, then the best country was Bolivia (1.43) in 2010 and the worst country was Nicaragua in both 1990 and 2010. In

addition, the same occurred with Opportunity PSP (social indicators), where Uruguay was the best-ranked in 1990 (1.22), in 2000 and 2010 it was Chile, and in 2019 it was Costa Rica. On the contrary, Paraguay and Guatemala registered the lowest results in 1990 and 2000.

By ranking, if we consider the first and last three positions during the period of 1990-2019, the best country for many years are Panama, Chile, and Belize, while the worst scores are Venezuela, Nicaragua, and Paraguay.

Figure 1 shows the evolution of the PSP indicator of the best performers, with scores ranging from 0.94 to 2.23. During the first decade, Panama was the best performer, however the three countries registered a decrease in their PSP. On the contrary, Belize started to improve in 1998, which is probably because this year fell during a period of economic crisis in most of the countries and inflation values were very high. Accordingly, when comparing between the countries under analysis, Belize was among the countries with a lower inflation rate, which helped to improve its PSP. Chile demonstrates the most constant pattern during the whole period.

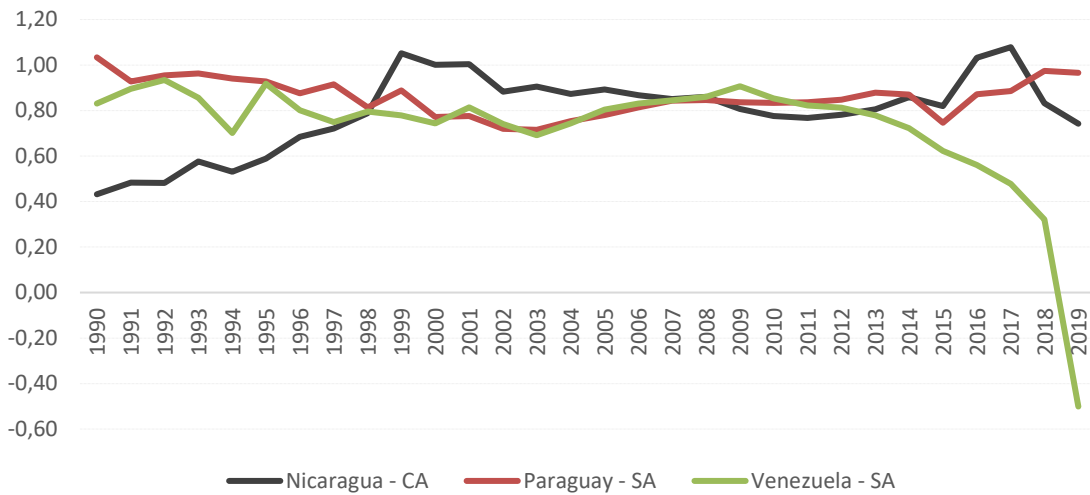
Figure 1: Evolution of the Total PSP - top three countries



Source: Authors’ calculations, CA - Central America, SA - South America,

On the other hand, the three weakest PSP performers in the sample are Venezuela, Nicaragua, and Paraguay (Figure 2), as shown by scores ranging from 0.43 to 1.08, except during 2019 and 2020, which is when Venezuela registered a negative PSP value in 2019 (as a result of the consequence of negative GDP growth rates). None of the countries appears to have improved, at least not along the period under study, all remaining within the same range.

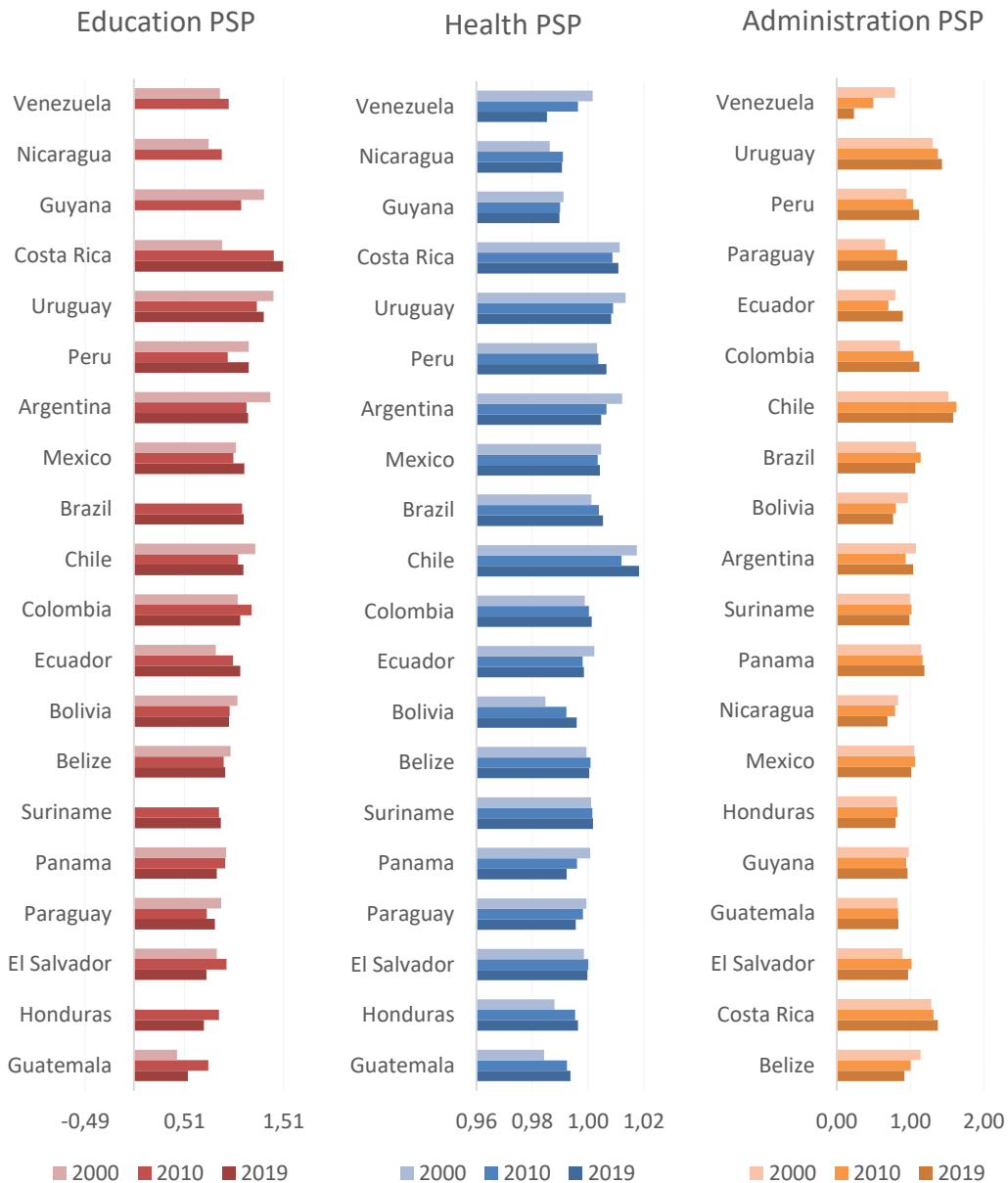
Figure 2: Evolution of Total PSP – bottom three countries



Source: Authors' calculations, CA - Central America, SA - South America,

Analysing PSP by the areas and for each 10 years, as shown in Figure 3, Uruguay was leading the group of countries in Education, however Costa Rica took the first place in 2000, and later in 2010 and 2019. The worst country in Latin America in 2000 was Guatemala, while Paraguay was in 2010, and Guatemala was again the worst country in 2019. Moving to the results for Health, the first-placed country for the same three years was Chile, with the worst-ranked country being respectively Guatemala (2000), Guyana (2010), and Venezuela (2019). For Administration, Chile once again led the ranking for the three years in question, with the worst performers being Paraguay and Venezuela.

Figure 3: PSP by Area: Education, Health, and Administration



Source: Authors' calculations.

Contrary to Economic PSP, Belize was the best performer in 1990, Mexico in 2000, and lately in Panama occupied this place in 2010 and 2019. The worst-performing countries were Guyana in 1990, Ecuador in 2000, Belize in 2010, and Venezuela in 2019. In terms of the stability indicators, Panama is also highlighted in 1990 and 2000, with Bolivia being ranked in first place in 2010, and in 2019 this place changed to El Salvador. On the other hand, Peru was placed at the bottom of the ranking in 1990 for Stability, followed by Venezuela in 2000 and 2010, while Suriname was ranked with the worst result for this factor in 2019.

4.3. DEA Efficiency Scores

Three models each using different inputs were used for the application of the DEA methodology, applying both input-oriented and output-oriented approaches.

The first model uses Total Public Spending as percentage of GDP as the input and Total PSP Scores as the output, while Table 2 reports the results.

Table2: DEA Efficiency Scores Model 1 (total PSP)

	2009				2013				2019			
	Input oriented		Output oriented		Input oriented		Output oriented		Input oriented		Output oriented	
Country	VRSTE	Rank.	VRSTE	Rank.	VRSTE	Rank.	VRSTE	Rank.	VRSTE	Rank.	VRSTE	Rank.
Belize	.		.	.	0.54	16	0.89	10	0.48	15	0.93	4
Costa Rica	0.94	5	0.96	6	0.88	5	0.94	5	0.85	3	0.95	3
El Salvador	0.68	11	0.82	12	0.73	11	0.86	12	1.00	1	1.00	2
Guatemala	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
Guyana	0.65	13	0.73	17	0.80	8	0.90	7	0.51	12	0.83	7
Honduras	0.64	14	0.77	14	0.59	14	0.71	19	0.64	9	0.74	12
Mexico	0.80	7	0.87	7	0.76	10	0.88	11	0.73	5	0.80	8
Nicaragua	0.70	10	0.71	18	0.82	7	0.75	18	0.71	6	0.56	16
Panama	1.00	1	1.00	1	0.95	4	0.98	3	.	.	.	.
Suriname	.		.	.	0.42	20	0.85	13	0.34	17	0.53	17
Argentina	0.72	9	0.83	10	0.62	13	0.77	17	0.61	10	0.61	14
Bolivia	0.44	18	0.82	11	0.50	18	0.90	6	.	.	.	.
Brazil	0.54	16	0.79	13	0.52	17	0.79	16	0.46	16	0.58	15
Chile	1.00	4	1.00	1	1.00	1	1.00	1	0.58	11	0.84	5
Colombia	0.68	12	0.83	9	0.70	12	0.84	14	0.70	7	0.76	11
Ecuador	0.59	15	0.76	15	0.56	15	0.83	15	0.49	14	0.70	13
Paraguay	1.00	1	1.00	1	0.99	3	0.89	8	0.81	4	0.78	9
Peru	0.74	8	0.86	8	0.79	9	0.89	9	0.68	8	0.84	6
Uruguay	0.91	6	0.97	5	0.87	6	0.96	4	0.50	13	0.77	10
Venezuela	0.50	17	0.73	16	0.44	19	0.65	20	.	.	.	.
Average	0.75		0.86		0.72		0.86		0.65		0.78	
Maximum	1.00		1.00		1.00		1.00		1.00		1.00	
Minimum	0.44		0.71		0.42		0.65		0.34		0.53	
Std Deviation	0.19		0.10		0.19		0.09		0.19		0.15	

Source: Authors' calculations.

Assuming variable returns to scale and considering an input-oriented approach (how much input quantities can be proportionally reduced without changing the output quantities produced), DEA displayed the results described below.

Using available data from 17 of the 20 countries, the average input efficiency score in 2000 was 80%, which implies that countries could achieve the same level of PSP by using 20% less government spending. The countries situated on the production possibility frontier are Guatemala and Panama, with Mexico and Argentina ranked after them, while the countries ranked in the last positions are Brazil, Venezuela, and Bolivia, which means that they are located the furthest from the efficiency frontier. A summary of efficiency scores is reported in Appendix A (the detailed results per year are described in the Online Appendix).

During the period under analysis, the most efficient countries are Guatemala, Panama, Chile, and Paraguay. This contrasts with the previously-obtained PSP results, where Panama and Chile are also ranked as the best performers, although, interestingly, Paraguay is not in this case, as it was ranked the worst in the PSP results. On analysing the data for Paraguay, it can be seen that its efficiency score is high as a result of the low values of government spending as a percentage of GDP when compared to the other countries.

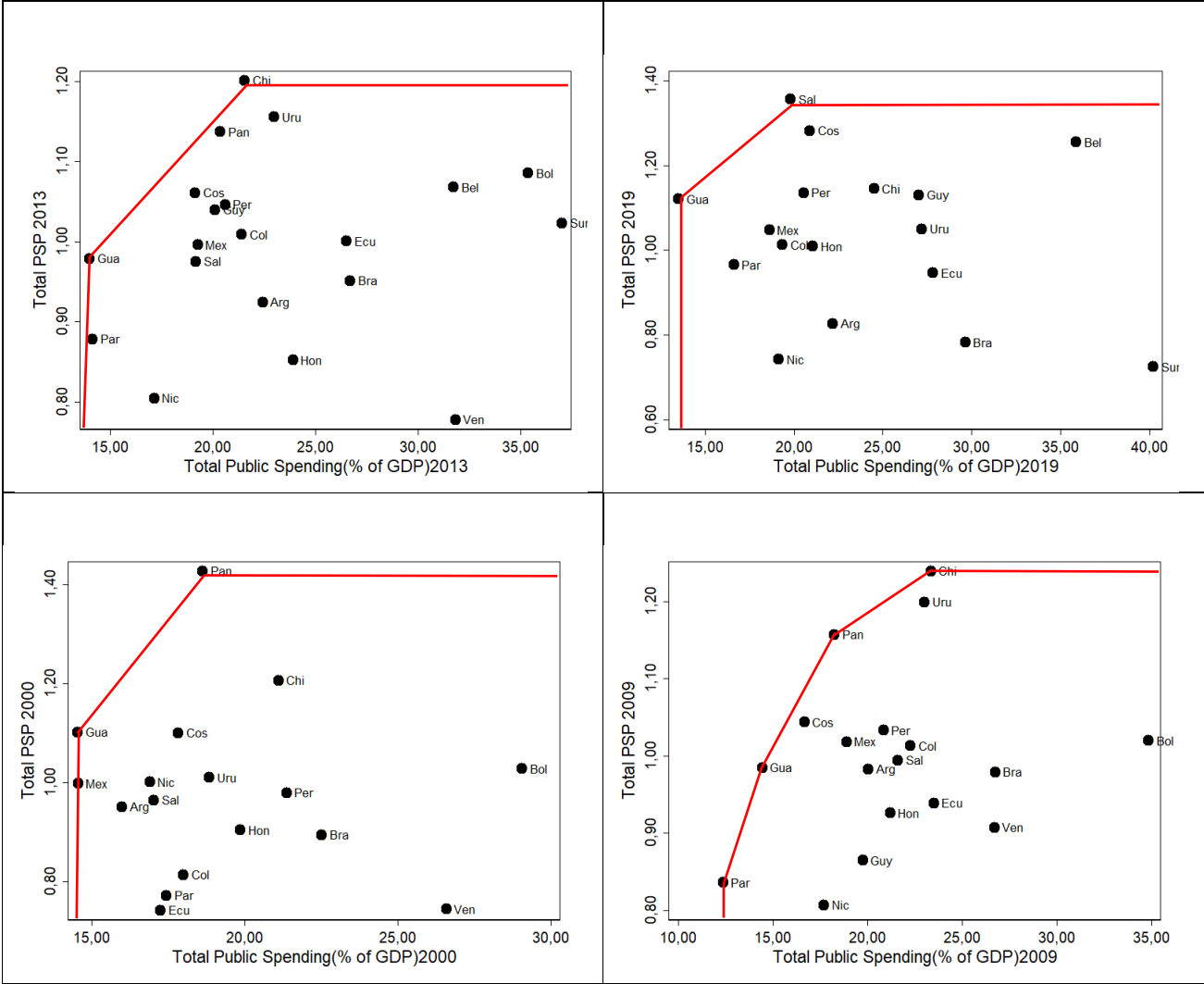
With regards the results of the output-oriented approach (i.e., how much output quantities can be proportionally increased without changing the input quantities used), the same 17 countries had an output efficiency score on average of 73% in 2000, implying that countries could have increased their performance by 27% with the same level of inputs. The countries located on the production possibility frontier were once again Guatemala and Panamá, followed by Mexico and Chile in third and fourth place respectively. The worst-performing countries were Venezuela, Brazil, and Peru.

The efficient countries located on the production possibility frontier in 2009 are Guatemala, Panama, Chile, and Paraguay. Guatemala and Chile remain in the same ranking in 2013 and, interestingly another country emerged at the top of the ranking in 2019, which is El Salvador, together again with Guatemala. In addition, in the same year Chile dropped to 11th position, and 2019 was therefore obviously not a good year for Chile.

Analysing the differences in the results according to the method used (input – output), most countries remain in the same position, or close to it. In particular there are some countries, such as Bolivia or Nicaragua that demonstrate a large difference in the results. Nicaragua is more efficient in terms of inputs and is ranked in the Top 10, however, when in terms of output it is ranked among the last positions, and is this one of the worst countries. Bolivia is the opposite, as the inputs results show zero efficiency, albeit this result improves for outputs. It is important to mention that Bolivia has one of the highest percentages of public spending (over 30%), and that Nicaragua belongs to the group of countries that spend less than 20%.

Figure 4 illustrates the production possibility frontier for Model 1 (with one input and one output) over a period of four years. The efficient countries in 2000 are Guatemala and Panama, with Mexico lying very close. The efficient countries in 2009 are Guatemala, Panama, Chile, and Paraguay while the efficient countries in 2013 are Guatemala and Chile. Finally, in 2019, the efficient countries are El Salvador and Guatemala.

Figure 4: Production Possibility Frontiers, Model 1.



Source: Authors' calculations.

We also assessed the level of efficiency by using two alternatives specifications. First, using Public Spending on Health (% of GDP) as the input and Health PSP as the output (Model 2), (mostly because of the health crisis due to Covid-19 and also in order to gain a view of this sector before this pandemic). Second, Model 3 uses Total Public Spending (% of GDP) as the input and the Economic component of the PSP as the output. The efficiency score results are reported in Table 3 and Table 4, respectively

From Table 3 we can observe that the input efficiency score increases from 33% in 2009 to 48% in 2013, which is the highest score, and then it starts to decrease until 2019, with 41%. The best year for the health sector appears to have been 2013, during which the increase of public spending was able to achieve better efficiency results.

Table 3: DEA Efficiency Scores - Model 2 (health performance)

	2009				2013				2019			
	Input oriented		Output oriented		Input oriented		Output oriented		Input oriented		Output oriented	
Country	VRSTE	Rank.	VRSTE	Rank.	VRSTE	Rank.	VRSTE	Rank.	VRSTE	Rank.	VRSTE	Rank.
Belize	.	.	.	.	0.24	19	0.99	12	0.20	16	0.98	12
Costa Rica	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1
El Salvador	0.21	15	0.99	9	0.34	14	0.99	11	0.33	9	0.99	10
Guatemala	0.35	5	0.98	15	0.70	4	0.99	17	0.59	4	0.98	15
Guyana	0.26	11	0.98	17	0.43	10	0.98	19	0.25	12	0.98	17
Honduras	0.16	17	0.98	14	0.29	17	0.99	14	0.34	8	0.98	13
Mexico	0.42	3	0.99	5	0.66	6	0.99	7	0.77	3	0.99	5
Nicaragua	0.16	16	0.98	18	0.27	18	0.98	20	0.22	15	0.98	16
Panama	0.25	12	0.99	13	0.50	7	0.99	15	.	.	.	.
Suriname	.	.	.	.	0.70	3	0.99	8	0.36	6	0.99	8
Argentina	0.65	2	1.00	4	0.96	2	1.00	4	0.98	2	0.99	3
Bolivia	0.33	6	0.98	16	0.69	5	0.99	16	.	.	.	.
Brazil	0.27	10	0.99	6	0.44	9	0.99	6	0.36	7	0.99	7
Chile	0.13	18	1.00	1	0.22	20	1.00	1	0.15	17	1.00	1
Colombia	0.28	9	0.99	8	0.36	13	0.99	10	0.24	13	0.99	9
Ecuador	0.31	7	0.99	10	0.38	12	0.99	9	0.29	11	0.98	11
Paraguay	0.38	4	0.99	11	0.50	8	0.99	13	0.41	5	0.98	14
Peru	0.28	8	0.99	7	0.40	11	0.99	5	0.32	10	0.99	4
Uruguay	0.24	13	1.00	3	0.31	15	1.00	3	0.22	14	0.99	6
Venezuela	0.23	14	0.99	12	0.30	16	0.98	18	.	.	.	.
Average	0.33		0.99		0.48		0.99		0.41		0.99	
Maximum	1.00		1.00		1.00		1.00		1.00		1.00	
Minimum	0.13		0.98		0.22		0.98		0.15		0.98	
Standard Deviation	0.21		0.01		0.23		0.01		0.26		0.01	

Source: Authors' calculations

In contrast, the output-oriented score is 99% for the three years, where there are proportional changes in terms of public spending, although these did not affect the level of efficiency and neither is there enough space for efficiency improvement.

In the case of Chile, it is interesting to see that while in the output-oriented approach it is the most efficient country, it is not in the input-oriented category. This is because Chile is the country with the highest percentage of Public Spending in Health on average, with government spending being 3.53% of GDP during the period under analysis and it registered a significant

increase over the years, e.g., the growth rate is 92% from 2000 to 2019. It is only when analysing output that Chile obtains the best score, however when both input and output are contrasted and compared between other countries, DEA estimates highlight the efficiency of Costa Rica. The level of public spending in Costa Rica is on average 0.61% of GDP, which represents a vast difference from Chile. In terms of output, Costa Rica is ranked in second and third place, and, as a result, DEA methodology punishes Chile and it is calculated that in 2009 it could have obtained the same PSP results by using 87% less spending, and that in 2013 it could have used 78% less, while in 2019 it could have used 85% less on government spending. The overall conclusion is that Chile is not an efficient country in the health sector, and that it has considerable scope for improvement.

In Table 4, which shows the assessment for economic performance, it can be seen that countries could have achieved the same average level of PSP by using 32% less on government spending, and that countries could have increased their PSP by 24%, while using the same levels of spending. Furthermore, these scores worsen for 2019, during which countries could achieve the same level of PSP by using 39% less government spending, or countries could have increased their PSP by 38% by maintaining the same levels of spending. Economically-speaking, 2019 is the less-efficient year across all the countries.

See the Appendices for a summary of the main results of the three models for both input- and output oriented efficiency scores and also the complete data set for 2000-2019.

Table 4: DEA Efficiency Scores - Model 3 (economic performance)

	2009				2013				2019			
	Input oriented		Output oriented		Input oriented		Output oriented		Input oriented		Output oriented	
Country	VRSTE	Rank.	VRSTE	Rank.	VRSTE	Rank.	VRSTE	Rank.	VRSTE	Rank.	VRSTE	Rank.
Belize	.	.	.	.	0.44	18	0.31	20	0.38	16	0.48	14
Costa Rica	0.84	4	0.88	5	0.73	5	0.64	12	0.65	8	0.79	3
El Salvador	0.57	14	0.48	17	0.73	6	0.43	19	0.68	6	0.56	11
Guatemala	1	1	1	1	1	1	1	2	1	1	1	1
Guyana	0.63	9	0.48	18	0.70	9	0.48	18	0.50	12	0.65	9
Honduras	0.63	10	0.75	11	0.59	14	0.55	16	0.64	9	0.73	5
Mexico	0.76	5	0.86	7	0.73	7	0.66	11	0.73	3	0.81	2
Nicaragua	0.70	7	0.53	16	0.82	4	0.56	15	0.71	4	0.53	13
Panama	1	1	1	2	1	1	1	1	.	.	.	.
Suriname	.	.	.	.	0.38	20	0.67	8	0.34	17	0.37	15
Argentina	0.76	6	0.90	4	0.62	13	0.67	9	0.61	10	0.34	16
Bolivia	0.38	18	0.76	10	0.51	17	0.88	4	.	.	.	.
Brazil	0.46	17	0.64	14	0.52	16	0.57	13	0.46	15	0.25	17
Chile	0.59	12	0.81	8	0.67	11	0.70	6	0.55	11	0.71	7
Colombia	0.56	15	0.62	15	0.65	12	0.53	17	0.70	5	0.66	8
Ecuador	0.54	16	0.69	13	0.53	15	0.68	7	0.49	14	0.53	12
Paraguay	1	1	0.87	6	0.99	3	0.96	3	0.81	2	0.77	4
Peru	0.62	11	0.70	12	0.68	10	0.66	10	0.66	7	0.71	6
Uruguay	0.59	13	0.79	9	0.70	8	0.77	5	0.50	13	0.58	10
Venezuela	0.67	8	0.99	3	0.44	19	0.56	14	.	.	.	
Average	0.68		0.76		0.67		0.66		0.61		0.62	
Maximum	1.00		1.00		1.00		1.00		1.00		1.00	
Minimum	0.38		0.48		0.38		0.31		0.34		0.25	
Standard Deviation	0.18		0.17		0.18		0.18		0.16		0.19	

5. CONCLUSION

On average, governments in Latin America spent about 25.6% of GDP on the provision of public goods, services, and transfers in 2020. Furthermore, the available statistics reflect a vast increment in public spending for the last years (2013 and 2019), with an average growth rate of 32.9%. During periods of recession, such as the economic crisis of 2008-2009 or the health and economic crisis of 2019, governments tend to spend more on public expenditures. This paper aims to calculate how efficient public spending has been over the last 20 years.

By collecting indicators for different areas of government activities for all countries in Latin America, the biggest challenge was to find comparable measures for all the countries and a complete data set for every year, and consequently the final sample analysed is for 10 countries in South America, and 10 from Central America for the period of 2000-2019. Once the indicators were determined, transformations were applied to each with the aim to obtain the

same scales and then normalise them. The next phase was to calculate the “Public Sector Performance (PSP)” composite indicator, in order to obtain a comparable and unique measure that represents the outcome for all the countries in the overall sample. Finally, Data Envelopment Analysis technique was applied to compute efficiency scores and rankings for each year.

With regards the original indicator of “Public Spending as a percentage of GDP”, figures show that health, education, and social protection are key areas of spending, albeit within the group of countries the level of spending differs, while in the South American region, the highest spending is on social protection, whereas in Central America it is on education.

From the analysis of the PSP indicator, those countries that performed better during the period of 1990-2019 are Panama, Chile, and Belize. Interestingly, these three countries are diverse in their level of public spending, while Belize is situated in the group that spend over 30% of GDP, while Chile belongs to the group that spend between 20%-30% of GDP and Panama is within the group that spend less than 20% of GDP. On the other hand, the worse-performing performance countries are Venezuela, Nicaragua, and Paraguay, where the public spending of Nicaragua and Paraguay is less than 20% of GDP and Venezuela spends between 20%-30% of GDP.

Furthermore, DEA results showed a degree of diversity between the countries, but commonly there is potential for increase efficiency in public spending. Three models were applied for each year: i) a general model, using Total Public Spending (% GDP) as the input and Total PSP as the output; ii) Model 2, which uses Health PSP as the input and Public Spending on Health as the output; iii) Model 3, with Economic PSP as the input and Total Public Spending as the output.

With respect to Model 1, assuming variable returns to scale and adopting both the input and output approach, the set of countries that define the theoretical production possibility frontier in 2019 are El Salvador and Guatemala. The average input score during the period of 2000 to 2019 decreased from 80% in 2000 to 65% in 2019 (when countries could have used 35% less spending to achieve the same levels of PSP). On the contrary, using the output-oriented approach, the efficiency scores slightly increased from 73% in 2000 to 78% in 2019 (when countries could have increased their performance by 22% with the same level of inputs).

Analysing the years of the global economic crisis of 2008-2009, scores in both approaches are worse, suggesting that when Latin American countries passed through crises and increased the public spending, their efficiency decreased, with 2019 recording an emphasised decrease.

The least efficient countries differ in their approaches, with Suriname, Brazil, and Belize being at the bottom of the ranking in 2019 for the input approach. It should be noticed that Belize was among the best performers in PSP, but when this is contrasted with the spending incurred, it is not efficient, representing a case that shows the importance of applying DEA methodology to describe efficiency. In addition, in terms of output approach, the worst countries are Nicaragua, Suriname, and Brazil.

Model 2 gave rise to interesting findings, in that the average input efficiency score during the period is 40%, which is a very low score, indicating that countries could have used 60% less spending on health to attain the same outcomes if they had been fully efficient. On the other hand, the average output score is surprisingly high, with an average of 99%, suggesting that countries are almost attaining the maximum possible return from most of the outputs with the level of spending in the health area. From the point-of-view of the input-oriented approach, the best country for health is Costa Rica, which remain fully efficient along the period under analysis, with Chile positioned at the bottom of the ranking.

Finally, the results of Model 3 led to an average input efficiency score of 68% from 2000 to 2019, with those countries that could have achieved the same level of PSP using 32% less government spending. In contrast, the average output efficiency score is 66%, implying that countries could have increased their performance by 34% with the same level of inputs. Accordingly, governments have a large space for improvement in economic areas.

Surprisingly, the findings from Model 3 suggest that the lower the spending ratios, the more efficient are the countries. Guatemala, Panama, and Paraguay rank as the best performers in both the input- and output-oriented approach, all of which are countries with a public expenditure as a % of GDP less than 20%.

To conclude, the analysis of the three models provides an important understanding of the differences between countries when analysing public spending in general vs in particular areas, such as health or Total PSP (which aggregates many fields) vs Economic or Health PSP. For example, Chile, which topped the ranking for many years of the more efficient countries in Model 1, does not do so when only health or economic areas are analysed. The results divided by individual spending areas seem to present a more promising approach for measuring efficiency and effectiveness on a cross-country basis.

Future research can continue this analysis with the application of appropriate methodologies to better understand the determinants of the efficiency scores already calculated, and, in addition, they could identify what governments can do to achieve greater efficiency. Advances also need to be made regarding, for instance, the effects of taxation on the efficiency scores as

manifested in the literature review. In addition, in order to make the most use of the large cross-country panel dataset presented in this study, it would be interesting to apply alternative DEA models, such as the DEA-Windows method, which would enable a year-to-year comparison of the results and help contrast the existing scores obtained for each year.

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Table A.1: Indicators - Description and Sources

Opportunity Indicators	Indicator	Description	Source	Serie Availability	Modifications
Administration	Voice and Accountability: Estimate	Captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.	Governance Indicators World Bank	1996,1998,2000,2002,2003-2019	Original estimates ranging from - 2.5(bad) to 2.5(good). Changed to 0 to 5.
	Rule of Law: Estimate	Captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.	Governance Indicators World Bank	1996,1998,2000,2002,2003-2019	Original estimates ranging from - 2.5(bad) to 2.5(good). Changed to 0 to 5.
	Regulatory Quality: Estimate	Captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.	Governance Indicators World Bank	1996,1998,2000,2002,2003-2019	Original estimates ranging from - 2.5(bad) to 2.5(good). Changed to 0 to 5.
	Government Effectiveness: Estimate	Captures perceptions of the quality of public services, civil service and the degree of its independence from political pressures, quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	Governance Indicators World Bank	1996,1998,2000,2002,2003-2019	Original estimates ranging from - 2.5(bad) to 2.5(good). Changed to 0 to 5.
Education	School enrollment, secondary (% gross)	Ratio of total enrollment, regardless of age, on secondary education	World Bank: UNESCO Institute for Statistics	1990-2019	
	Quality of the education system	Quality of educational system on a scale from 7 (very well) to 1 (not well at all).	The Global Competitiveness Index Historical Dataset © 2007-2017 World Economic Forum.	2008-2018	
Health	Mortality rate, under-5 (per 1,000 live births)	Probability per 1,000 that a newborn baby will die before reaching age five.	World Bank	1990-2019	Changed to (1000-IMR)/1000
	Adolescent fertility rate (births per 1,000 women ages 15-19)	Number of births per 1,000 women ages 15-19.	World Bank	1990-2019	Changed to (1000-AFR)/1000
	Maternal mortality ratio (modeled estimate, per 100,000 live births)	Number of women who die from pregnancy-related causes while pregnant or within 42 days of pregnancy termination per 100,000 live births.	WHO, UNICEF, UNFPA, World Bank Group, and the United Nations Population Division. Trends in Maternal Mortality: 2000 to 2017.	2000-2017	Changed to (100000-MM)/100000
Infrastructure	Quality of overall infrastructure, 1-7 (best)	Infrastructure quality on a scale from 7 (extensive and efficient) to 1 (extremely underdeveloped)	The Global Competitiveness Index Historical Dataset © 2007-2017 World Economic Forum.	2008-2018	
Musgravian Indicators	Indicator	Description	Source	Serie Availability	Modifications
Distribution	Gini index (estimate)	Gini index on a scale from 100(perfect inequality) to 0(perfect equality).	World Bank	1990-2019	Changed to 100-GINI
Economic	Unemployment rate (% of total labor force)	Number of unemployed persons as a percentage of the labor force	International Monetary Fund	1990-2019	5 year average and Reciprocal value 1/x
	Gross domestic product per capita, constant prices	GDP is expressed in constant international dollars per person. Data are derived by dividing constant price purchasing-power parity (PPP) GDP by total population.	International Monetary Fund	1990-2019	5 year average
	Gross domestic product, constant prices (Percent change)	Annual percentages of GDP constant price	International Monetary Fund	1990-2019	5 year average
Stability	Coefficient of variation of Growth	Coefficient of variation=standard deviation/mean of GDP growth based on 5 year data. GDP constant prices (percent change).	International Monetary Fund	1990-2019	Coefficient of variation: Standard Deviation/Average and Reciprocal value 1/x
	Inflation, average consumer prices	Annual percentages of average consumer prices.	International Monetary Fund	1990-2019	5 year average and Reciprocal value 1/x

Table A.2: Total Public Sector Performance (PSP) 1990-2019

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Belize	1.67	1.72	1.94	1.61	1.45	1.41	1.17	1.08	1.02	1.18	1.30	1.43	1.74	1.62	1.32	1.13	1.06	0.98	0.94	0.96	0.96	0.97	1.03	1.07	1.23	1.20	1.17	1.14	1.21	1.25
Costa Rica	1.11	1.16	1.03	1.07	1.05	1.03	1.03	1.00	1.04	1.07	1.10	1.07	1.19	1.22	1.45	1.36	1.11	1.08	1.05	1.04	1.06	1.07	1.07	1.06	1.07	1.11	1.15	1.17	1.18	1.28
El Salvador	0.78	0.80	0.80	0.83	0.86	0.98	0.90	0.89	0.87	0.98	0.96	1.00	1.03	1.09	1.06	0.97	0.96	0.96	1.02	0.99	1.00	0.99	0.97	0.98	1.02	1.11	1.10	1.22	1.26	1.36
Guatemala	1.09	0.98	1.27	1.22	1.17	1.13	1.02	1.10	0.98	1.28	1.10	1.17	1.13	1.11	1.07	1.01	0.96	0.94	0.97	0.98	0.98	0.98	0.98	0.99	1.05	1.05	1.04	1.06	1.12	
Guyana	0.42	0.47	0.49	0.56	0.67	0.78	1.13	1.20	0.94	0.99	0.96	0.98	0.89	0.82	0.85	0.79	0.83	0.83	0.82	0.86	0.88	0.99	1.00	1.04	1.06	0.75	1.03	1.08	1.10	1.13
Honduras	0.99	0.86	0.88	0.89	0.86	0.86	0.86	0.91	0.83	0.85	0.90	0.94	0.94	0.93	0.91	0.96	0.95	1.00	1.00	0.93	0.90	0.89	0.87	0.85	0.82	0.98	1.01	0.98	0.99	1.01
Mexico	0.95	0.97	1.07	1.15	1.24	0.95	0.95	0.93	0.95	0.96	1.00	1.14	1.10	1.10	1.07	1.06	1.07	1.10	1.08	1.02	1.00	0.99	1.00	1.00	0.98	1.05	1.07	1.07	1.08	1.05
Nicaragua	0.43	0.48	0.48	0.58	0.53	0.59	0.68	0.72	0.79	1.05	1.00	1.00	0.88	0.91	0.87	0.89	0.87	0.85	0.86	0.81	0.78	0.77	0.78	0.81	0.86	0.82	1.03	1.08	0.83	0.74
Panama	2.23	1.92	1.98	2.07	2.03	1.78	1.77	1.78	1.46	1.56	1.43	1.43	1.26	1.35	1.35	1.27	1.24	1.17	1.17	1.16	1.10	1.09	1.11	1.14	1.16	1.15	1.18	1.22	1.28	1.36
Suriname	0.71	0.68	0.73	0.70	0.50	0.53	0.66	0.71	0.75	0.80	0.91	0.90	0.89	0.89	0.88	0.92	1.08	1.04	1.02	1.05	1.11	1.08	1.04	1.02	0.94	0.83	0.73	0.69	0.74	0.72
Argentina	0.80	0.96	0.85	0.90	0.99	1.01	1.07	1.02	1.46	0.98	0.95	0.90	0.85	0.85	0.86	0.91	0.93	0.96	1.06	0.98	0.98	0.98	0.95	0.92	0.88	0.86	0.88	0.89	0.87	0.83
Bolivia	0.59	0.71	0.95	0.97	1.02	1.07	1.05	1.03	1.53	1.10	1.03	1.04	1.03	1.08	1.04	1.03	1.03	1.04	0.93	1.02	1.05	1.08	1.11	1.09	1.12	1.08	1.10	1.07	1.07	1.12
Brazil	0.93	0.80	0.71	0.68	0.65	0.69	0.81	0.77	0.82	0.79	0.89	0.88	1.02	0.98	0.97	0.98	0.97	0.97	0.94	0.98	1.01	1.00	0.97	0.95	0.92	0.85	0.80	0.79	0.79	0.78
Chile	1.16	1.40	1.25	1.25	1.08	1.14	1.24	1.22	1.18	1.14	1.21	1.16	1.22	1.21	1.24	1.34	1.29	1.33	1.33	1.24	1.24	1.19	1.23	1.20	1.21	1.17	1.17	1.13	1.18	1.14
Colombia	1.46	1.17	1.11	1.12	1.08	1.12	0.97	1.03	0.89	0.84	0.81	0.78	0.80	0.82	0.84	0.96	0.99	1.03	1.00	1.01	1.00	1.00	1.01	1.01	1.02	1.01	0.97	0.95	0.96	1.01
Ecuador	0.83	0.82	0.81	0.88	0.86	0.94	0.88	0.87	0.84	0.76	0.74	0.75	0.73	0.77	0.77	0.84	0.90	0.89	0.92	0.94	0.94	0.95	0.97	1.00	1.03	0.99	1.00	1.00	1.01	0.95
Paraguay	1.03	0.93	0.95	0.96	0.94	0.93	0.88	0.91	0.81	0.89	0.77	0.78	0.72	0.72	0.75	0.78	0.81	0.84	0.85	0.84	0.83	0.84	0.85	0.88	0.87	0.75	0.87	0.89	0.97	0.97
Peru	0.67	0.69	0.64	0.63	0.67	0.78	0.87	0.90	0.91	0.97	0.98	0.95	0.97	0.98	1.04	1.07	1.12	1.19	1.05	1.03	1.08	1.08	1.07	1.05	1.03	1.00	1.01	0.99	1.02	1.14
Uruguay	1.03	1.06	1.04	0.98	0.98	0.99	1.08	1.03	1.04	0.93	1.01	0.94	0.95	0.93	0.91	0.94	0.96	0.97	1.08	1.20	1.21	1.19	1.19	1.16	1.14	1.04	1.05	1.04	1.02	1.05
Venezuela	0.83	0.90	0.93	0.86	0.70	0.92	0.80	0.75	0.80	0.78	0.74	0.81	0.74	0.69	0.74	0.80	0.83	0.84	0.86	0.91	0.85	0.82	0.81	0.78	0.72	0.62	0.56	0.48	0.32	-0.50
Average	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

*The values highlighted are the best scores for each year.

Table A.3: Summary of DEA Input Efficiency Scores

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
Model 1	Average	0.80	0.79	0.78	0.77	0.75	0.75	0.76	0.74	0.72	0.75	0.78	0.79	0.76	0.72	0.70	0.68	0.63	0.65	0.64	0.65	
Total PSP	Maximum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Minimum	0.50	0.46	0.42	0.47	0.42	0.42	0.40	0.40	0.36	0.44	0.55	0.48	0.49	0.42	0.36	0.35	0.40	0.39	0.40	0.34	
	Standard Deviation	0.15	0.17	0.18	0.18	0.17	0.18	0.19	0.19	0.21	0.19	0.16	0.18	0.17	0.19	0.21	0.21	0.18	0.19	0.19	0.19	
	Total Efficient Countries	2	3	3	2	3	2	3	2	2	2	4	3	3	2	2	4	4	2	3	2	2
Countries on the frontier	GUA, PAN	GUA, MEX, PAN	GUA, PAN, ARG	PAN, PAR	COS, GUA, PAR	COS, PAR	COS, CHI, PAR	CHI, PAR	CHI, PAR	CHI, PAR	GUA, PAN, CHI, PAR	GUA, CHI, PAR	GUA, CHI, PAR	GUA, CHI	GUA, CHI	BEL, GUA, PAN, CHI	BEL, GUA, PAN, CHI	GUA, PAN	SAL, GUA, PAN	SAL, BOL	SAL, GUA	
Model 2	Average	0.39	0.38	0.35	0.44	0.36	0.35	0.31	0.31	0.35	0.33	0.39	0.37	0.45	0.48	0.45	0.45	0.45	0.45	0.43	0.41	
Health PSP	Maximum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Minimum	0.17	0.17	0.16	0.16	0.15	0.15	0.14	0.14	0.15	0.13	0.16	0.16	0.20	0.22	0.20	0.19	0.18	0.17	0.17	0.15	
	Standard Deviation	0.23	0.22	0.22	0.25	0.24	0.23	0.23	0.22	0.22	0.22	0.21	0.21	0.21	0.22	0.23	0.23	0.23	0.23	0.24	0.26	0.26
	Total Efficient Countries	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Countries on the frontier	COS	COS	COS	COS	COS	COS	COS	COS	COS	COS	COS	COS	COS	ARG	COS	COS	COS	COS	COS	ARG	COS	
Model 3	Average	0.78	0.77	0.76	0.75	0.72	0.72	0.73	0.71	0.66	0.68	0.68	0.69	0.71	0.67	0.63	0.61	0.60	0.61	0.59	0.61	
Economic PSP	Maximum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Minimum	0.50	0.46	0.42	0.45	0.40	0.40	0.43	0.40	0.35	0.38	0.42	0.42	0.47	0.38	0.36	0.37	0.37	0.41	0.37	0.34	
	Standard Deviation	0.14	0.16	0.17	0.18	0.18	0.19	0.20	0.20	0.22	0.18	0.18	0.17	0.16	0.18	0.19	0.18	0.18	0.17	0.17	0.16	
	Total Efficient Countries	2	1	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	1	1
Countries on the frontier	GUA, MEX	MEX	GUA, MEX, ARG	GUA, MEX, PAR	GUA, MEX, PAR	GUA, MEX, PAR	GUA, MEX, PAR	GUA, MEX, PAR	GUA, MEX, PAR	GUA, ARG, PAR	GUA, PAN, PAR	GUA, PAN, PAR	PAN, PAR	GUA, PAN	GUA, PAN	GUA, PAN	GUA, PAN	GUA, PAN	GUA, PAN	BOL	GUA	

*GUA – Guatemala; PAN – Panama; MEX – Mexico; ARG – Argentina; COS – Costa Rica; PAR – Paraguay; CHI – Chile; BEL – Belize; SAL – Salvador; BOL – Bolivia

Table A.4: Summary of DEA Output Efficiency Scores

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
Model 1 Total PSP	Average	0.73	0.74	0.80	0.75	0.72	0.76	0.82	0.80	0.82	0.86	0.87	0.89	0.86	0.86	0.85	0.85	0.87	0.85	0.83	0.78	
	Maximum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Minimum	0.52	0.54	0.59	0.51	0.51	0.58	0.64	0.62	0.65	0.71	0.69	0.69	0.66	0.65	0.59	0.65	0.62	0.57	0.59	0.53	
	Standard Deviation	0.14	0.15	0.14	0.13	0.15	0.12	0.12	0.12	0.12	0.12	0.10	0.10	0.10	0.10	0.09	0.11	0.12	0.11	0.12	0.13	0.15
	Total Efficient Countries	2	3	2	1	2	1	3	2	2	2	4	3	4	2	2	4	4	2	3	2	2
Countries on the frontier	GUA, PAN	GUA, MEX, PAN	GUA, PAN	PAN	COS, GUA	COS	COS, CHI, PAR	CHI, PAR	CHI, PAR	CHI, PAR	GUA, PAN, CHI, PAR	GUA, CHI, PAR	GUA, PAR, URU	GUA, CHI	GUA, CHI	BEL, GUA, PAN, CHI	BEL, GUA, PAN, CHI	GUA, PAN	SAL, GUA, PAN	SAL, BOL	SAL, GUA	
Model 2 Health PSP	Average	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	
	Maximum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Minimum	0.97	0.97	0.97	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.97	0.98
	Standard Deviation	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Total Efficient Countries	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	3	2
Countries on the frontier	COS, CHI	COS, CHI	COS, CHI	COS, CHI	COS, CHI	COS, CHI	COS, CHI	COS, CHI	COS, CHI	COS, CHI	COS, CHI	COS, CHI	COS, CHI	COS, ARG, CHI	COS, CHI	COS, CHI	COS, CHI	COS, CHI	COS, CHI	COS, ARG, CHI	COS, CHI	
Model 3 Economic PSP	Average	0.67	0.56	0.56	0.56	0.59	0.65	0.70	0.75	0.79	0.76	0.76	0.72	0.66	0.66	0.64	0.63	0.59	0.59	0.65	0.62	
	Maximum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	Minimum	0.45	0.36	0.27	0.14	0.25	0.31	0.40	0.44	0.45	0.48	0.47	0.45	0.31	0.31	0.32	0.32	0.29	0.30	0.33	0.25	
	Standard Deviation	0.17	0.18	0.22	0.24	0.20	0.18	0.17	0.18	0.18	0.18	0.17	0.16	0.16	0.17	0.18	0.19	0.18	0.19	0.20	0.18	0.19
	Total Efficient Countries	1	1	2	1	2	2	2	3	3	2	3	2	2	2	2	2	2	2	2	1	1
Countries on the frontier	MEX	MEX	GUA, MEX	MEX	GUA, MEX	GUA, MEX	GUA, MEX	GUA, MEX, PAR	GUA, ARG, PAR	GUA, PAN	GUA, PAN, PAR	PAN, PAR	GUA, PAN	GUA, PAN	GUA, PAN	GUA, PAN	GUA, PAN	GUA, PAN	GUA, PAN	BOL	GUA	