MASTER

BOLOGNA MASTER'S DEGREE IN ECONOMICS

MASTER'S FINAL WORK

DISSERTATION

GOVERNMENT SPENDING EFFICIENCY IN LATIN AMERICA

GABRIELA ESTEFANÍA BAQUERO FRAGA

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SUPERVISION:

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To my parents Teresa and José, my brothers Felipe and David, my grandmother “Abuelita”, my uncle Gali, my goddaughters Maty and Lulu, and Niña

Glossary

DEA – Data Envelopment Analysis.

ECLAC – Economic Commission for Latin America and the Caribbean.

EU – European Union.

FDH – Free Disposable Hull.

GDP – Gross Domestic Product.

IMF – International Monetary Fund.

JEL – Journal of Economic Literature.

MFW – Master's Final Work.

OECD– Organization for Economic Co-operation and Development.

PISA – Programme for International Student Assessment.

PSE – Public Sector Efficiency.

PSP – Public Sector Performance.

VRS – Variable Returns to Scale

Abstract

This dissertation analyses the public spending efficiency for 20 Latin American countries over the period 2000-2019. The main objective is to estimate efficiency scores per country by using the non-parametric method called Data Envelopment Analysis (DEA). DEA calculates efficiency scores based on the relationship between inputs and outputs. For the output measure, the Public Sector Performance composite indicator was calculated using annual panel data of socio-economic indicators. For the input measure was considered the Total Public Spending as percentage of GDP and by area, such as Public Spending on Health. At the end, a complete set of efficiency scores covering 20 countries between 2000 and 2019 was obtained.

The results showed that public spending during the last 20 years increased but governments were not efficient. On the contrary, the scores reflect a large space for improvement during the period because values have worsened during the years. One of the findings is that during periods of global recessions governments of Latin America increased the spending but at the same time, their efficiency scores are worst. To have different perspectives three models were computed using DEA both input and output-oriented approaches. With the first model, the key conclusion is that on average governments could have used 27 percent less of spending to achieve the same levels of PSP, or the other way, governments could have increased their performance by 18 percent with the same level of spending. From model 2 the main result is that in health governments are far from being efficient, the average input efficiency score during the period is 40%, which means that 60% of the economic resources were not effective. Finally, model 3 focuses on Economic PSP, both input and output efficiency scores average around 60-80 percent. Interestingly results from model 3 also suggest that the most efficient countries, meaning located in the production efficiency frontier, were the ones with lowest levels of public spending among the 20 countries.

KEYWORDS: Public Efficiency; Data Envelopment Analysis; Production possibility frontier; non-parametric method; Government Spending.

JEL CODES: H11; C13; C14; H50

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GOVERNMENT SPENDING EFFICIENCY IN LATIN AMERICA

By Gabriela Baquero Fraga

1. INTRODUCTION

The role of fiscal policy has been summarized in three functions: the allocation of resources, the distribution of income and the stabilization of the economy. The first refers to efficiently supplying public goods and services to better allocate resources when there are market failures. In the second, fiscal policy is intended to modify the way in which assets are distributed among members of a society. Finally, the third function seeks to mitigate the variations in economic cycles, reduce the volatility of macroeconomic variables and contribute to economic growth, to employment and price stability. Taxation and government expenditure are the two tools for achieving these functions.

As governments endeavour to accomplish these roles, it turns important to analyse the quality of public spending and how effective has been the use of public resources, especially in a region mostly depending on commodities revenues, meaning non-permanent income. This dissertation analyses the government expenditure and its efficiency in 20 Latin American countries between 2000 and 2019. The cross-country analysis allows to compare and give insights of the countries that used better the economic resources and performed well within the same region.

The reality in Latin America is that government spending increased the last two decades, and at a higher speed since 2010. Within the global economic crisis large part of the region's countries implemented expansive fiscal policies that were intended to increase aggregate demand. Thus, spending on subsidies, transfers and certain social programs was increased, which, although they helped mitigate the impact of the crisis on the most vulnerable sectors, in some cases led to a permanent rise in spending. Consequently, the public spending as percentage of GDP in the 20 countries included in this dissertation increased by 32.9% from 2000 to 2020.

Besides, the average spending of Latin American countries in the areas of health, education and social protection went from representing 1.5%, 3.2% and 3.4% of GDP in 2000, to represent 2.8%, 4.3% and 5.6% of GDP in 2020, respectively.

The objective of this dissertation is to measure the efficiency of this increment of public spending during the period. Lately, most of the literature has used the non-parametric approach called Data Envelopment Analysis (DEA). This method uses an input and output relation, in which the input is the public spending, and the output is any result indicator that represents an outcome of the accomplishment of public policies. In order to have one indicator that represents governments' actions, was calculated the Public Sector Performance (PSP).

One of the most important contributions of this thesis is the focus on Latin American countries and the size of data. As proved by Afonso et al (2020) less evidence is available for Asia, Africa, or Latin America about public efficiency. There is much research about OECD and European countries, normally one or two years. On the contrary, this study includes for the first time a long run period of 20 years and we computed a large cross-country panel dataset of government indicators, performance indicators and public sector efficiency scores covering 20 countries. The set of raw data includes many socio-economic areas, which make possible to make analysis about individual spending areas.

The general outline of this work is as follows. Chapter 2 consists of the literature review. Chapter 3 describes the methodology applied starting first with the indicators that were chosen to construct the performance composite indicators and second Data Envelopment Analysis methodology. Chapter 4 focuses on all the empirical work and results with an analysis of the evolution of public spending as percentage of GDP, the Public Sector Performance estimation, and the results of efficiency scores obtained by DEA. Finally, Chapter 6 present the main conclusions.

2. Literature Review

2.1. Importance of Public Spending

Empirical research about the effect of public expenditure on economic growth gave different answers. Some studies reported positive and significant relation between government spending and economic growth while several others found significant negative or even no relation between an increase in government spending and economic growth in real output.

Referring to Latin America, Bienvenu et al (2019) studied the effects of public expenditure on economic growth in 22 Latin American countries and found that private investment, population growth rate and corruption reduction expenditures have a positive influence on economic growth and on the other hand climate investment, and the impact of foreign aid is not significant.

Furthermore, a positive effect must be influenced by the efficiency of the spending and the correct allocation of the public resources.

Many studies have referred to the increase in public revenues in Latin American countries since 2000s, mostly explained to the rise of commodities prices that are produced in this continent. According to a study of the IMF in 2007, the revenues had risen by an average of about 3.5% of GDP since 2002. In the case of Mexico, Ecuador, and Venezuela, primary oil producers, the revenues increased over 7% of GDP, due to the high prices of oil. On the other hand, Bolivia, Chile, and Peru benefited from the boom in metals prices. Non-commodity revenues also rose about 1% of GDP (Clements, et al., 2007).

Therefore, this rise of fiscal incomes, allowed increasing the public expenditure in both as a percentage of GDP and of total public spending. Moreover, it was widespread across countries, but it varied, for example, in Venezuela spending rose over 9% of GDP compared with Bolivia and Chile that rose by 4.5% of GDP (Clements, et al., 2007).

This growth pattern of revenues led to the improvement of fiscal balances, as mentioned by Castillo (2010), the countries in Latin America since 2004 onwards experimented superavits, after more than a decade of deficits. Nevertheless, this fiscal evolution stopped in 2008-2009 when the international crisis hit the economies worldwide, especially for the countries depending on temporary revenues such as oil, metals, commodities, etc. Moreover, this also evidences the propensity of the region for pro-cyclical expenditure policies.

Latin America has a propensity to increase expenditure when output is also expanding, while in recessions decrease expenditure and increase taxes. Several studies showed this phenomenon such as Gavin & Perotti (1997), and Bello & Jiménez (2008). Other authors also proved that the cyclicality of spending is higher in Latin America comparing to other developing countries, regions, and Asian countries. Singh & Cerisola (2006), for example, calculated a much higher correlation between the cyclical component of real spending and real GDP over 1990–2005 in Latin America than in Asia. Additionally, Gavin & Perotti (1997) found that government expenditure has been markedly more pro-cyclical in Latin America than in industrial countries.

Expansions as well as recessions in some cases have led to a permanent rise in spending. In addition, large part of the region's countries implemented expansive fiscal policies, thus spending on subsidies, transfers and certain social programs increased.

As referred by Podestá (2020) in her recent study, the average public spending of 16 Latin American countries at the central government level went from 17.8% of GDP in 2000 to 20.7% of GDP in 2018, although in that last year it appreciates a reduction compared to the value of 2017, which reflects the fiscal consolidation process carried out in the countries.

By sub-regions, data showed that the rate of growth for South American countries is greater than Central American countries due to the increase of prices of commodities and consequently boosted tax revenues from exportation. On average, South America reached 23.1% spending as percentage of GDP compared to 18.3% in Central America in 2018 (Podestá, 2020).

Social sector absorbs a large share of total government spending. In the sample of 16 Latin American countries, higher expenditures were used to finance social policies, particularly in the areas of health, education, and social protection. Only for South America social protection represented the highest percentage (6.4%), explained mostly by the delivery of conditional cash transfers in many countries such as Brazil and Chile.

In addition, as a percentage of total public spending, in 2018 on average, 19% was for social protection, 19% for education and 11% for health (Podestá, 2020).

2.2. Efficiency of Public Spending

Efficiency was measured for a long time as the marginal productivity of labour, as the change in output employing one additional employee. However, a measure combining both inputs and outputs is the correct way for measuring efficiency. In (1957) Farrell provided a new measurement for that time. The author used the simple case of a firm to explain how productive efficiency should be measured. Topics like the efficient production function, the efficient isoquant, price efficiency, convexity, etc, were developed by the author. He also emphasized that it could be applicable to any productive organization, inclusively internationally, meaning, in different countries when comparable data is available. For industries, he named Structural Efficiency as the efficiency reflected by the performance of its firms. He used data of the agricultural production industry in the United States because of comparability and information available, the inputs identified were land, labour, material and capital and the output in millions of dollars. He estimated the technical efficiencies using different combinations in which he combined two, three or four factors. His conclusion was chosen according to the distribution of efficiencies and the estimates with the 4 factors were the best analysis. Regardless the limitations of data and accurate explanations of the phenomenon, this was the first attempt of calculating the efficiency of a specific industry using a method with inputs and output together.

Based on this methodology, the literature expanded the analysis and developed methods such as Free Disposal Hull (FDH), Data Envelopment Analysis (DEA), and composite performance indicators to study the efficiency of public spending across countries.

For example, in 2004, Afonso and St. Aubyn computed the efficiency of public spending specifically in education and health sectors for a sample of OECD countries. The authors compared both non-parametric methods: Free Disposal Hull (FDH) analysis and Data Envelopment Analysis (DEA). For education measures they used different input indicators such as average class size, number of teachers per student, availability of computers; hours per year in school and output indicators such as performance on PISA

2000. For both methodologies, they found that in the education sector (input and output) Finland, Japan, Korea and Sweden were the most efficient countries, meaning that in these countries students achieved the best results with fewer resources and Belgium(input) and Portugal(output) the least efficient. The average input efficiency score in education was 0.89, which means that on average countries could have used 11% less resources to achieve the same output. On the other hand, 11 out of 24 countries were ranked as efficient in the health sector with FDH analysis, Japan and Norway are among the top performers, but under DEA analysis the number of efficient countries reduced to eight. (Afonso & Aubyn, 2004)

In (2005) Afonso et al did one of the first efficiency analysis using public sector performance (PSP) and public sector efficiency (PSE) indicators for 23 OECD industrialized countries for the period 1990 and 2000. Subsequently, they performed the Free Disposal Hull (FDH) technique. For the countries analysed the division in 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 4 expenditure categories that are education, health, public infrastructure, and administration. These were called the “Opportunity Indicators”, and the “Musgravian” indicators that reflected allocation, distribution, and stabilisation. Results showed that small governments, on balance, report better economic performance (PSP) than big governments or medium sized governments. Countries with the highest values were Switzerland in administration and infrastructure, Japan in education, Iceland in health, Austria in distribution, Norway in economic stability and Luxembourg in economic performance. United States and Japan are the best performers for the total PSP measure. In contrast, the EU (weighted average) performed below average.

When the authors compared the efficiency between 1990 and 2000 while some countries improved their performance like Portugal, Spain, Greece, other countries decreased like Japan and Switzerland. Regarding PSE, again Japan, United States, Switzerland, Australia, and Luxembourg showed the best results, but analysing by groups, “small” governments on average posted 40% higher scores than “big” governments. And finally, in the FDH Analysis results showed that Japan, United States and Luxembourg were placed in the “production possibility frontier”, that big governments could, on average, use 35% lower spending to get the same PSP, that15 EU countries were identified as relatively low efficiency when compared with the United States and the average of the other OECD countries in the sample, they were using 27% more resources than the “most efficient” countries with similar PSP indicators, while the other OECD countries were using “only” 11% higher.

The same authors applied the same public sector performance (PSP) and public sector efficiency indicators (PSE) but for the average period 2001-2003 on 22 countries that included 12 new EU members at that time (2004 and 2007) plus emerging markets such as Brazil, Chile, Mexico and others. For the input and output efficiency scores they used the Data Envelopment Analysis (DEA) and finally complemented with a Tobit analysis to check if exogenous or nondiscretionary factors explain some expenditure inefficiency. They also studied the same sectors of health, education, and administration. The authors found important differences across the countries. Brazil is one of the worst countries in PSP. Even though most of the emerging economies performed lower than the old industrialized countries, the Asian Newly industrialized countries economies performed well. Regarding efficiency scores, the Asian countries got higher scores with lower public spending. Analysing the DEA results, in the production frontier was Thailand, Cyprus, Ireland, and Korea with **Chile** following them. Finally, the Tobit analysis showed that per Capita GDP, public sector competence, educational levels, and the security of property rights, seemed to help the prevention of inefficiencies in the public sector. Contrary to the other paper, transparency in the political system didn´t influence significantly. (Afonso, et al., 2010)

There are few studies that address public efficiency in Latin America. Clements et al (2007)calculated the efficiency of spending in infrastructure (rails, roads, electricity, water, and telecommunications) in seven Latin American countries (Argentina, Bolivia, Brazil, Chile, Colombia, Mexico, and Peru) for the 1990s and early 2000s using the Free Disposal Hull Analysis technique (non-parametric production function). Results gave better efficiency in **Chile** and Mexico and in the other hand Bolivia and Colombia. Another conclusion of the study is that countries where the public infrastructure is provided by the state tend to be less efficient. And it is remarkable to mention that the authors used an adjusted measure in order to assess the impact of the private sector participation in the efficiency rankings, since infrastructure outcomes in the countries analysed were the result of private and public cooperation, therefore this calculus implied a downward adjustment for some countries.

In (2013) Afonso et al, with the Inter-American Development Bank, analysed 23 countries using the Public Sector performance (PSP), Public Sector Efficiency (PSE) indicators and Data Envelopment Analysis (DEA) efficiency scores for the period 2001-2010. They divided the countries according to their public spending as a share of GDP. Small the ones which spent under 25% of GDP, medium between 26% and 30% of GDP and large over 30% of GDP. The authors used the Public Sector Performance methodology as defined by Afonso et al (2005), so they used “Opportunity” and “Musgravian” indicators reflecting the Health, Education, Public infrastructure, and Administration sectors. Their results showed again that the bigger 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. In education, Costa Rica, Trinidad and Tobago, and Guyana took the first places. In health, Costa Rica and Chile top the list, while in the provision of public infrastructure Chile. Next, the overall PSE score placed Guatemala, Chile, and Peru in 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 are not among the top list by PSE scores. In the DEA analysis **Chile**, Guatemala and Perú were placed in the efficiency frontier, and, on average, countries can achieve the same level of outcome using 40 percent less spending or can increase their performance by 19 percent with the same level of inputs. Finally, to complement the analysis the authors computed Tobit regressions in which they found that more transparency and regulatory quality improve the efficiency scores, both from an output and from an input-oriented perspective. In addition, control of corruption, better regulatory quality and property rights increase output-oriented efficiency.

Ribeiro (2008) also analyses 17 countries of Latin America between 1998 and 2002. Following the same process, the author computed the PSP indicator for 5 areas: Health, education, public administration, equality, and economic performance. Finally, the author computed DEA analysis to get efficiency scores and the analysis of the non-discretionary variables but using the bootstrap methodology. For this, the author used GDP per capita, protection of property rights and level of education. The countries with the best PSP scores were **Chile** in health, administration and economic performance, Costa Rica in education and health and Uruguay in equality, and the worst scores in the region got Guatemala, Paraguay and Bolivia. According to the DEA analysis, the countries located at the production frontier are Costa Rica, Dominican Republic, and Guatemala. On the contrary, Bolivia, Brazil and Honduras the more inefficient countries.

Finally, one of the latest studies of efficiency in Latin America was published in 2018 by the Inter-American Development Bank in which the analysis compares countries of Latin America versus countries OECD. The methodology used was DEA in sectors of health, security and public administration with indicators like the public salaries, transfers and subsidies, public purchases. They estimated on average about 4.4% of GDP of inefficiency, which represents about 16% of public spending. Regarding security, their calculus showed on average 70% of efficiency, meaning that 30% of crime was not prevented. The results are diverse across countries, and the authors detected a correlation between better institutions with greater efficiency. In addition, in the health sector **Chile** was the only Latin-American country that placed in the production frontier, while Barbados, Costa Rica, Cuba, and Uruguay also got good efficiency scores. On the contrary, Bolivia, Ecuador, Guatemala, Guyana, Panama and Suriname got low efficiency scores in health. (Inter-American Development Bank, 2018)

It is important to note that in all the studies mentioned above where Chile is included in the analysis, this country is on the production frontier, on top of that in three studies Costa Rica is one of the best performers in health. Contrasting, in three analysis Bolivia was considered as an inefficient country, as well as Brazil in two studies.

Recent literature has also investigated the relationship of tax system and spending efficiency, with the idea that not only changes in revenues affect the level of public spending. Afonso et al (2020), for instance, evaluated if structural tax reforms affect positively or negatively to public spending efficiency, for OECD economies in the period 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 showed an average efficiency score around 0.6-0.7, therefore on average spending could be 30-40% lower. Moreover, in the efficiency frontier were located Chile, Korea, and Switzerland. Later, they used a panel analysis to assess the impact of taxes reforms in the computed DEA input efficiency scores and it reported that countries that increased the tax rates experienced lower spending efficiency. When the authors controlled for endogeneity, they got 2 results: increasing tax rate reforms worsens public sector efficiency and increasing tax base reforms improve efficiency. Regarding the control variables, they found that population, primary balance, and number of internet users positively affect public sector efficiency.

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

The relationship between the size of the government and its efficiency has been also discussed in most research that assessed public efficiency. Accordingly, Afonso & Schuknecht (2019) used the DEA efficiency scores of 20 OECD countries to explain "optimal spending" levels. In addition, results suggested that the "optimum" public expenditure lies between 30 to 35 percent of GDP for the countries analysed. Interestingly same values argued 20 years ago. Switzerland had this range of spending and was in the efficiency frontier. Therefore, the research concluded that there was a significant scope for expenditure savings for many governments in advanced economies.

3. METHODOLOGY

3.1. Public Sector Performance Composite Indicator

Data Limitations and indicators

The total countries in Latin America and the Caribbean includes 42, but not for all of them exists data available, especially for Caribbean countries. The sources used to get the information of the social and economic indicators are mainly World Bank, International Monetary Fund (IMF) and Economic Commission for Latin America and the Caribbean (ECLAC). From the 42 countries, this study analyses 20 countries that belong to Central (10) and South (10) America for the period between 1990 and 2019.

Following the same methodology of Afonso et al (2005), the efficiency of Public Spending is first measured by the Public Sector Performance (PSP) composite indicator, which includes the analysis of 7 socio-economic areas of government activity, which are referred as the PSP sub-indicators:

Administration: Compound by the Governance indicators of World Bank, which reflect the perceptions of the quality of public services, capacity to regulate and implement policies and rules of society, the freedom of expression as well as active participation of society in the government. The 4 indicators used are available for all the countries over the period 1996 – 2019. The original estimates range from -2.5(bad) to 2.5(good). For the calculations, they were re scaled from zero to 5.

Education: Measured by the average of school secondary enrolment and quality of education system over the period 1990-2019 for the first indicator, but the second indicator is only available from 2008-2018 without information for Belize, Guatemala, and Suriname. Countries with less data available over the period are Guyana, Nicaragua, Paraguay, Honduras, Suriname, Bolivia, and Brazil. For calculations were used original series each year.

Health: Includes 3 indicators, 2 of them have complete data for the whole series since 1990, but Maternal Mortality only since 2000 has information for all countries, before it is missing for Honduras, Nicaragua, Panama, Suriname, Bolivia, Paraguay, and Peru.

- Mortality rate, under-5 years old (per 1.000 live births): Changed to (1.000 Value)/1.000

- Adolescent fertility rate (births per 1.000 women ages 15-19): Changed to (1.000-Value)/1.000
- Maternal mortality ratio (modelled estimate, per 100.000 live births): Changed to (100.000-Value)/100.000

Infrastructure: Measured by the indicator "Quality of Infrastructure" from World Economic Forum, with information available only for the period 2008-2018 except for Belize, Guyana, and Suriname.

Distribution: Only includes Gini Index, unfortunately there is lack of data for many countries during the period. Only since 2000 data is more available. Countries like Belize, Guatemala, Guyana, Nicaragua, and Suriname don't have information. For calculations was changed to 100-Gini Value.

Economic: Has 3 indicators: unemployment rate, GDP per capita and GDP growth. The values calculated are 5-year average since they are macro indicators which change in the long term. This means data set has a value for each year, but it corresponds to the average of the 5 precedent years. Data is available for all countries.

Stability: Composed of a 5-year estimation of the coefficient of the variation of growth and inflation indicator. All countries have information during the period.

- Coefficient of variation of Growth: Standard Deviation (5-year average)/Average 5 year and changed to 1/x.
- Inflation: 5-year average and used1/x.

Additionally for further details of the indicators, see Appendix Table A.1.

After all the transformations done, each indicator was normalized by its sample mean and were used to construct the performance composite indicators.

Public Sector Performance

Each PSP sub-indicator is the average of its indicators for each country in every year, and the total PSP is the average of the seven PSP sub-indicators (equal weights assigned). The first 4 categories: administration, education, health, and infrastructure are considered as the "Opportunity Indicators", referring to the government as the provider of public services and equal opportunities to the society. In addition, the next three categories:

distribution, economic and stability are called the “Musgravian Indicators”, representing the ability of government to promote equal distribution of production and stabilization of the economy.

PSP was computed for the period 1990-2019 with the limitation of data described above. It is highly important to mention that PSP values over time are measured relative to those of other countries, meaning that over time PSP values could increase or decrease not only because of the evolution of the indicators but also because of the behaviour of the other countries. In addition, there is no differentiation of initial conditions among countries, so better countries in terms of outcomes may obtain low improvements because the higher changes will experience the less developed countries. (Afonso, et al., 2013)

3.2. Data Envelopment Analysis (DEA)

As referred by Afonso et al (2007) this analysis has its roots in the seminar work of Farrell (1957), in which he provided a measure of productive efficiency which considers inputs and outputs, therefore he estimated a production function with constant returns to scale. His work was developed considering a firm as an example, which produce one product using two factors of production and identified the efficient production function. His paper explains all the assumptions of the model, the equations, the combinations of inputs, defines the technical efficiency of the firm, the price efficiency, convexity, decreasing and diminishing returns to scale, etc.

Recent papers have used non-parametric approaches for measuring relative expenditure efficiency across countries and this thesis follows the description of DEA made by Afonso et al (2007), so the measurement of public sector efficiency will follow a function for each country *i* out of 20 given by:

$$(1) \qquad Y_i(t) = f\big(X_i(t)\big)$$

Where Y_i = Composite indicator representing the output

X_i = Government Spending representing input

Based on it, country *i* will be efficient if: $Y_i > f\,(X_i)$, meaning that for the input level the output is the best to obtain.

DEA estimates a theoretical efficiency frontier, therefore inefficiency of country i is measured by computing the distance to the theoretical frontier.

The linear programming problem supposes there are k inputs and m outputs for the 20 countries. 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.

DEA can have 2 approaches: Input and Output oriented. Input efficiency scores represent the proportional reduction in inputs while holding output constant, and in contrast Output oriented measure the proportion increase in outputs holding inputs constant.

The DEA model is then specified for a given *i-th* country, and for an input-oriented approach, the efficiency scores are obtained through the solution of the following:

$$(2) \qquad \text{Min} \ {}^{\beta}_{\mu}\, \beta$$

$$\text{s.t } -y_i + Y_{\boldsymbol{\mu}} \geq 0 \text{ and}$$

$$\beta x_i - X_{\boldsymbol{\mu}} \geq 0 \text{ and}$$

$$\boldsymbol{\mu} \geq 0 \text{ and } \boldsymbol{I1'\mu} = 1$$

β is a scalar that satisfies $\beta \leq 1$, and it is the efficiency score that measures technical efficiency. If $\beta < 1$, the country is inside the frontier meaning it is inefficient, while if $\beta = 1$ the country is on the frontier meaning it is efficient. The restriction $I1'\mu = 1$ imposes convexity of the frontier, considering variable returns to scale.

The $\boldsymbol{\mu}$ is a vector of constants *(nx1)* that estimates the weights used to compute the location of an inefficient country if it were to become efficient. The inefficient country would be projected on the production frontier as a linear combination of those weights, related to the peers of the inefficient country.

On the other hand, and expanding the application of DEA, some studies used what is called window-DEA, which seem to be a better method to evaluate efficiency over time. According to Flokou et al (2017), the normal DEA calculates a unique frontier each period, and window-DEA or "intertemporal perspective" calculates a single common frontier for the whole period. The authors used this methodology to measure the efficiency of Greek NHS hospitals between 2009 and 2013. This methodology was proposed back in (1985) by Charnes et al, and it is important to mention it as part of the different approaches that have been studied, although it won´t be applied in this dissertation.

4. EMPIRICAL ANALYSIS

4.1. Public Spending Data Analysis

The data of Total Public Spending as percentage of GDP, is not complete from 1990 to 2000. There is missing information for many countries: Guyana, Honduras, Mexico, Panama, Suriname, Ecuador, Peru, and Venezuela. Therefore, the analysis will focus since 2000 onwards.

The last two decades the government spending in Latin America shows an upward trend as presented in Figure 1, on average in 2000 it represented 19.3% of GDP and increased to 25.6% of GDP in 2020, with a growth rate of 32.9%. Results also show that the government spending in South America is greater than the one in Central America. Comparing between both regions, in 2000 the average spending was 20.8% in South America and 17.0% in Central America, which increased to 26.3% and 25.1% of GDP in 2020 respectively[1]. However, the growth rate of the percentage of government spending between 2000 and 2020 was bigger for Central America (46.9%) than South America (26.4%). Figure 1 displays the evolution of this indicator, in which, for the years of the global economic crisis in 2008-2009 government spending reached a peak, mostly due to the expansive fiscal policies taken by governments to increase aggregate demand and mitigate the impact of the crisis on the private sector and households.

The following years after the crisis, the increase of public spending continues with a higher speed reaching the next peak in 2014. The average growth rate between 2010 and 2014 is 2.6%, while between 2000 and 2009 was 1.1%. Since 2015, values showed a slight reduction until 2018, from then it increased again and in 2020 we see the highest value of total spending of government, explained by the measures and policies taken by the government to face the economic, social and health crisis because of Covid-19. This

[1] At the moment, there is no data update for Panama (2018,2019 and 2020), Bolivia (2019 and 2020) and Venezuela (2015 to 2020)

year governments increased spending at not expected rates, many countries over 17% (El Salvador, Guatemala, Argentina, Brazil, Paraguay and Perú).

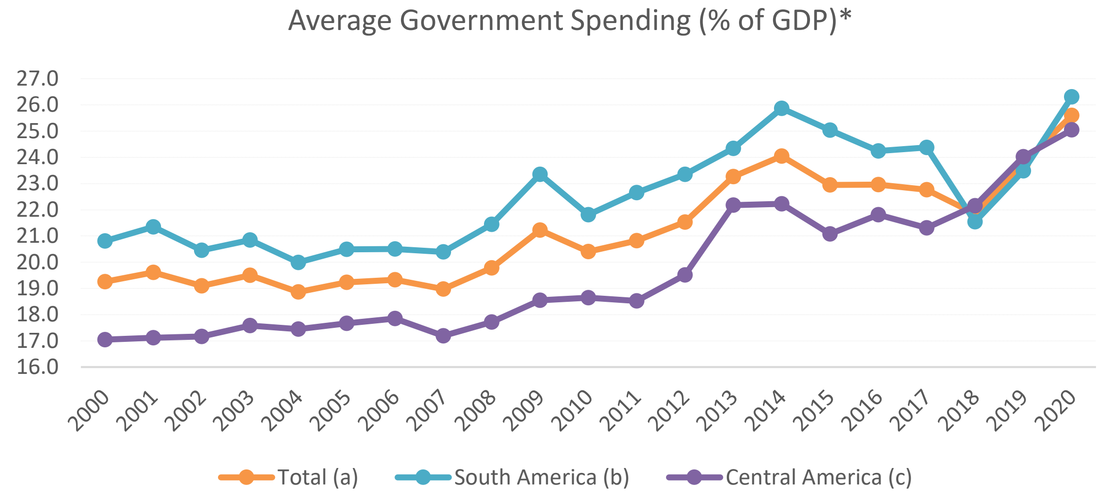

Figure 1: Average Government Spending (% GDP)

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 that is General Government Spending.

This expansion of the public spending along the period was possible due to the boom in commodities prices, which started in the beginning of the 2000s and lasted about a decade. This rose public revenue. Moreover, even though, the following months of the economic crisis in 2008-2009 the increase of prices stopped, the strong Chinese demand soon resumed the prices back (Ocampo, 2017).

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

The total government expenditure was allocated in different areas represented in the following graphs by sub-region, most of it directed to social expenditure, meaning health, education, social protection and transfers and subsidies. The average expenditure on these areas rose from 1.5% of GDP on health in 2000 to 2.8% of GDP in 2020. In Education the average expenditure is higher and rose from 3.2% of GDP in 2000 to 4.3% in 2020. In addition, in Social Protection the expenditure increased from 3.4% of GDP in 2000 to 5.6% of GDP in 2020.

The spending on health is quite similar between South and Central America until 2012 as depicted in Figure 2, after 2013 in South America the spending on health is greater, that year South American countries spent on average 7.4% more than 2012, and in Central America in 2013 the growth was negative (-0.7%). In 2020 the average growth rate of spending was 11.1%, a maximum historic value. All countries made great effort to stand up to the difficult challenges Covid-19 brought to this sector, Guyana increased 38%, Argentina 57%, Peru 41%.

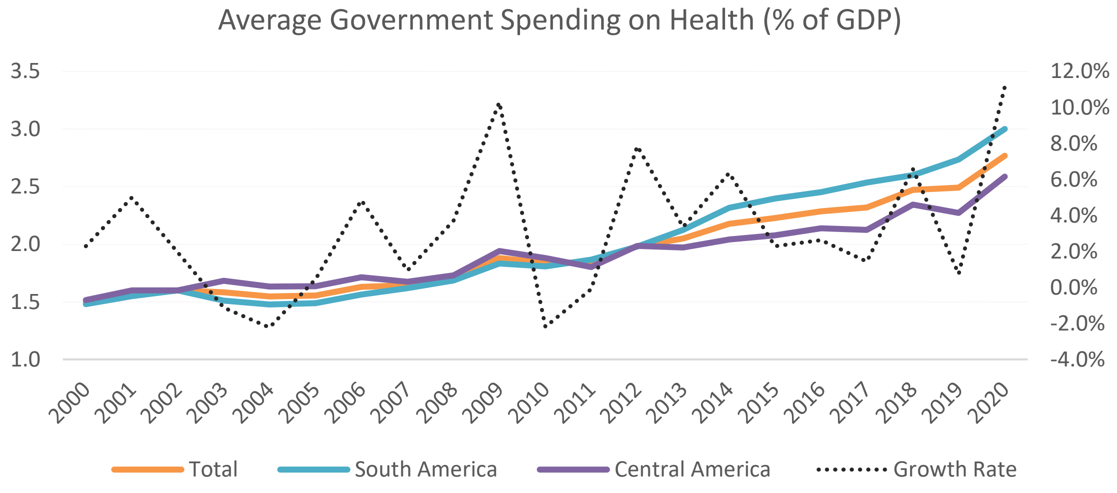

Figure 2: Average Government Spending on Health (% of GDP)

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

On the other hand, values in Figure 3 indicate that government spending on education is greater in Central America than in South America during the whole period analysed, and the gap has increased from a difference of 0.4 p.p in 2000 to 1.3 p.p in 2020. Though this is the second most important sector in public spending, in 2020 there are no increases, might be explained to the urgency of allocate more resources in the health sector.

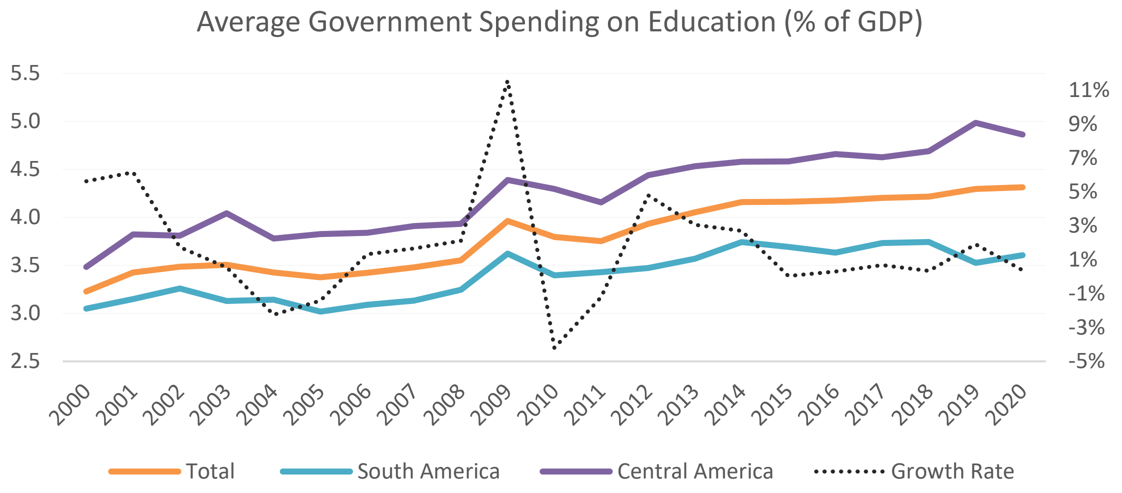

Figure 3: Average Government Spending on Education (% of GDP)

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

About social protection expenditure, in 2000 countries spent on average 3.4% of GDP and increased until 5.6% of GDP in 2020. This category includes retirement payments in some countries and the Conditional Cash Transfer programs, which became very popular in all Latin-American countries last decade. Figure 4 clearly shows that in this area there is remarkable difference between the regions, South America locates forward comparing to Central America since 2000 with an average gap difference of 4.4 p.p. This spending is also influenced by the crises in 2009 and 2020 where the higher peaks are. However, 2020 showed a huge increment: the growth rate is 28.1%, all countries increased in high amounts. They made a greater effort due to Covid-19, comparing to 2019 countries like El Salvador and Guatemala stands out the growth rate having 194% and 115% respectively. Nevertheless, within the group the level of spending differs, while countries like Brazil and Argentina spent 14% and 17% of GDP, Honduras and Nicaragua spent less than 1% of GDP.

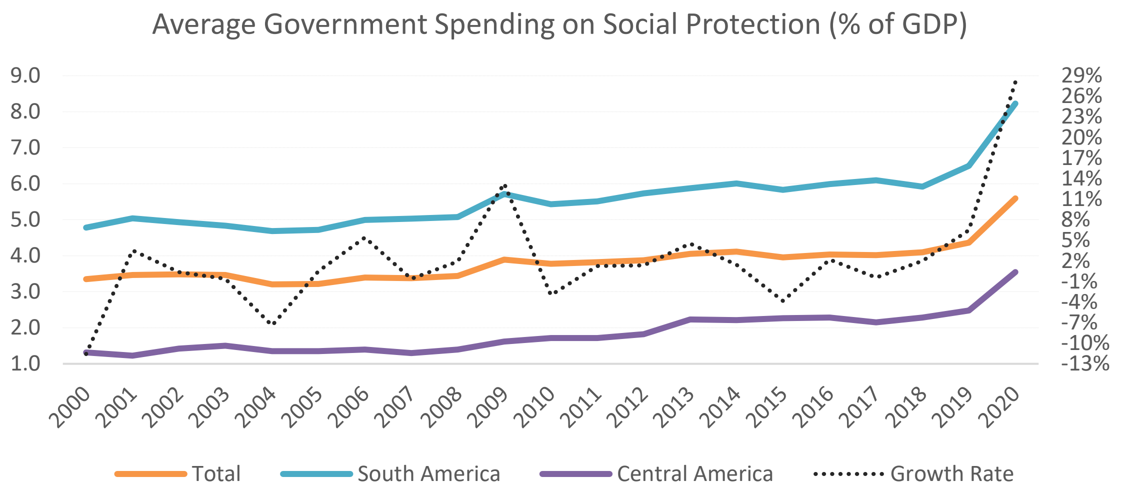

Figure 4: Average Government Spending on Social Protection (% of GDP)

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

In the following graphs (Figure 5) it is clear the differences between the spending amounts of the 2 regions, while in South America the spending goes in majority to social protection, in Central America the priority is in Education:

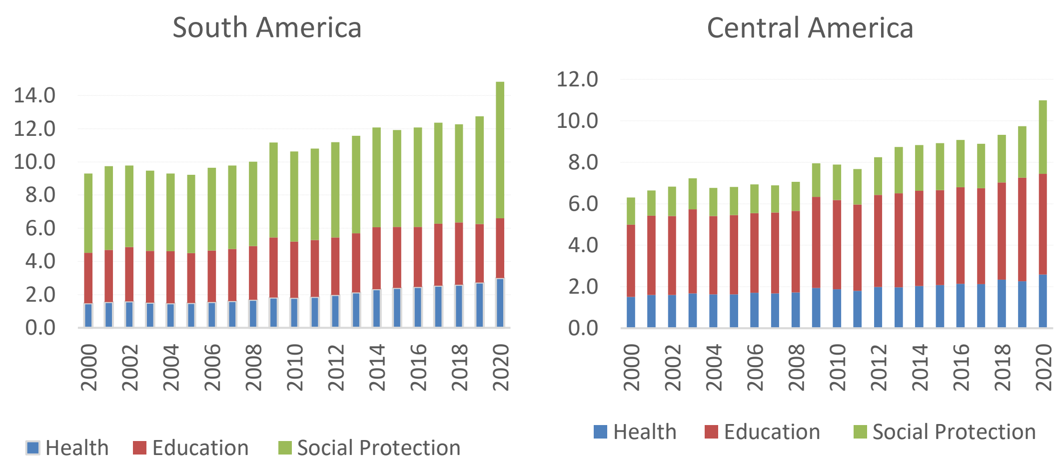

Figure 5: Government Spending by area and region

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

Government spending by country

Figure 6 shows the total government spending as percentage of GDP by country and its evolution from year 2000 to year 2009 to year 2019. For all the countries, the public spending has increased, except for Guatemala. Among the countries in Central America, Guyana in 2019 increased 7 p.p., the highest growth, followed by Costa Rica that had 4 p.p more comparing to 2009. More or less the other countries of Central America had an increase below the 10%.

On the other hand, in South America countries increased the public spending at higher rates since 2000. Ecuador is in the first place, it rose 36.2% from 2000 to 2009 followed by a continuous growth of 18.5% from 2009 to 2019. In the same case Uruguay, whose growth rates are 22.1% (2000-2009) and 18.3% (2009-2019). While Argentina and Brazil also had bigger growths the first decade, 25.3% and 18.8% respectively, between 2009 to 2019 both countries increased around 10.9%.

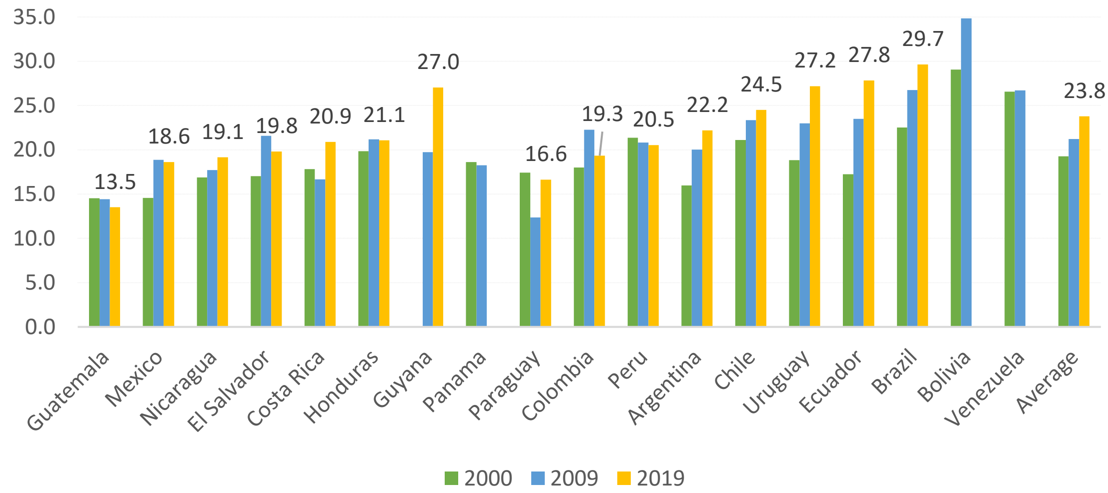

Figure 6: Government Spending by country (% of GDP)

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

4.2. Public Sector Performance Results

Table I shows the results of the standardized PSP for 1990, 2000, 2010 and 2019 for the 20 countries. These results represent outcome indicators without considering the spending incurred. In 1990 and 2000 Panama had the highest total PSP (2.23 and 1.43 respectively) compared with Guyana (0.42) in 1990 and in 2000 between Venezuela and Ecuador (which had almost the same 0.74) that scored the lowest PSP in the same years. In 2010 the first place changed to Chile which got the highest score (1.24) between the countries and took this position for many years also until 2013, the worst place also changed to Nicaragua which got 0.78. In 2019 the best and worst performers changed back to Panama (1.36) and Venezuela (-0.5).

Table I: Public Sector Performance Indicator by type[2]

	1990			2000			2010			2019		
Country	**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
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

[2] 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.

Source: Author calculations

Analysing by type of indicator, if it is Musgravian or Opportunity PSP, results show that best or worst scores don’t represent the same countries as in Total PSP. For example, if we only check for Musgravian PSP (economic indicators) in 2010 the best country was Bolivia (1.43), or in 1990 and 2010 the worst country was Nicaragua. In addition, the same happens with Opportunity PSP (social indicators), in 1990 Uruguay was the best (1.22), in 2000 and 2010 was Chile and in 2019 was Costa Rica. On the contrary, Paraguay and Guatemala got the lowest results on 1990 and 2000.

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

Figure 7 shows the evolution of the indicator of the best performers, scores ranged between 0.94 and 2.23. The first decade clearly Panama was the highest, but the three countries showed a decrease in their PSP. On the contrary, Belize started to grow on 1998, but this is because it was a period of economic crisis in most of the countries and inflation values were very high, hence comparing between the countries analysed Belize was one of the countries whose inflation rate was low, and this helped to improve its PSP. Chile shows a more constant pattern during the whole period, which gives a sign of stability.

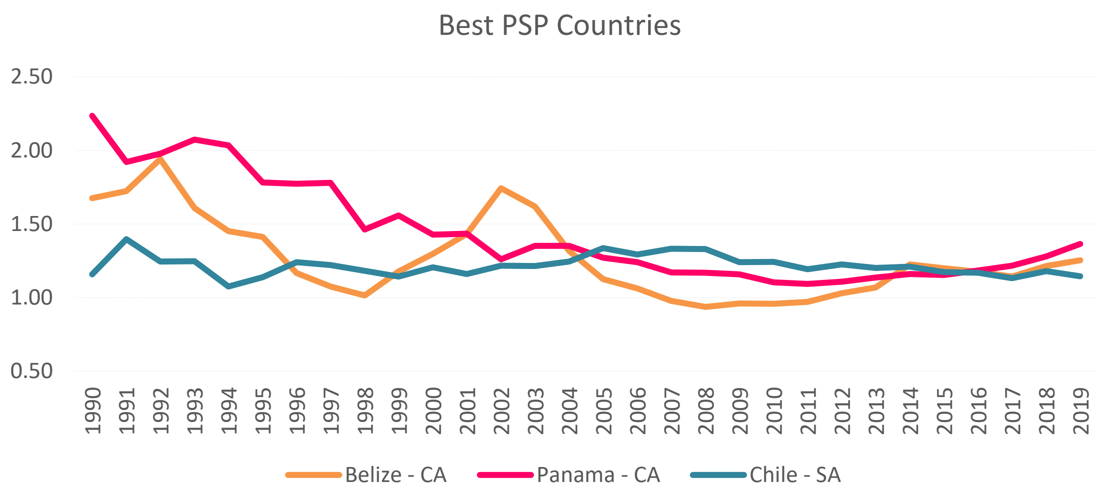

Figure 7: Evolution of the Total PSP - First three countries

Source: Author calculations
*CA- Central America, SA-South America

On the other hand, the three worst countries in the ranking of PSP are Venezuela, Nicaragua, and Paraguay (Figure 8). Scores ranged between 0.43 and 1.08, except last 2 years that Venezuela fell until reaching a negative PSP value in 2019 (Note that negative PSP in Venezuela is consequence of negative GDP growth rates). None of the countries seemed to have improved or not along the period, they have remained in the same range.

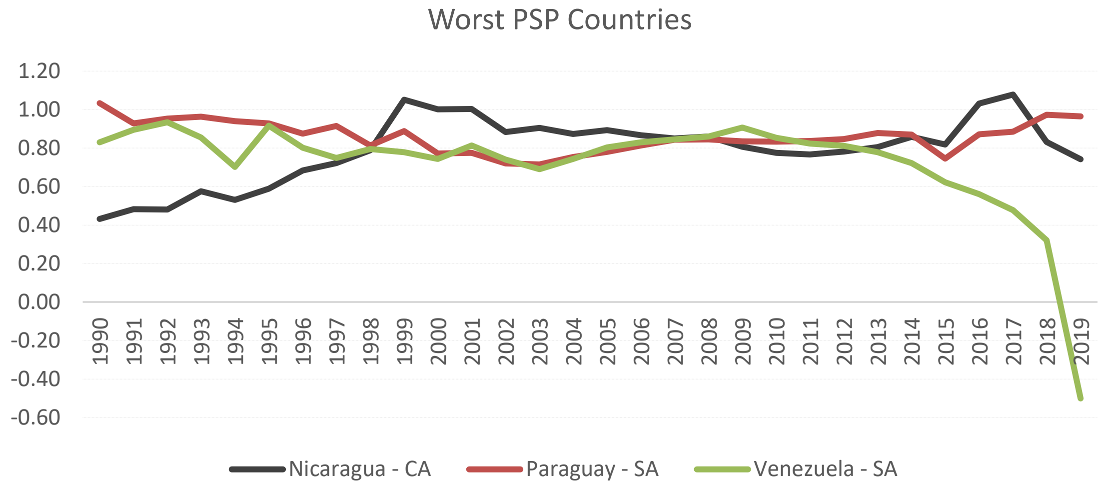

Figure 8: Evolution of the Total PSP - Last three countries

Source: Author calculations
*CA- Central America, SA-South America

Analysing PSP by the areas and each 10 years in Figure 9, in Education on 2000 Uruguay was leading the group of countries but after in 2010 and 2019 Costa Rica took the first place. The worst country in this area in 2000 was Guatemala, in 2010 was Paraguay and in 2019 Guatemala again. Looking to Health results, the first country for the three years was Chile and the worst country was Guatemala (2000), Guyana (2010) and Venezuela (2019) respectively. In Administration, Chile again leads the ranking for the three years, and the worst performers were Paraguay and Venezuela.

Contrasting with Economic PSP, in 1990 Belize was the best performer, in 2000 Mexico, and lately in 2010 and 2019 Panama took this place. The worst countries were Guyana in 1990, Ecuador in 2000, Belize in 2010 and Venezuela in 2019. In the stability indicators, Panama also highlighted in 1990 and 2000, in 2010 Bolivia ranked first and in 2019 changed this place to El Salvador. On the other hand, in 1990 Peru placed in the bottom in Stability, followed by Venezuela in 2000 and 2010 and in 2019 Suriname got the worst result in this area.

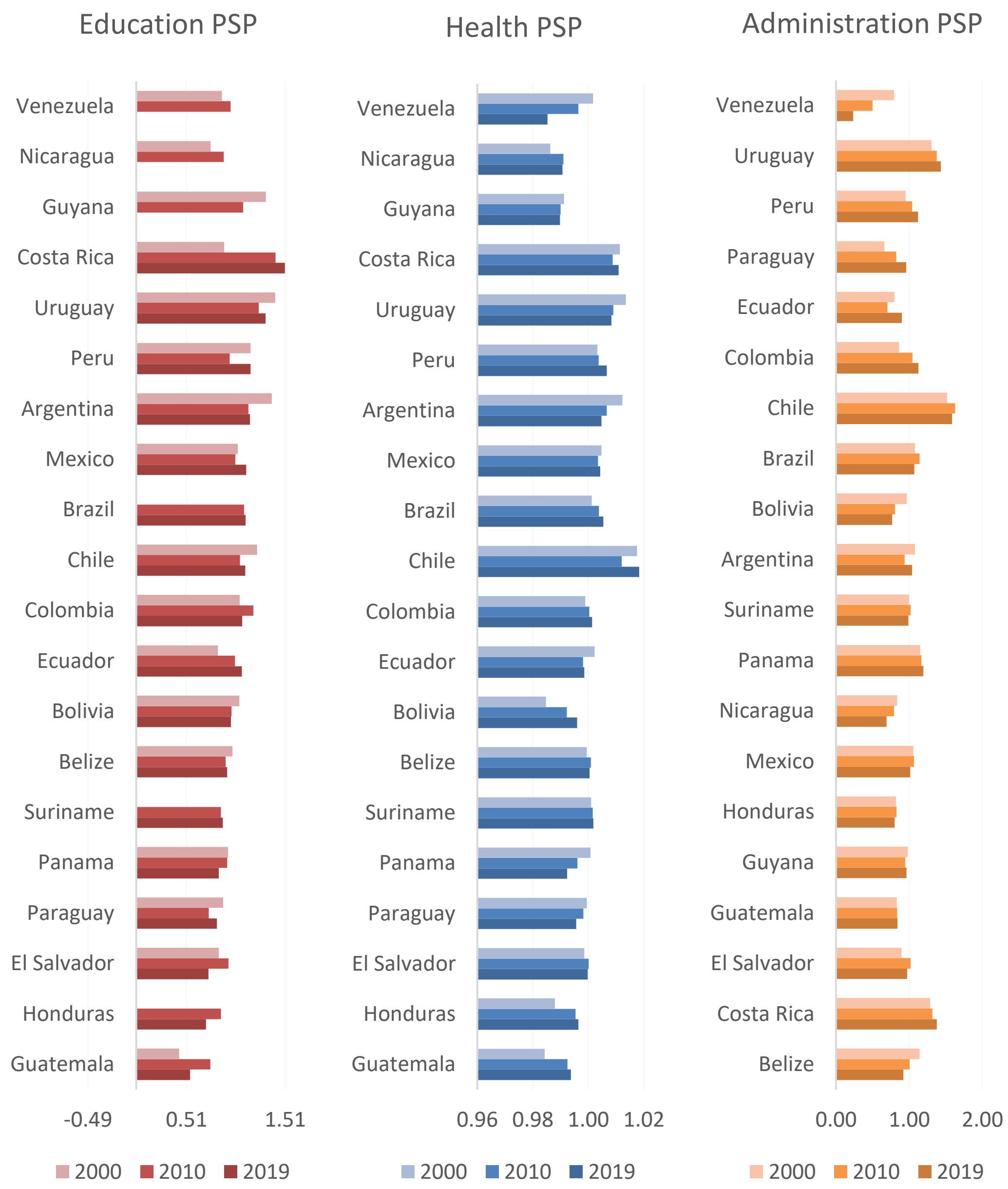

Figure 9: PSP by Area: Education, Health, Administration

Source: Author calculations

4.3. DEA Efficiency Scores

For the application of the DEA methodology, were calculated 3 models using different inputs, applying both input-oriented and output-oriented approaches.

The first model applied calculated the efficiency scores using as input the Total Public Spending as percentage of GDP and as output the Total PSP Scores. 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 following results:

In 2000, with data available for 17 countries from the set of 20, on average the input efficiency score was 80 percent, which means that countries could achieve the same level of PSP using 20 percent less government spending. The countries in the production possibility frontier were Guatemala and Panama. In the ranking after them are Mexico and Argentina, while the countries ranked in the last positions are Brazil, Venezuela, and Bolivia, meaning they are located the furthest from the efficiency frontier. The complete input efficient scores are included in the Appendices section.

Surprisingly, the average input efficiency score during the period from 2000 to 2019 has decreased as shown in Figure 10, meaning that countries have used their public resources not efficiently. In 2019 the average efficiency score was 65 percent (countries could have used 35 percent less of spending to achieve the same levels of PSP). The countries in the efficiency frontier were El Salvador and Guatemala, followed by Costa Rica, and the less efficient were Suriname, Brazil, and Belize.

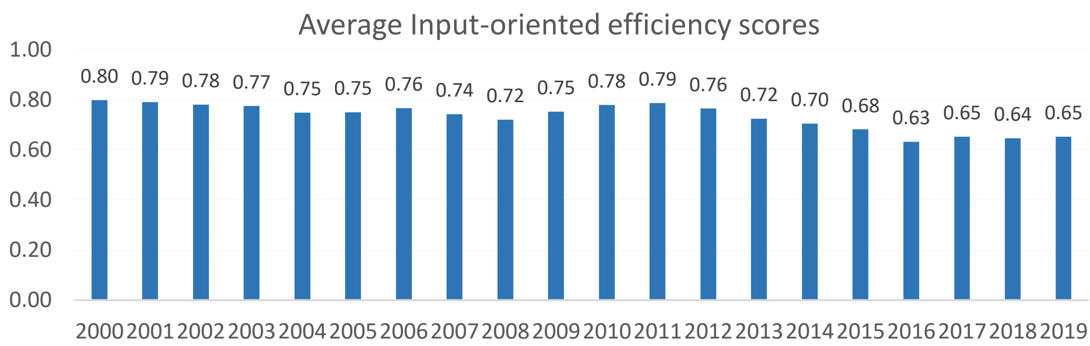

Figure 10: Average Input-oriented efficiency scores 2000-2019 Model 1

Source: Author calculations

Along the period the most efficient countries, meaning located on the production frontier many years, are Guatemala, Panama, Chile, and Paraguay. This contrasts the PSP results obtained before, in which Panama and Chile appeared also as best performers, but interestingly for Paraguay is not the case, because in results of PSP was the worst. Analysing Paraguay data, its efficient score is because of the low values of government spending as percentage of GDP compared to the other countries.

Regarding the results of the output-oriented approach (how much output quantities can be proportionally increased without changing the input quantities used), they are shown in Figure 11. In 2000, the same 17 countries got on average an output efficiency score of 73 percent, meaning that countries could have increased their performance by 27 percent with the same level of inputs. The countries located on the production possibility frontier were also Guatemala and Panamá, followed by Mexico and Chile in the 3rd and 4th place respectively. Moreover, the worst countries were Venezuela, Brazil, and Peru.

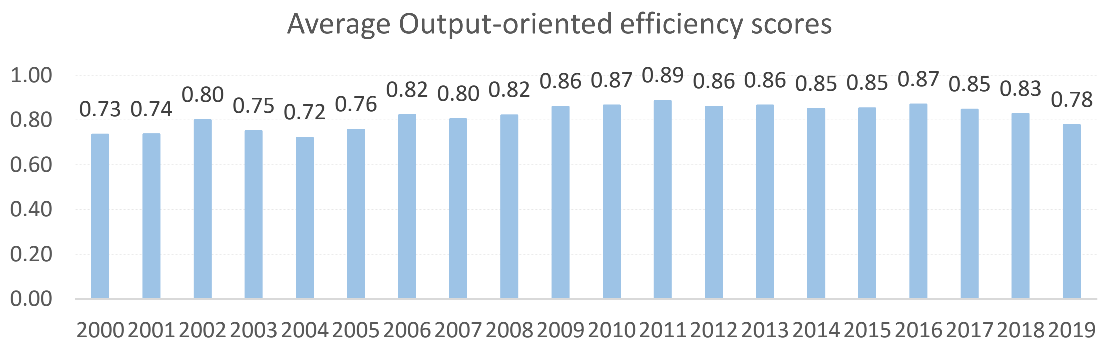

Figure 11: Average Output-oriented efficiency scores 2000-2019 Model 1

Source: Author calculations

As shown in Figure 11, historically the output efficiency score increased until the highest average in 2011 that was 89 percent, so countries apparently used better the resources and improved their results, but since 2012 there is a volatility in the period and in 2019 the average score decreased until 78 percent, more less the same average of 19 years before.

To be able to see differences along the period and between the 2 approaches, Table II shows the results for 3 years in which the public spending increased much more. From 2008-2009 the average public spending increased by 7.3%, from 2012-2013 by 8.0% and from 2018-2019 by 8.8%. These are the years with highest growth rates of public spending since 2000.

Table II: DEA Efficiency Scores Model 1 for 3 years

	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	
Standard Deviation	0.19		0.10		0.19		0.09		0.19		0.15	

Source: Author calculations

In 2009, year of global economic crisis, the average input-oriented efficiency score was 75 percent, in 2013 it slightly decreased to 72 percent, and finally in 2019, year of social, health and economic crisis due to Covid-19, the efficiency score decreased to 65 percent. Countries performed worst. Contrasting to the output-oriented score, in 2009 was 86 percent, and kept the same value in 2013, but in 2019 countries decreased to 78 percent, 9 points of difference. Clearly, year 2019 in which countries had to increase their public spending, the scores in both approaches were worst. This reflects that when Latin

American countries passed through crisis and increased the public spending, their efficiency decreased, and this is an important finding that contrast the literature that proved no evidence of higher benefits when countries have higher public spending. This can be explained by the lack of strong policy programs and low ability of governments to control the expenditure and its destiny, in crisis, they only spend to face difficulties but have weak management systems and processes, which has led to high levels of corruption in the region.

The efficient countries located in the production possibility frontier in 2009 are Guatemala, Panama, Chile, and Paraguay. In 2013 remains Guatemala and Chile and interestingly in 2019 emerged another country which is El Salvador, together again with Guatemala. In addition, Chile dropped to position 11, seems it was not a good year for Chile.

Analysing the difference of results according to the method used (input – output), most countries remain in the position or close to it. Particularly there are some countries like Bolivia or Nicaragua that have a big difference in results. Nicaragua is more efficient input-oriented locating in the top 10 but when is output oriented locates in the last positions, meaning, the worst countries. Bolivia is the opposite, while results of input show no efficiency, it gets better in output oriented. It is important to mention that Bolivia has one of the highest percentages of public spending (over 30%), and Nicaragua belongs to the group of countries that spend less than 20%.

Figure 12 illustrates one example of the production possibility frontier for Model 1 (1 input and 1 output), and it could be appreciated how far the countries are from the efficient ones. The figure contains 4 years. In 2000 the efficient countries are Guatemala and Panama with Mexico very close. In 2009 the efficient countries are Guatemala, Panama, Chile, and Paraguay. In 2013 the efficient countries are Guatemala and Chile. Finally, in 2019 the efficient countries are El Salvador and Guatemala.

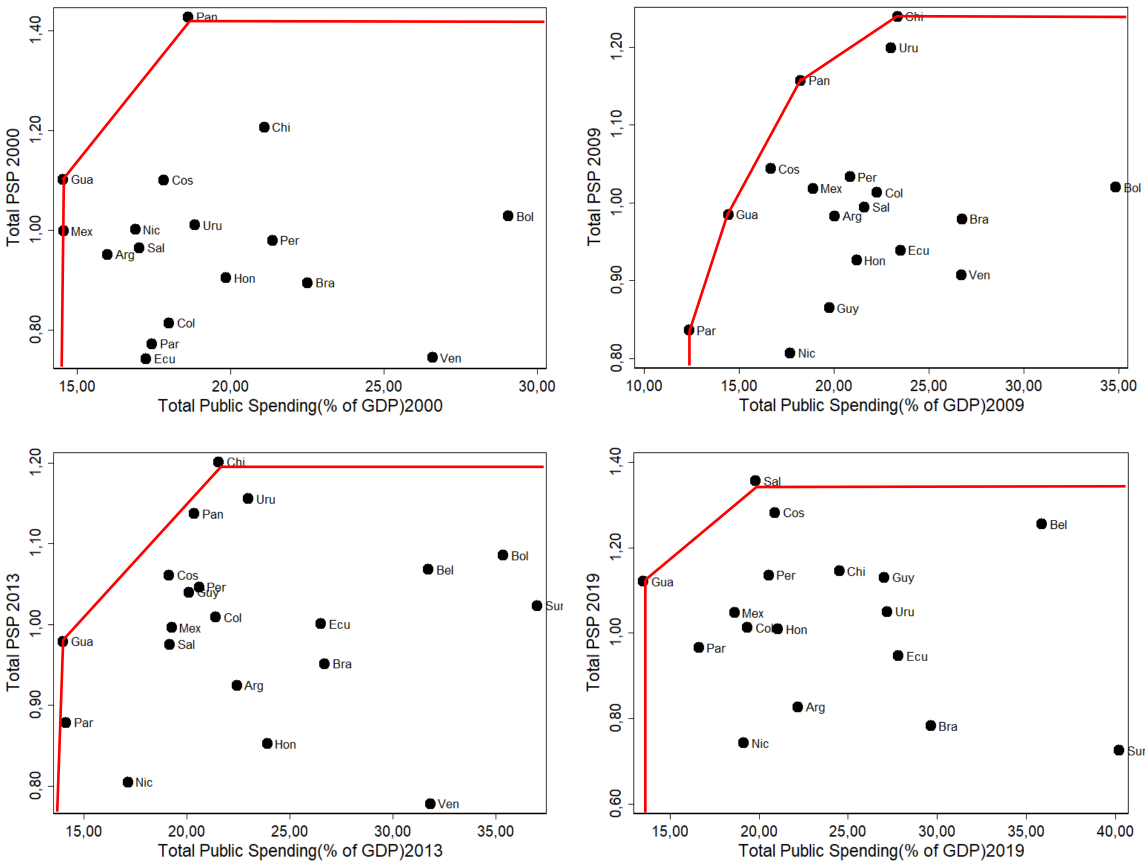

Figure 12: Production Possibility Frontier Model 1

Source: Author calculations

To continue the analysis, Model 2 uses as input the Public Spending on Health (% of GDP) and as output Health PSP (mostly because of the health crisis due to Covid-19 and to have a view of the sector before this pandemic), and Model 3 uses Total Public Spending (% of GDP) and as output the Economic PSP.

The results of Model 2 are shown in Figure 13 and Figure 14, the average input efficiency score during the period is 40%, a very low score, countries could have achieved the same level of outputs using 60 percent less government spending. On the other hand, the efficiency in the output-oriented approach is surprisingly high, the average is 99%, so countries are almost getting the most of outputs they can with the level of spending.

According to it countries could have increased their performance by only 1 percent with the same level of inputs.

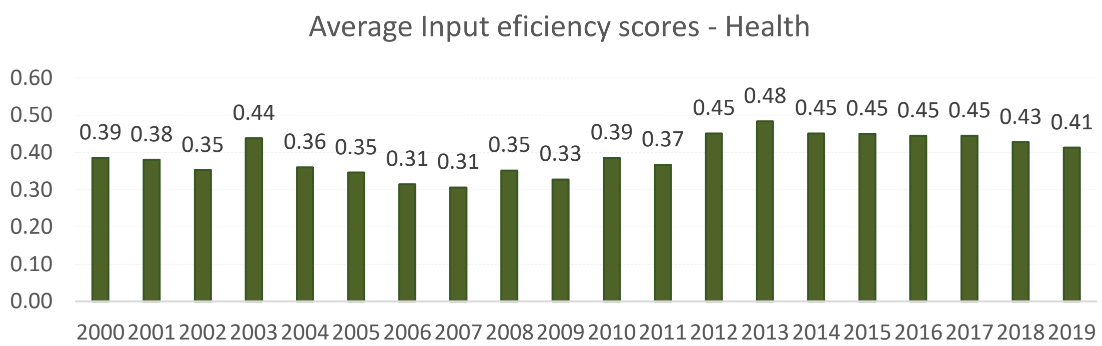

Figure 13: Average Input-oriented efficiency scores 2000-2019 Model 2

Source: Author calculations

The input scores were more volatile during the period, there are two turning points, one in 2003 and the other in 2013 that scores started to decrease. In addition, the output scores remain with the increasing trend until 2017 that slightly decreased.

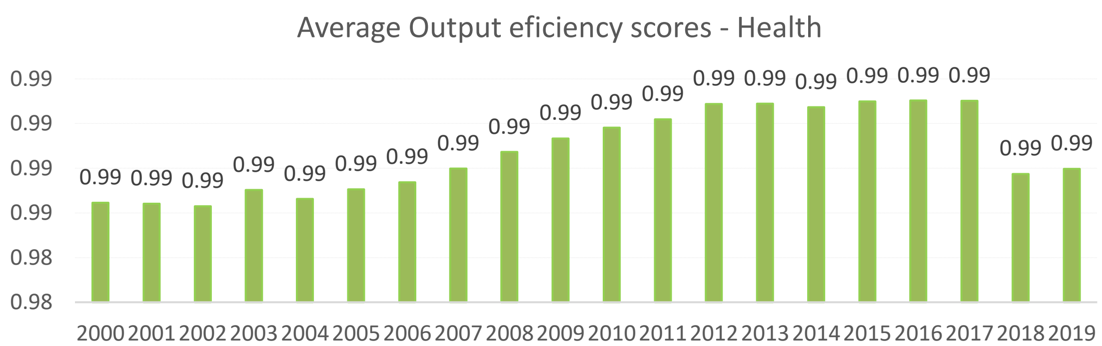

Figure 14: Average Output-oriented efficiency scores 2000-2019 Model 2

Source: Author calculations

It is worth noting that in the health sector, input-oriented scores identify one country, which remains efficient along the period, and it is Costa Rica that locates in the production possibility frontier, only 2 years: in 2012 and 2018 the first place was for Argentina, which is the country in second place most of the years. In addition, output-oriented scores in all the years from 2000-2019 reveal 2 countries in the production possibility frontier as the best performers that are Costa Rica again and Chile shows up.

Table III shows the results of model 2 for the same 3 years analysed before. The input efficiency score does increase from 33% in 2009 to 48% in 2013 that is the highest score and then starts to decrease until 2019 with 41%. Apparently, for health sector the best years were 2013 in which the increase of public spending could achieve better results of efficiency.

Table III: DEA Efficiency Scores Model 2 for 3 years

	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: Author calculations

In contrast, the output-oriented score is 99% the 3 years, changes in the proportion of public spending don´t affect the efficiency and there is not enough space for efficiency improvement.

It is interesting to see here the case of Chile that while in the output-oriented approach is the more efficient country, it is not in the input oriented. This because Chile is the country with the highest percentage of Public Spending in Health, on average during the period analysed government spending was 3.53% of GDP and it had a significant increase along the years, for instance from 2000 to 2019 the growth rate is 92%. Only analysing the output Chile gets the best score also, however when both input and output are contrasted and compared between other countries, DEA estimates shows up Costa Rica. The level of public spending in this country is on average 0.61% of GDP, vast difference from Chile, and when reviewing the output Costa Rica is in the second and third place of best scores. As a result, DEA methodology punishes Chile and calculated that in 2009 it could have gotten the same PSP results using 87% less of spending, in 2013 using 78% less and in 2019 85% less of the government spending. The conclusion finally is that Chile is not an efficient country in the health sector and has a huge space for improvement.

Model 3 has as input the Total Public Spending as percentage of GDP and as output the Economic PSP, which was measured based on unemployment rate, GDP growth and GDP per capita. From 2000 to 2019, the average input efficiency score is 68%, countries could have achieved the same level of PSP using 32 percent less government spending. In contrast, the average output efficiency score is 66%, meaning that countries could have increased their performance by 34 percent with the same level of inputs.

The most efficient countries located in the production frontier are Guatemala in almost all the years, Mexico the first years until 2007, Panama the last decade since 2009, and Paraguay between 2003 and 2011 shares the efficiency frontier together with the other countries mentioned. Checking the cases of Guatemala and Paraguay, these countries have the lowest percentages of Public Spending among Latin America, on average around 14 percent. As regards Mexico and Panama have on average around 18 percent. Hence, countries located in the efficiency frontier are the ones with an average public spending of less than 20%.

Figure 15 displays the evolution of the average input-oriented scores for model 3, the evolution of the average has a negative trend with the lowest value in 2008, after the economic crisis countries slightly improved, and then from 2013 scores started to decrease up to now. This clearly implies that the years with higher public spending of the whole period (2013-2017 as found in the last section analysis) are the years that economically countries were less efficient in their expenditures. Looking deeper into the Economic PSP, unemployment rates in those years also increased, which is probably the indicator that has a higher effect.

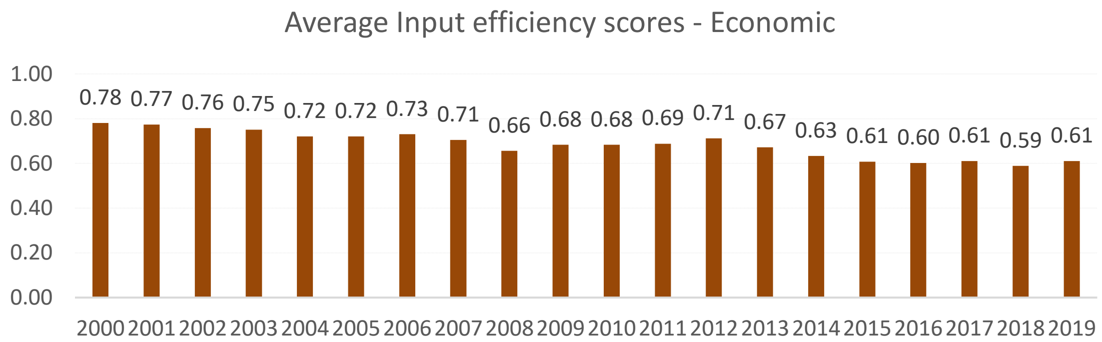

Figure 15: Average Input-oriented efficiency scores 2000-2019 Model 3

Source: Author calculations

Figure 16 displays the average output-oriented scores for the economic PSP and the total public spending, from 2001 until 2008 the score significantly improves passing from 56% to 79%. Then in 2009 the trend shifted and started to decrease, meaning countries last decade have been less efficient and could have gained better output indicators using the same public spending. In the frontier of output-oriented is also Guatemala, Panama, Mexico, and Paraguay.

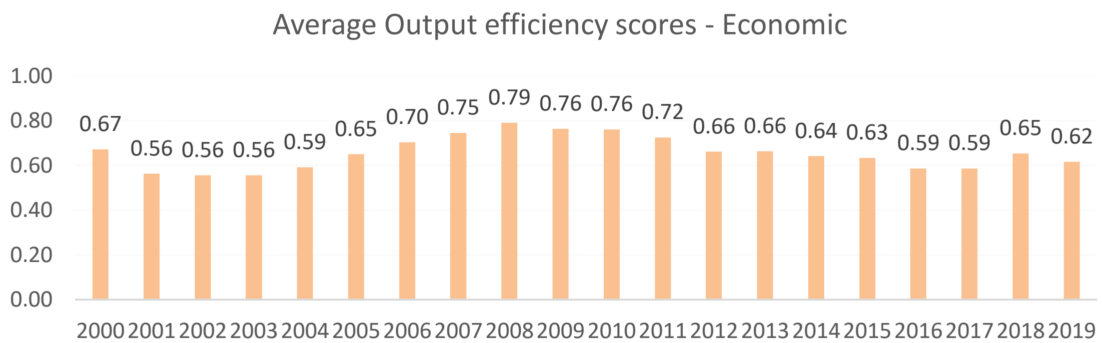

Figure 16: Average Output-oriented efficiency scores 2000-2019 Model 3

Source: Author calculations

Analysing model 3 in the 3 years of major public spending, Guatemala and Panama are the best performers in both input and output-oriented approach. With an input-oriented approach, Bolivia and Brazil are the least efficient in 2009 and with the output-oriented approach is Guyana and El Salvador. In 2019 Suriname and Belize are the worst input – oriented and Brazil with Argentina in the output-oriented approach.

Table IV: DEA Efficiency Scores Model 3 for 3 years

	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	

Source: Author calculations

In table IV we can see that in 2009 on average countries could achieve the same level of PSP using 32 percent less government spending, or countries could have increased their PSP by 24% using the same levels of spending. Moreover, these scores worsen for 2019 when countries could achieve the same level of PSP using 39 percent less government spending, or countries could have increased their PSP by 38% using the same levels of spending. Economically 2019 is the year with less efficiency across all countries.

See Appendices for a summary of the main results of the 3 models both input and output oriented efficiency scores and also the complete data set from 2000-2019.

5. CONCLUSIONS

Governments in Latin America spent on average about 25.6% of GDP on the provision of public goods, services, and transfers in 2020. Moreover, statistics reflect a vast increment of public spending the last years with an average growth rate of 32.9%. During recession periods, such as the economic crisis of 2008-2009 or the health and economic crisis of 2019, governments made great public expenditures. This dissertation aimed to calculate how efficient this public spending has been over the last 20 years.

By collecting indicators of 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, consequently the final sample is ten countries from South America and ten from Central America for the period 2000-2019. Once I had the indicators, some transformations were applied to each, in order to, get same scales and normalize them. The next phase was to calculate the composite indicator "Public Sector Performance (PSP)" to have a comparable and unique measure that represents the outcome for all the countries. Finally, Data Envelopment Analysis technique was applied to compute efficiency scores and rankings each year.

Regarding the original indicator "Public Spending as % of GDP", figures show that health, education, and social protection are key areas of spending but within the group of countries the level of spending differs, while in South American region the higher spending is on social protection, in Central America is on education.

From the analysis of the PSP indicator, during the period 1990-2019, the countries that performed better were Panama, Chile, and Belize. Interestingly these 3 countries are diverse in the level of public spending, while Belize is in the group that spent over 30% of GDP, Chile belongs to the group that spend between 20%-30% of GDP and Panama is inside the group that spend less than 20% of GDP. On the other hand, the countries with worst performance are Venezuela, Nicaragua, and Paraguay. In this case, Nicaragua and Paraguay public spending is less than 20% and Venezuela spends between 20%-30% of GDP.

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

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

Analysing the years of global economic crisis, scores in both approaches are worst suggesting that when Latin American countries passed through crisis and increased the public spending, their efficiency decreased and year 2019 showed an emphasized decrement.

The least efficient countries differ between approaches, countries in the bottom of the ranking in 2019 are Suriname, Brazil, and Belize for the input approach. Notice that Belize was among the best performers in PSP, but when it is contrasted with the spending incurred, it is not efficient. A case that shows the importance of applying DEA methodology to describe efficiency. In addition, for output approach worst countries are Nicaragua, Suriname, and Brazil.

Model 2 brought interesting findings, the average input efficiency score during the period is 40%, a very low score, this means that countries could have used 60 percent less spending in health to attain the same outcomes if they were fully efficient. On the other hand, average output score is surprisingly high, the average is 99%, suggesting that countries are almost getting the most of outputs they can with the level of spending in the health area. From the input oriented approach, the best country in health is Costa Rica, which remain fully efficient along the period analysed, and in the bottom locates Chile.

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

Surprisingly in model 3, findings suggest that the lowest the spending ratios the most efficient countries. Guatemala, Panama, and Paraguay are the best performers in both input and output-oriented approach, and all of them are countries with public expenditure as % of GDP below 20%.

To conclude, the analysis of the 3 models gave an important understanding of the differences between countries when analysing the 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, while many years top the list among the more efficient countries in model 1, it is not when we analyse only health or economic. Results divided by individual spending areas seem to be a more promising approach to measure efficiency and effectiveness on a cross-country basis.

Future research can continue the analysis with the application of methodologies to understand the determinants of the efficiency scores calculated, moreover identify what governments can improve to achieve efficiency. Advance for instance with the effects of taxation in the efficiency scores as seen in the literature review. In addition, to make the most of the large cross-country panel dataset presented here will be interesting to apply alternative DEA models such as the DEA-Windows method that enables year-to-year comparison of the results. This will help to contrast the scores obtained each year.

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APPENDICES

This section includes in Table A.1 a complete detail of the indicators used to generate the composite performance indicators, it´s source, years available and the modifications done. Table A.3 and Table A.4 presents a summary of the 3 DEA models in both input and output approach respectively. Finally, the following tables are the complete data estimates of PSP for period 1990-2019 and DEA efficiency scores for each model for the period 2000-2019.

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	0.98	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

*Values highlighted are the best scores 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	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	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	0.21	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
	Countries on the frontier	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	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, 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	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
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	0.52	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	0.10	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	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	GUA, PAN, CHI, PAR	GUA, CHI, PAR	GUA, CHI, 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	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
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	0.97	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	0.97	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
	Total Efficient Countries	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, ARG, CHI	COS, CHI	COS, CHI	COS, CHI	COS, CHI	COS, CHI	COS, ARG, CHI	COS, CHI
Model 3	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
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	0.45	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	0.17	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	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	BOL	GUA

Table A. 5: Input-oriented DEA VRS Efficiency Scores Model 1

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Belize	.	.	.	.	.	.	.	.	.	.	.	.	0.57	0.54	1.00	1.00	0.49	0.49	0.54	0.48
Costa Rica	0.82	0.84	0.93	0.91	1.00	1.00	1.00	0.98	0.98	0.94	0.91	0.98	0.94	0.88	0.81	0.80	0.82	0.81	0.83	0.85
El Salvador	0.85	0.82	0.71	0.82	0.73	0.67	0.66	0.74	0.74	0.68	0.77	0.76	0.78	0.73	0.74	0.81	0.77	1.00	1.00	1.00
Guatemala	1.00	1.00	1.00	0.98	1.00	0.98	0.91	0.86	0.92	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.91	1.00
Guyana	.	.	.	.	0.68	0.57	0.62	0.59	0.55	0.65	0.66	0.74	0.73	0.80	0.70	0.63	0.54	0.57	0.51	0.51
Honduras	0.73	0.69	0.67	0.66	0.65	0.67	0.70	0.69	0.61	0.64	0.63	0.62	0.66	0.59	0.61	0.60	0.56	0.59	0.56	0.64
Mexico	1.00	1.00	0.90	0.93	0.87	0.87	0.89	0.85	0.82	0.80	0.83	0.80	0.81	0.76	0.69	0.62	0.63	0.71	0.65	0.73
Nicaragua	0.86	0.93	0.85	0.74	0.74	0.74	0.71	0.65	0.61	0.70	0.68	0.75	0.83	0.82	0.77	0.69	0.66	0.70	0.62	0.71
Panama	1.00	1.00	1.00	1.00	0.80	0.91	0.90	0.86	0.92	1.00	0.90	0.95	0.93	0.95	1.00	1.00	1.00	1.00	.	.
Suriname	.	.	.	.	.	.	.	.	.	.	.	.	.	0.42	0.36	0.45	0.40	0.45	0.41	0.34
Argentina	0.91	0.88	1.00	0.97	0.96	0.87	0.90	0.80	0.88	0.72	0.75	0.71	0.67	0.62	0.55	0.52	0.49	0.53	0.53	0.61
Bolivia	0.50	0.46	0.42	0.47	0.42	0.42	0.49	0.45	0.36	0.44	0.55	0.52	0.54	0.50	0.41	0.35	0.40	0.39	1.00	.
Brazil	0.65	0.61	0.58	0.55	0.55	0.50	0.53	0.51	0.49	0.54	0.60	0.56	0.54	0.52	0.49	0.41	0.42	0.42	0.40	0.46
Chile	0.75	0.68	0.77	0.76	0.77	0.85	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.70	0.63	0.69	0.58
Colombia	0.81	0.74	0.71	0.71	0.65	0.66	0.72	0.67	0.66	0.68	0.75	0.76	0.74	0.70	0.68	0.60	0.62	0.61	0.62	0.70
Ecuador	0.84	0.79	0.87	0.86	0.82	0.88	0.91	0.74	0.55	0.59	0.61	0.61	0.59	0.56	0.56	0.50	0.52	0.55	0.54	0.49
Paraguay	0.83	0.96	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.94	0.99	0.94	0.82	0.84	0.84	0.78	0.81
Peru	0.68	0.79	0.77	0.76	0.74	0.74	0.82	0.95	0.78	0.74	0.87	0.93	0.86	0.79	0.67	0.59	0.62	0.61	0.57	0.68
Uruguay	0.77	0.72	0.61	0.58	0.62	0.67	0.60	0.57	0.67	0.91	0.94	0.96	0.90	0.87	0.74	0.53	0.51	0.49	0.45	0.50
Venezuela	0.55	0.51	0.54	0.48	0.47	0.46	0.40	0.40	0.38	0.50	0.55	0.48	0.49	0.44	0.37	.	.	.	.	.
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
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

Table A. 6: Output-oriented DEA VRS Efficiency Scores Model 1

Country	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Belize	.	.	.	.	.	.	.	.	.	.	.	.	0.84	0.89	1.00	1.00	0.99	0.93	0.96	0.93
Costa Rica	0.81	0.81	0.97	0.90	1.00	1.00	1.00	0.98	0.99	0.96	0.94	0.99	0.97	0.94	0.91	0.96	0.97	0.95	0.93	0.95
El Salvador	0.74	0.74	0.82	0.81	0.73	0.72	0.75	0.74	0.82	0.82	0.85	0.87	0.87	0.86	0.86	0.96	0.93	1.00	1.00	1.00
Guatemala	1.00	1.00	1.00	0.88	1.00	0.85	0.88	0.86	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.96	1.00
Guyana	.	.	.	.	0.59	0.58	0.65	0.62	0.66	0.73	0.77	0.86	0.84	0.90	0.88	0.65	0.87	0.88	0.87	0.83
Honduras	0.63	0.66	0.74	0.69	0.63	0.71	0.73	0.75	0.75	0.77	0.75	0.75	0.71	0.71	0.68	0.84	0.85	0.80	0.78	0.74
Mexico	0.91	1.00	0.94	0.84	0.78	0.78	0.86	0.85	0.88	0.87	0.90	0.89	0.89	0.88	0.83	0.90	0.90	0.88	0.87	0.80
Nicaragua	0.78	0.82	0.75	0.67	0.60	0.66	0.67	0.65	0.73	0.71	0.73	0.73	0.73	0.75	0.74	0.71	0.87	0.88	0.66	0.56
Panama	1.00	1.00	1.00	1.00	0.94	0.94	0.96	0.88	0.94	1.00	0.94	0.97	0.96	0.98	1.00	1.00	1.00	1.00	.	.
Suriname	.	.	.	.	.	.	.	.	.	.	.	.	.	0.85	0.77	0.70	0.62	0.57	0.59	0.53
Argentina	0.78	0.71	0.80	0.74	0.73	0.71	0.87	0.80	0.92	0.83	0.84	0.83	0.78	0.77	0.73	0.73	0.74	0.72	0.69	0.61
Bolivia	0.72	0.72	0.82	0.80	0.72	0.76	0.80	0.78	0.70	0.82	0.85	0.90	0.90	0.90	0.92	0.90	0.93	0.87	1.00	.
Brazil	0.63	0.61	0.81	0.72	0.67	0.72	0.75	0.73	0.71	0.79	0.82	0.83	0.79	0.79	0.75	0.72	0.68	0.65	0.62	0.58
Chile	0.85	0.81	0.96	0.90	0.86	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.92	0.94	0.84
Colombia	0.59	0.54	0.63	0.61	0.58	0.71	0.76	0.77	0.75	0.83	0.84	0.87	0.85	0.84	0.85	0.87	0.82	0.78	0.76	0.76
Ecuador	0.56	0.54	0.63	0.61	0.58	0.69	0.88	0.74	0.69	0.76	0.75	0.79	0.79	0.83	0.85	0.84	0.85	0.82	0.80	0.70
Paraguay	0.58	0.65	0.63	0.68	0.69	0.75	1.00	1.00	1.00	1.00	1.00	1.00	0.84	0.89	0.85	0.67	0.78	0.78	0.84	0.78
Peru	0.69	0.68	0.77	0.72	0.72	0.79	0.86	0.95	0.84	0.86	0.92	0.96	0.92	0.89	0.86	0.86	0.85	0.81	0.81	0.84
Uruguay	0.71	0.65	0.75	0.69	0.63	0.69	0.74	0.73	0.81	0.97	0.97	1.00	0.97	0.96	0.94	0.89	0.88	0.85	0.81	0.77
Venezuela	0.52	0.57	0.59	0.51	0.51	0.59	0.64	0.63	0.65	0.73	0.69	0.69	0.66	0.65	0.59	.	.	.	.	.
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	0.10	0.10	0.10	0.10	0.09	0.11	0.12	0.11	0.12	0.13	0.15

Table A. 7: Input-oriented DEA VRS Efficiency Scores Model 2

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Belize	.	.	.	.	.	.	.	.	.	.	.	.	0.23	0.24	0.22	0.22	0.22	0.23	0.23	0.20
Costa Rica	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.88	1.00	1.00	1.00	1.00	1.00	0.97	1.00
El Salvador	0.29	0.27	0.26	0.31	0.24	0.22	0.20	0.20	0.23	0.21	0.25	0.24	0.35	0.34	0.34	0.34	0.34	0.34	0.36	0.33
Guatemala	0.38	0.39	0.40	0.44	0.39	0.34	0.30	0.33	0.39	0.35	0.44	0.49	0.69	0.70	0.71	0.72	0.71	0.74	0.71	0.59
Guyana	.	.	.	.	0.27	0.27	0.23	0.23	0.27	0.26	0.33	0.30	0.39	0.43	0.35	0.35	0.30	0.28	0.26	0.25
Honduras	0.18	0.19	0.16	0.16	0.15	0.15	0.14	0.15	0.17	0.16	0.18	0.19	0.26	0.29	0.30	0.32	0.30	0.32	0.34	0.34
Mexico	0.81	0.76	0.68	0.76	0.63	0.49	0.45	0.42	0.45	0.42	0.50	0.46	0.60	0.66	0.66	0.69	0.72	0.74	0.79	0.77
Nicaragua	0.19	0.22	0.19	0.20	0.17	0.15	0.15	0.14	0.17	0.16	0.21	0.20	0.25	0.27	0.24	0.24	0.25	0.24	0.23	0.22
Panama	0.24	0.20	0.20	0.34	0.17	0.22	0.19	0.21	0.23	0.25	0.30	0.30	0.47	0.50	0.41	0.40	0.49	0.48	.	.
Suriname	.	.	.	.	.	.	.	.	.	.	.	.	.	0.70	0.71	0.69	0.53	0.53	0.26	0.36
Argentina	0.46	0.48	0.51	0.86	0.77	0.84	0.78	0.69	0.80	0.65	0.84	0.78	1.00	0.96	0.93	0.87	0.91	0.92	1.00	0.98
Bolivia	0.36	0.36	0.30	0.33	0.27	0.26	0.23	0.24	0.38	0.33	0.38	0.39	0.65	0.69	0.54	0.43	0.44	0.44	0.40	.
Brazil	0.26	0.27	0.26	0.33	0.25	0.24	0.24	0.24	0.29	0.27	0.31	0.29	0.39	0.44	0.41	0.40	0.38	0.39	0.38	0.36
Chile	0.17	0.17	0.16	0.19	0.16	0.15	0.15	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
Colombia	0.33	0.30	0.24	0.29	0.24	0.24	0.22	0.22	0.29	0.28	0.31	0.31	0.40	0.36	0.34	0.30	0.30	0.27	0.27	0.24
Ecuador	0.65	0.63	0.50	0.57	0.42	0.39	0.35	0.32	0.31	0.31	0.38	0.37	0.42	0.38	0.35	0.33	0.33	0.30	0.30	0.29
Paraguay	0.36	0.41	0.38	0.73	0.60	0.52	0.38	0.38	0.52	0.38	0.41	0.35	0.39	0.50	0.42	0.43	0.44	0.47	0.45	0.41
Peru	0.27	0.24	0.23	0.29	0.23	0.21	0.21	0.20	0.19	0.28	0.36	0.33	0.41	0.40	0.35	0.34	0.36	0.36	0.34	0.32
Uruguay	0.26	0.28	0.27	0.32	0.28	0.28	0.24	0.23	0.25	0.24	0.28	0.24	0.30	0.31	0.29	0.28	0.25	0.24	0.24	0.22
Venezuela	0.33	0.31	0.27	0.35	0.26	0.25	0.21	0.20	0.24	0.23	0.29	0.23	0.30	0.30	0.25	.	.	.	.	.
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
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	0.21	0.21	0.21	0.22	0.23	0.23	0.23	0.23	0.24	0.26	0.26

Table A. 8: Output-oriented DEA VRS Efficiency Scores Model 2

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Belize	.	.	.	.	.	.	.	.	.	.	.	.	0.99	0.99	0.99	0.99	0.99	0.99	0.98	0.98
Costa Rica	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
El Salvador	0.98	0.98	0.98	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
Guatemala	0.97	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.98	0.98
Guyana	.	.	.	.	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	0.98	0.97	0.98
Honduras	0.97	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.98	0.98
Mexico	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	1.00	0.99	0.99
Nicaragua	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	0.97	0.98
Panama	0.99	0.98	0.98	0.99	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	.	.
Suriname	.	.	.	.	.	.	.	.	.	.	.	.	.	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Argentina	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	0.99
Bolivia	0.97	0.97	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.98	.
Brazil	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
Chile	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
Colombia	0.99	0.98	0.98	0.98	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
Ecuador	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	0.98	0.98
Paraguay	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	0.98	0.98
Peru	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	1.00	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Uruguay	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	0.99	0.99
Venezuela	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	0.98	0.98	.	.	.	.	.
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	0.97	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

Table A. 9: Input-oriented DEA VRS Efficiency Scores Model 3

Country	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Belize	.	.	.	.	.	.	.	.	.	.	.	.	0.51	0.44	0.40	0.37	0.37	0.41	0.37	0.38
Costa Rica	0.82	0.84	0.83	0.89	0.82	0.85	0.93	0.94	0.90	0.84	0.75	0.76	0.79	0.73	0.71	0.65	0.65	0.65	0.62	0.65
El Salvador	0.85	0.82	0.69	0.73	0.66	0.62	0.59	0.65	0.54	0.57	0.58	0.65	0.78	0.73	0.70	0.65	0.68	0.65	0.62	0.68
Guatemala	1.00	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00	0.91	1.00
Guyana	.	.	.	.	0.65	0.57	0.61	0.59	0.55	0.63	0.61	0.63	0.69	0.70	0.63	0.63	0.54	0.53	0.46	0.50
Honduras	0.73	0.69	0.68	0.68	0.66	0.68	0.71	0.67	0.53	0.63	0.58	0.58	0.66	0.59	0.61	0.60	0.56	0.59	0.56	0.64
Mexico	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.91	0.76	0.77	0.74	0.78	0.73	0.69	0.62	0.60	0.67	0.64	0.73
Nicaragua	0.86	0.93	0.86	0.73	0.73	0.72	0.68	0.65	0.59	0.70	0.68	0.75	0.83	0.82	0.77	0.69	0.66	0.66	0.62	0.71
Panama	0.78	0.76	0.77	0.88	0.67	0.78	0.75	0.77	0.87	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.	.
Suriname	.	.	.	.	.	.	.	.	.	.	.	.	.	0.38	0.36	0.45	0.40	0.45	0.41	0.34
Argentina	0.91	0.88	1.00	0.91	0.92	0.85	0.89	0.84	1.00	0.76	0.87	0.77	0.69	0.62	0.55	0.52	0.49	0.53	0.53	0.61
Bolivia	0.50	0.46	0.42	0.45	0.40	0.40	0.45	0.40	0.35	0.38	0.42	0.42	0.47	0.51	0.41	0.38	0.42	0.42	1.00	.
Brazil	0.65	0.61	0.57	0.52	0.53	0.47	0.48	0.45	0.41	0.46	0.44	0.47	0.54	0.52	0.49	0.41	0.42	0.42	0.40	0.46
Chile	0.69	0.67	0.64	0.70	0.69	0.74	0.83	0.77	0.64	0.59	0.62	0.65	0.66	0.67	0.62	0.55	0.53	0.54	0.51	0.55
Colombia	0.81	0.74	0.71	0.69	0.63	0.63	0.64	0.56	0.50	0.56	0.56	0.62	0.69	0.65	0.64	0.60	0.62	0.61	0.62	0.70
Ecuador	0.84	0.79	0.89	0.88	0.84	0.91	0.92	0.74	0.48	0.54	0.50	0.54	0.59	0.53	0.52	0.50	0.52	0.55	0.54	0.49
Paraguay	0.83	0.96	0.91	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.94	0.99	0.94	0.82	0.84	0.84	0.78	0.81
Peru	0.68	0.79	0.76	0.72	0.69	0.67	0.69	0.72	0.57	0.62	0.60	0.66	0.73	0.68	0.62	0.59	0.62	0.61	0.57	0.66
Uruguay	0.77	0.72	0.60	0.52	0.59	0.62	0.53	0.50	0.49	0.59	0.66	0.66	0.68	0.70	0.63	0.53	0.51	0.49	0.45	0.50
Venezuela	0.55	0.51	0.55	0.48	0.47	0.48	0.43	0.45	0.50	0.67	0.65	0.50	0.49	0.44	0.37	.	.	.	.	.
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
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

Table A. 10: Output-oriented DEA VRS Efficiency Scores Model 3

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Belize	.	.	.	.	.	.	.	.	.	.	.	.	0.31	0.31	0.32	0.32	0.29	0.32	0.42	0.48
Costa Rica	0.83	0.73	0.79	0.86	0.80	0.80	0.88	0.91	0.94	0.88	0.84	0.78	0.72	0.64	0.58	0.59	0.57	0.61	0.73	0.79
El Salvador	0.52	0.42	0.45	0.47	0.46	0.47	0.52	0.52	0.53	0.48	0.47	0.45	0.44	0.43	0.40	0.42	0.41	0.42	0.52	0.56
Guatemala	0.95	0.81	1.00	0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00	0.92	1.00
Guyana	.	.	.	.	0.36	0.31	0.40	0.44	0.45	0.48	0.51	0.52	0.49	0.48	0.49	0.43	0.42	0.43	0.54	0.65
Honduras	0.75	0.64	0.67	0.71	0.72	0.77	0.77	0.78	0.78	0.75	0.74	0.67	0.59	0.55	0.51	0.51	0.48	0.52	0.65	0.73
Mexico	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.86	0.86	0.76	0.70	0.66	0.63	0.68	0.64	0.66	0.81	0.81
Nicaragua	0.55	0.49	0.47	0.53	0.55	0.51	0.53	0.53	0.59	0.53	0.55	0.53	0.53	0.56	0.49	0.54	0.56	0.61	0.64	0.53
Panama	0.76	0.67	0.65	0.68	0.68	0.70	0.78	0.89	0.98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.	.
Suriname	.	.	.	.	.	.	.	.	.	.	.	.	.	0.67	0.65	0.56	0.43	0.37	0.46	0.37
Argentina	0.62	0.52	0.35	0.33	0.45	0.61	0.74	0.85	1.00	0.90	0.92	0.84	0.72	0.67	0.61	0.66	0.50	0.46	0.50	0.34
Bolivia	0.79	0.64	0.64	0.65	0.63	0.66	0.69	0.69	0.76	0.76	0.77	0.77	0.78	0.88	0.92	0.87	0.82	0.83	1.00	.
Brazil	0.55	0.44	0.47	0.47	0.55	0.58	0.59	0.62	0.64	0.64	0.65	0.62	0.58	0.57	0.55	0.49	0.35	0.30	0.33	0.25
Chile	0.89	0.72	0.71	0.72	0.75	0.82	0.85	0.85	0.87	0.81	0.79	0.74	0.69	0.70	0.70	0.71	0.66	0.64	0.75	0.71
Colombia	0.48	0.36	0.36	0.38	0.45	0.55	0.59	0.62	0.63	0.62	0.60	0.58	0.53	0.53	0.57	0.55	0.54	0.52	0.64	0.66
Ecuador	0.45	0.40	0.45	0.47	0.55	0.73	0.78	0.68	0.69	0.69	0.64	0.63	0.62	0.68	0.69	0.66	0.60	0.56	0.63	0.53
Paraguay	0.56	0.38	0.35	0.41	0.50	0.59	0.72	1.00	1.00	0.87	1.00	1.00	0.81	0.96	0.86	0.75	0.67	0.71	0.85	0.77
Peru	0.58	0.43	0.48	0.49	0.55	0.59	0.64	0.69	0.71	0.70	0.73	0.69	0.66	0.66	0.63	0.62	0.58	0.59	0.72	0.71
Uruguay	0.55	0.44	0.27	0.21	0.25	0.40	0.48	0.59	0.74	0.79	0.83	0.78	0.76	0.77	0.77	0.69	0.61	0.59	0.67	0.58
Venezuela	0.59	0.49	0.37	0.14	0.42	0.63	0.71	0.75	0.91	0.99	0.81	0.70	0.63	0.56	0.47	.	.	.	.	.
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	0.17	0.16	0.16	0.17	0.18	0.19	0.18	0.19	0.20	0.18	0.19