DETERMINANTS OF EFFICIENCY IN EDUCATION IN PUBLIC EXPENDITURE: A CROSS-COUNTRY PERSPECTIVE

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ABSTRACT:

This research aims to identify and analyse the variables that affect the efficiency of public spending in secondary education, in a cross-country perspective. Using Data Envelopment Analysis, Malmquist Index, and Panel Data Regression, we analyzed data from 65 countries that undertook the PISA examination. The results demonstrate that Brazil was the most inefficient in applying its resources over the period and achieved only 84.3% of its potential outputs. Finally, the significant variables in explaining the efficiency were the natural logarithm of the GDP per capita, the curriculum autonomy of schools, financial autonomy, and the level of corruption and the socioeconomic backgrounds of students.

Keywords: Efficiency of Public Expenditure; Panel Data Analysis; Malmquist Index; Cross-country Analysis; PISA exam.

1 INTRODUCTION

For decades, governments have emphasized the importance of education. In addition, the expansion of societies is partially explained by the accumulation of human capital, mainly provided by education. Increase the efficiency level of education spending has become a goal in government programs in several countries. At the same time, education systems are subject to measures intended to contain expenditure and improving educational outcomes (Giménez, Prior & Thieme, 2007). In 2006, the *European Expert Network on Economics of Education* report highlighted that the efficiency should be one of the main objectives of European education systems (OECD, 2014).

To measure the efficiency of an educational system, it is necessary to have a better understand its complex characteristic. In order to characterize the essential aspects and adequately measure the efficiency, it is necessary to think about inputs and outputs. Outputs are results such as school grades and service

rates. In addition, inputs consist of supplies that can affect outputs, such as tax proceeds, classroom sizes and hours in the classroom.

Every three years, students from several countries take the PISA (Programme for International Student Assessment). The goal of this exam is to evaluate educational systems in the world through a series of tests in subjects such as reading, mathematics, and science.

This research aims to identify and analyze the variables that affect the efficiency of public spending in high school in countries that have taken the PISA exam. We analyzed a group of 65 countries over 8 years. The variables identified were analyzed by a set of multivariate statistical methods. The methods used were Data Envelopment Analysis (DEA), Malmquist Index, and Regression using panel data. By means of linear scheduling problems, the DEA aims to know the Decision Making Units (DMU), which are able to maximize the production of outputs with a certain level of inputs. The method also allows minimizing the supply of inputs, keeping the quantity of outputs constant. The results can be compared to an efficiency frontier formed by the best practices of their peers.

Data Envelopment Analysis (DEA) is a technique based on linear programming designed to measure the performance of decision-making units (Senra et al., 2007). The concept of efficiency usually considered in DEA is the best form of converting inputs to products or outputs. Such outputs, or results, are related to the operational scale and management capacity of a decision-making unit (DMU), taking into consideration its production frontier. Thus, the efficiency frontier is empirically estimated based on the analyzed DMUs (Joro & Korhonen, 2014). Agasisti (2014) summarizes the technical efficiency measured by DEA as the capacity of a DMU in producing outputs, considering the existing inputs constraints.

In addition to the existing convexity, the DEA model usually assigns weights freely to each input or output so as to maximize the DMUs' productivity (Agasisti, 2011). The weights used are converted into a single virtual input or virtual output. The reason of both these items result in the efficiency associated to the DMU. The result of the virtual input or output determines the DMU's relative efficiency. The technique used is an attempt to find the best virtual unit for each real unit (Aristovnik & Obadic, 2014) in education.

Thus, the work emphasize the importance of controlling public spending, and identifies the variables that affect efficiency in education. Considering the role of education as a driver of economic growth, the research highlights that the results of countries have used expenditures efficiently, with transparency, and the impact that external variables have presented on this efficiency in education outcomes.

2 LITERATURE REVIEW: CROSS COUNTRY COMPARATIVE ANALYSIS ON EFFICIENCY OF EDUCATION EXPENDITURE

Most of the empirical studies that analyzed the education efficiency, with the assit of the DEA on a cross-country scale, had as sample the developed countries or a combination of developed and developing countries. The predominance of studies with these samples are justifiable due to the lack of information on developing countries.

According to Agasisti (2014), attempts to identify viable methods for comparing efficiency among different teaching institutions involving countries were not so popular in the past. There were problems related to the comparability, homogeneity and robustness of data in the conduct of studies among countries. However, these problems seem smaller nowadays, since annual bases such as Education at a Glance, promoted by the OECD , has as its goals to collect data from different education systems and make them comparable (Agasisti, 2014).

Clearly, the vast majority of studies on efficiency of education have used public expenditure in this sector as *input*, and proficiency tests as output. Some other variations, such as the work of Giménez, Prior and Thieme (2007), used the hours taught, the facilities available, the materials consumed and the quality of the teachers as input variables. However, all variables are directly linked to the amount of resources applied in the system, except for the quality of teachers. For this reason, it was decided to use expenditures as a plausible educational input.

Other scientific works (Agasisti & Johnes, 2009; Agasisti, 2011) were directed to the analysis of the efficiency of universities, from a cross-country perspective. The vast majority of these works were performed at universities in Europe.

Following are the main studies (Aristovnik & Obadic, 2014; Agasisti, 2014; Cuellar, 2014; Coco & Lagravinese, 2014; Fonchamnyo & Sama, 2016) who guided the choice of variables used in the present research.

Aristovnik and Obadic (2014) analyzed efficiency through the DEA (VRS oriented by output) of OECD and European countries, with a special focus on Slovenia and Croatia in the period 1999-2007. For this, they created four models with different inputs and outputs. Model 1 used as input the Public expenditure by high school student, as % of GDP per capita and as outputs the primary school enrollment rate, in % of the total, the average of the PISA exam in 2006; And the teacher / High Scholl student ratio. In Model 2, the teacher / High Scholl student ratio was used as input; And the other variables remained. In Model 3, the teacher/High Scholl student were used as input, and as an output, the average of the PISA was used in 2006 and the service rate colleges, in% of the total. In model 4, in turn, the primary education serve rate, in% of the total was used as input, and as outputs were used the average of the PISA exam , in 2006 the service rate of college, in% of the total.

Agasisti (2014) conducted an empirical study using the DEA (VRS oriented by output), comparing the efficiency of public spending with education in 20 European countries during the period from 2006 to 2009. The average ability of 15 years old students is used as an output of the educational process and, measured by means of the grades of the PISA exam in mathematics in the 2006 and 2009 editions. The expenditure per student in PPP in US $, as a proxy for the investment destined to education; And the teacher / student ratio as a proxy for the intensity of the educational process and the human resources involved in that process were used as input.

Cuellar (2014) covered emerging countries. This study examined the efficiency of public spending in achieving universality primary education and quality secondary education. Through the DEA and the FDH (input and output orientation, with particular attention to the output orientation), he analyzed 15

Latin American countries between 2000 and 2009 (average for the period), based on data from Unesco, EdStats (World Bank Education Statisticians), and OECD data. Cuellar (2014) analyzed in particular the characteristics of education in Colombia and looked for comparing them with their efficient peers, in order to identify the best practices of these countries.

Fonchamnyo and Sama (2016) analyzed with the assistance of the DEA (VRS with an output orientation) the efficiency of public spending, from 2000 to 2012 on education and health in three African countries: Cameroon, Central African Republic and Chad. In addition, the factors influencing this efficiency were analyzed. The outputs for education were i) service rate; And (ii) literacy rate in % of people over 15 years old. For health, the outputs used were the mortality rate, life expectancy, and immunization rate. In the second stage, the authors used as independent variables: i) the inflation rate; ii) economic growth - measured by GDP growth; (iii) market opening - measured by the sum of total exports and imports divided by GDP; (iv) the growth of international reserves; V) financial management measured by the country's CPIA Index; vi) the country's level of corruption, measured by the Corruption Perception Index (CPI), as a proxy for the level of corruption in the country. All data were collected from the World Bank's World Development Indicator (WDI) database.

Addressing an unprecedented variable, Coco and Lagravinese (2014) studied the impact of sponsorship and corruption on the efficiency of the education system in 34 OECD countries. Sponsorship was measured by an index that measures the perceived relevance of hard work in relation to the personal connections that determine the success in people's lives developed by the World Value Survey (WVS). The DEA (VRS, output orientation) was used to measure the inefficiency of educational systems based on the PISA score.

In the research of Coco and Lagravinese (2014), developing countries such as Poland, Mexico and Chile were inefficient. The three efficient countries by the DEA were South Korea, Slovak Republic and Turkey, and the most inefficient were Spain, Italy, Chile and Israel. For the second stage, the authors present three format specifications through truncated regression and bootstrap. In the first specification (Model A), all variables were used and five of them were significant: sponsorship; Parenting schooling; Relative income and share of immigrant parents. In Model B, the binary variables were excluded, and the same variables of Model A were significant. For Model C, were excluded the variables "room size" and "difference in unemployment rates", both insignificant in the first two models, Thus, Model C presented all the remaining variables as significant, indicating that there is a strong relationship between socioeconomic variables and inefficiency scores. It is perceived that sponsorship is always significant, even with different format specifications.

3 RESEARCH METHOD

The research was carried out with a population of 65 countries that undertook in the PISA Exam. PISA examines reading, math and adolescent science skills. The period analyzed was between the years 2004 to 2012. The criterion for the country to be part of the sample was to have participated in the all examinations of PISA in this period.

The sample was grouped into three clusters. We followed the procedure suggested by Agasisti (2014) and used averages grouped for periods of three years. The reasons are as follows: one of the output variables is collected only every three years (PISA), so the inputs should be aligned as a three years window; we minimize the impact of potential measurement errors; how education is cumulative, to consider the role of input in a period of three years on the output , we can partially capture such characteristic. This average was performed for all inputs, outputs and independent variables.

The PISA Exam scores for each country were obtained directly from the OECD website. The OECD provides a range of academic and financial information, both students and their families. The data are obtained through questionnaires applied together with the tests. We also collect data from the World Bank, UNESCO Institute for Statistics, and Transparency International.

In order not to affect the statistical analysis, due to variations among countries, we transform the GDP per capita variable into its natural logarithm.

All data were organized and tabulated using Excel® software. Statistical tests, Malmquist Index and regression with panel data were performed on Stata®. The efficiency scores of the DEA were obtained using SIAD software v.3.0.

3.1 First stage: dea models and malmquist index

Based on the theoretical reference, we developed a DEA model with the following variables.

a) PUBLIC EXPENDITURE ON EDUCATION: Public spending is the most important tool that governments have to expand educational outputs and raise the education level of the population. In this survey, we collected expenditure data per student in secondary education, converted into US$. This variable was used as input in the measurement of efficiency. According to Cuellar (2014), the use of public spending on these metrics makes the analysis comparable and which is still controlled by the size of the educational system.

b) PISA EXAM: Hanushek and Kimko (2000) and Lee and Barro (2001) pioneered the use of cognitive tests as a proxy for the quality of education and human capital in a country. We use the variable (PISA) as an educational output. It should be noted, however, that PISA score used in the present study is an average of the three tests (reading, mathematics and science). This variable can be interpreted as the quality of human capital that a country is developing.

c) SECONDARY EDUCATION NET TAX RATE: the attendance rate is commonly used to understand the government's ability to provide education age groups. Several studies have already used this rate as an output (Gupta, Verhoeven, 2001; Agasisti, 2011; Aristovnik, Obadic, 2014; Cuellar, 2014) at different levels of education. Thus, the variable (RATE) was used as the second output in the measurement of efficiency through the DEA. This variable is collected annually by UNESCO.

We developed a DEA model with the GPE input variable, which represents the investments made by each country. The output variables were PISA and RATE. The first represents the quality of education, and the second, the reach of high school attendance. In the present research, we used the VRS Data Envelopment Analysis model. We consider that the efficiency of the

educational system of the countries is influenced by variables such as the number of students and the amount of resources invested. Therefore, the return of the results in education should vary according to these different schedules (Agasisti, 2011). The choice is consistent with several cross-country studies for the analysis of the efficiency of spending on education (Agasisti, 2011; Aristovnik & Obadic, 2014; Fonchamnyo & Sama, 2016).

The efficiency found in the present study varies from (0,1).The Decision Making Units (DMUs) that has scores between 0 and 1 are considered inefficient, and the DMUs that has score 1 are considered technically efficient. The scores obtained in the application of the DEA are interpreted as follows: when a DMU scores 0.7, it means that the unit has only 70% of the total production output required to make it efficient, in which case there is room for managerial improvements in that DMU . The Decision Making Units (DMUs) that score 1 are considered technically efficient. The DMU of this research is the educational system (high school) of a country. The input reflects the amount of resources invested in education. Thus, this method allows the efficiency of countries in transforming public investments into educational outcomes (quality and service).

In the first stage, the Malmquist Index DEA was used to measure the changes of productivity and the efficiency in the periods understood by the research. The Malmquist Index applied to the DEA has analyzed every two periods. Its use to evaluate changes in efficiency for over .Since the scores obtained through the DEA are relative and vary from sample to sample. If the periods were analyzed in isolation, the conclusions could be imprecise.

Thus, it can be seen that three distinct indices are presented by the Malmquist Index for each country: one that measures the changes in productivity and efficiency in the periods from (2004-2006) for the period (2007-2009), another that measures these changes from the period (2004-2006) to (2010-2012), and the last one that measures the change from the period (2007-2009) to (2010-2012). However, it should be emphasized that, as well as the procedure performed in the calculation of the efficiency of the DEA in the Malmquist Index, averages were also performed within the periods for the variables that are collected annually (GPE and RATE).

3.2 Second stage: panel data regression

The DEA (VRS) takes into account only supplies that the manager has control and can be altered by management. However, in the case of services provided by the public sector, many factors that are beyond government control, at least in the short and medium term, can affect the efficiency of these systems. Thus, it is important that the exogenous factors related to the initially estimated efficiency scores be investigated.

Understanding the characteristics of data that are organized in cut-off data and also in time-series data, it was decided to perform a regression of those in panel to find the influence of independent variables on the efficiency of high school. The regression models for panel data are very useful for studying the behavior of a given phenomenon that changes between individuals or organizations and simultaneously on a temporary basis.

The following are all the independent variables that make up the regression model.

a) Student /Teacher Ratio:considered the most important non-monetary input (Cuellar, 2014). The teacher/ student ratio can be understood as the amount of human capital involved in the education process. Hanushek and Kimko (2000), Hanushek and Luque (2003), Afonso and Aubyn (2006), Agasisti (2011), Cuellar (2014), Agasisti (2014), Aristovnik and Obadic (2014) have already used this variable to evaluate educational efficiency. Thus, the variable was used as one of the independent of the model. It was calculated by the number of students per teacher relative to secondary school students and collected annually by UNESCO.

b) TEACHER QUALITY: the studies of Agasisti (2014) and Alexander, Haug and Jaforullah (2010) found a positive relation between the quality of teachers and the efficiency of teaching systems, however Giménez, Prior, Thieme (2007) did not find significance in their results. Thus, they chose to use full-time teachers' salaries as a variable independent of the second stage of the research. This variable was collected in the database of the World Bank and has an annual periodicity.

c) STUDENT QUALITY: Rich (2006), Johnes (2006), and Agasisti (2011) identified that the learner's commitment has an important contribution to academic performance. The variable (ALUN) was collected in the OECD database. It is a variable independent of our regression model.

d) BACKGROUND FAMILY (BACK): several academic studies (Hanushek & Kimko, 2000; Hanushek & Luque, 2003; Lee & Barro, 2001; Afonso & Aubyn, 2006) found significance between school performance and this family background. To identify the background, we use the PISA Economic, Social and Cultural Index.

e) COMPUTERS : Mancebón et al. (2012) found statistical significance between learning and use of technologies. In this research, we used the amount of computers per student in the schools (COMP) as a variable independent of the regression model of the panel data. This variable was also collected in the OECD database.

f) CORRUPTION AND GOVERNANCE: The Corruption affects the efficiency of the educational system (Coco & Lagravinese, 2014). For the variable Corruption, we use as proxy variable the Corruption Perception Index (CPI) (Fonchamnyo & Sama, 2016). Closely related to corruption is the concept of governance and transparency. The variables that reflect the Governance were "School Accountability Index in Resource Allocation" (RECUR) and the "School Accountability Index in Curricular Organization and in the School Evaluation System" (Manricbón et al., 2012).).

g) UNEMPLOYMENT: Agasisti (2014) and Coco and Lagravinese (2014) did not find a significant relation between the efficiency and unemployment of the countries analyzed. The unemployment rate used is calculated in relation to the total workforce that is currently unemployed and looking for work and is collected annually by the World Bank.

h) GDP per capita: Agasisti (2011), Afonso and Aubyn (2006) found a significant relationship between GDP per capita and efficiency. In the present research, it was decided to use GDP per capita as a possible explanatory variable

for the efficiency of the secondary education in the countries analyzed. The World Bank collects this variable annually.

3.3 Construction of the panel data regression model

Some of the variables that were used in the second stage of the research could have been used as educational inputs. However, since the interest of the research is to find efficiency in the application of resources invested in the high school, the insertion of these variables into the DEA model would make it difficult to interpret these results. In addition, the greater the number of inputs and outputs inserted into the DEA, the greater the number of efficient DMUs. It was considered more interesting to use these variables as independent in the second stage and to know if they influence the efficiency of these systems.

The dependent variable of the panel data regression is the efficiency score, obtained through the DEA (VRS), with output orientation, in each of the analyzed periods. In the present research, the regression method with short panel data was used, since the number of countries in the sample exceeds the number of periods of the analysis. In addition, it is an unbalanced panel, since some variables for some countries are absent in some periods. The general expression of the panel data regression model is:

$$EFI_{it} = a_i + b_1 RAZAP_{it} + b_2 PROF_{it} + b_3 ALUN_{it} + b_4 BACK_{it} + b_5 COMP_{it} + b_6 CORR_{it} + b_7 CURRIC_{it} + b_8 RECUR_{it} + b_9 DESEMP_{it} + b_{10} lnPIBPC_{it} + \varepsilon_{it}$$

EFI_{it} represents the dependent variable (efficiency score that varies between individuals and was obtained in the first stage of this research over time); a_i represents the term of the intercept of each individual, and may assume fixed or random effects; b_j (j = 1,2, ..., k) are the coefficients for each variable; X_j (RAZAP, PROF, ALUN, BACK, COMP, CORR, CURRIC, RECUR, DESEMP, PIBPC) are the independent variables and ε represents the terms of the idiosyncratic error.

In order to know the best estimators for the Pooled Ordinary Least Squares (POOLS) fixed effects or random effects, had been made: the Chow F, the Brem-Pagan LM and the Hausman tests. The level of significance was set at $p < 0.05$ for the interpretation of the tests performed.

In the POOLS model, the parameters are estimated by the Ordinary Least Squares method (OLS) and consider the database as a large cross-section. Fixed-effects estimation, however, considers the existence of individual effects a_i (i = 1, 2, ..., k), where i is the number of individuals analyzed, representing the heterogeneity among individuals and capturing their invariant differences in time, that is, differences in intercepts (not slopes). The estimation by random effects is performed through the Generalized Least Squares. This estimation considers simultaneously the variation over time for a given individual (within variation) and the variation between individuals (between). Thus, the variation between individuals is considered random and uncorrelated with the explanatory variables.

We applied the Breush-Pagan test to verify if the variance between individuals is equal to zero, that is, if there are no significant differences between the countries analyzed. The following hypotheses has presented H_0: POLS, that

is, there is not panel effect; H_1: the effects are random (there are statistically differences between individuals in the sample). The second test to identify the best estimators for the model is Chow's F. The hypotheses of this test are presented below H_0: restricted model (POLS); H_1: the effects are fixed. The third and last applied test was the Hausman test, to determine if fixed or random effects should estimate the model. The hypotheses has presented below H_0: the effects are random; H_1: the effects are fixed. The results of the tests to define the most adequate estimator are in Table 1.

Table 1 - Identification of the most consistent estimators

Tests	**Significance**	
	Specification 1 Dependent: EFI (Model with all variables)	**Specification 2 Dependent: EFI (Model without the variable Teacher)**
Breusch-Pagan	0,0005	0,0002
F Chow Test	0,0000	0,0000
Test of Hausman	0,9014	0,2250
Indicated Estimator	**RANDOM EFFECTS**	**RANDOM EFFECTS**

Source: developed by the authors.

Thus, the Breusch-Pagan test allowed us to identify that the POLS model does not provide the most appropriate estimators for the Model 1 and 2 Specifications. The Chow F test also allows rejecting the void hypothesis that all individual effects ai from the countries are equal to zero. Thus, Hausman test showed that the random effects model provides the parameter estimators more consistent than the fixed effects model (it is not possible to reject H_0).

Finally, Table 2 shows a summary of the variables used in panel data regression and also the expected signal for each of the independent variables used in the second stage.

Table 2 - Expected signs for the independent variables

Variable	**Brief description**	**Expected Sign**
EFI	Dependent variable. It is obtained by the DEA model carried out in the first stage for each period (2004-2006, 2007-2009, 2010-2012).	n.a.
RAZAP	The division between the school Size and the number of teachers..	-
ALUN	The student quality measured by means of the "Index of interest in Science, Mathematics or Reading".	+
BACK	Students' background measured by the PISA Index of economic, social and cultural status.	+
COMP	Computers available per student in schools.	+
CORRUP	Proxy of corruption measured by the CPI.	+
RECUR	School governance measured by the " Index of responsibility in the resources allocation ".	+
CURRIC	School governance measured by the "Index of	+

	autonomy in the curricular organization and in the assesment system of each school".	
PROF	Quality of the teacher measured by means of the salaries noticed by the secondary education teachers.	+
DESEMP	Unemployment rate as % of total labor force.	-
lnPIBPC	GDP per capita. Proxy for relative income of the population.	+

Note: n.a. = not apply
Source: developed by the authors.

Based on Table 2, we can see that only two variables are expected to have negative signals (RAZAP and DESEMP). This is because classes with fewer students per teacher are expected to be more effective. Furthermore, it is believed that the unemployment rate has an inversely related to the efficiency of the high school.

4 RESULTS AND DISCUSSION

4.1 Efficiency analysis of spending on education with data envelopment analysis (VRS)

The efficiency scores were obtained for each period. As the period 2010-2012, the closest and that could bring more relevant information, the targets to be reached (for the outputs) by each country were only presented for this triennium. Thus, for the other periods, only the efficiency indexes are presented.

As suggested by Agasisti (2011), a test was performed to check the robustness of the scores obtained in this stage. Hong Kong (the most efficient DMU) and Brazil (the less efficient DMU) were removed from the sample in the 2010-2012 period, and a new DEA model was generated. Then, correlation tests were performed with the two samples. The results showed a correlation of 0.99. This indicates that the efficiency / inefficiency of the countries was not strongly altered by the subtraction of the most and less efficient DMUs, which shows the robustness of the results.

Table 3 shows the efficiency results obtained through the application of DEA. In addition to efficiency in the three periods of analysis, the targets (from PISA and RATE) to be achieved by inefficient countries in the 2010-2012 period are also evident. This Table 3 is also useful to demonstrate which countries were part of the analyzes in the different periods.

Table 3 - DEA efficiency analysis in all countries (RSV - output orientation)

	2010-2012 (n = 38)			2007-2009 (n = 33)	2004-2006 (n = 31)
DMU	**EFI**	**Target PISA**	**Target RATE**	**EFI**	**EFI**
HON	1	-	-	1	0,996
IND	1	-	-	1	-
IRE	1	-	-	0,993	0,956
ISR	1	-	-	1	1
JAP	1	-	-	1	1
PER	1	-	-	1	-
POL	1	-	-	1	1
SER	1	-	-	1	-
EST	0,994	532,07	91,63	0,953	1
LIT	0,992	490,22	93,66	0,981	1
HUN	0,983	493,96	93,61	0,971	0,957
FRA	0,981	527,94	99,25	0,987	0,97
FIN	0,975	544,64	95,32	1	1
NEW	0,972	522,89	98,43	-	-
SPA	0,961	540,76	99,06	0,950	0,940
LAT	0,960	516,45	90,34	0,947	-
NOR	0,958	514,67	99,44	0,985	0,973
NET	0,955	546,11	93,81	0,954	0,947
ITA	0,953	536,64	98,98	0,954	0,926
THA	0,951	458,46	91,59	1	-
MAC	0,947	556,66	82,98	-	-
AUS	0,947	541,16	91,1	0,955	0,958
SWI	0,944	552,37	87,38	0,9503	0,929
SLO	0,941	539,4	99,08	-	-
UNK	0,935	538,43	99,1	0,942	0,959
CHI	0,934	465,23	94,14	0,978	-
SWE	0,929	518,35	99,39	0,988	1
BUL	0,923	478,34	91,94	0,916	0,994
DEN	0,921	541,61	98,42	0,922	0,934
CYP	0,906	512,66	99,47	-	-
ICE	0,905	536,26	97,96	0,924	0,920
USA	0,903	542,42	97,6	0,920	0,916
LUX	0,901	544,13	95,84	0,886	0,877
MEX	0,895	463,84	91,47	0,924	0,967

	2010-2012 (n = 38)			2007-2009 (n = 33)	2004-2006 (n = 31)
DMU	**EFI**	**Target PISA**	**Target RATE**	**EFI**	**EFI**
COS	0,879	478,37	91,16	-	-
COL	0,867	448,97	91,82	0,915	1
MAL	0,845	494,78	90,81	-	-
BRA	0,843	473,62	92,8	0,865	0,977
BEL	-	-	-	-	0,923
GRE	-	-	-	-	0,906
JOR	-	-	-	-	1
KOR	-			1	1
POR	-	-	-	-	0,871
Average	**0,947**	**515,047**	**94,586**	**0,962**	**0,961**

Note: n = Number of countries with available data.
Source: developed by the authors, based on the research data.

Israel, Japan and Poland were efficient in all three periods of analysis. Israel and Poland are countries that spend relatively little and obtain satisfactory outputs compared to other countries. In the period 2010-2012, for example, Israel spent US$ 4730.42 per student, placed 97.8% of adolescents with adequate age in high school and managed to achieve 470 points in the PISA exam. The United States, for example, spent US$ 11459.46 per student (more than double Israel), obtained a net attendance rate of 88.17% and a PISA grade of 490. Inefficient by the DEA model.

In the period 2010-2012, Brazil was the most inefficient country in the application of its resources. With the current levels of investments, the country should reach 473 points in the PISA exam and has a net attendance rate of 92.8%. The benchmarks for Brazil of this period went to Japan, Poland and Serbia, the latter being the most representative benchmark. Thus, in order to reach the necessary targets, Brazil should seek to know the initiatives that these countries implement. Some of the 473 points on the PISA exam were Israel, Switzerland, Ireland and Hungary (470, 481, 485 and 485, respectively). For RATE, the United Kingdom, Lithuania and Finland are the closest countries to the target (92.64%, 92.92% and 92.94%, respectively). Understanding how these countries organize high school and how to manage this system may be important for Brazil to use as example and improve its efficiency.

4.2 Efficiency changes with the malmquist index dea

To better capture productivity changes and understand their trends, the Malmquist Index DEA was applied for the entire time series, from 2004 to 2012. The results of the model are presented in Table 4.

Table 4 - Malmquist with output orientation (2004-2006 → 2010-2012)

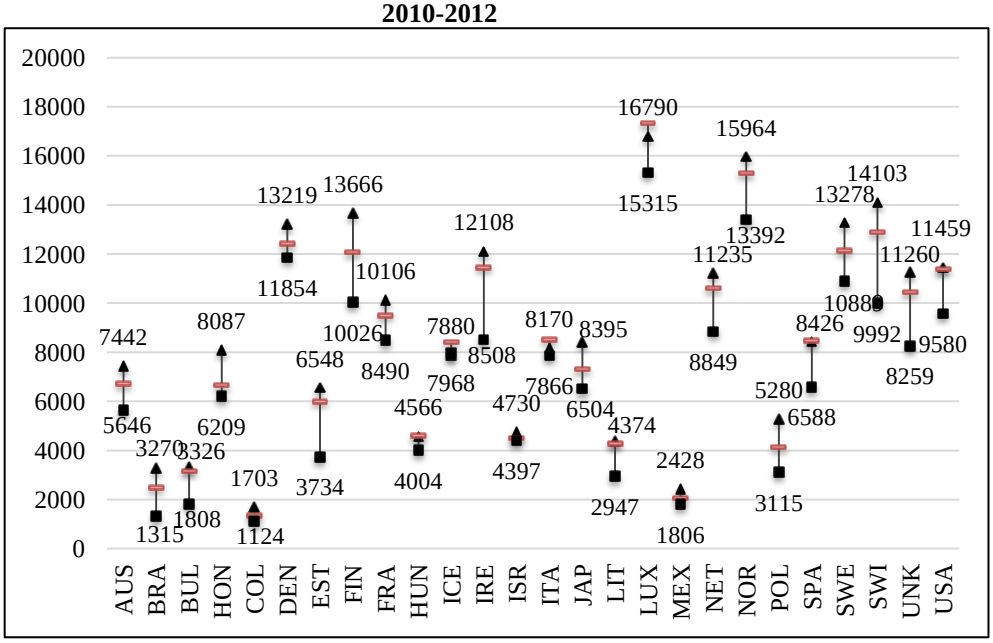
DMU	MALMQ	TECHCH	EFFCH	PECH	SECH
BRA	2,346	1,346	1,743	1,117	1,560
BUL	1,822	1,304	1,397	1,016	1,375
EST	1,737	1,458	1,191	1,006	1,184
POL	1,662	1,450	1,146	1,000	1,146
LIT	1,514	1,313	1,154	1,000	1,154
FIN	1,417	1,480	0,957	1,026	0,933
SWI	1,391	1,482	0,939	0,985	0,953
UNK	1,373	1,390	0,988	1,026	0,963
IRE	1,373	1,371	1,001	0,956	1,047
COL	1,369	1,369	1,000	1,000	1,000
AUS	1,338	1,482	0,903	1,035	0,872
MEX	1,325	1,482	0,894	0,972	0,920
SWE	1,294	1,330	0,973	1,076	0,904
NET	1,269	1,482	0,856	0,998	0,858
HON	1,267	1,482	0,855	1,000	0,855
JAP	1,260	1,383	0,911	1,000	0,911
SPA	1,246	1,327	0,939	0,977	0,961
USA	1,197	1,411	0,848	1,014	0,837
NOR	1,193	1,320	0,904	1,015	0,891
FRA	1,177	1,324	0,889	0,989	0,899
HUN	1,134	1,390	0,816	0,968	0,843
DEN	1,119	1,425	0,785	1,014	0,774
ISR	1,097	1,264	0,868	1,000	0,868
LUX	1,079	1,475	0,732	0,974	0,751
ITA	1,002	1,331	0,753	0,972	0,775
ICE	0,998	1,427	0,700	1,018	0,687
Average	**1,346**	**1,396**	**0,967**	**1,006**	**0,958**

Source: developed by the authors, based on the research data.

Using the Malmquist Index for the period 2004-2006 compared to the last period (2010-2012), it is to say that Brazil had a 134% gain in its total productivity, followed by Bulgaria, Estonia, Poland and Lithuania. With the exception of Brazil and Bulgaria, technological advances better benefited the productivity of all these countries in the period than by improvements in their relative efficiencies.

Another evidence that could be made to compare productivity changes is in relation to the expansion or retraction of investments by students made in the period (see Graph 1).

Graph 1 - Changes in the GPE in the period 2004-2006, 2007-2009 and 2010-2012



Note: ▲= 2010-2012 period ; ■ = 2004-2006 period; - = 2007-2009 period.
Source: developed by the authors, based on the research data.

During the periods 2004-2006 and 2010-2012, some countries like Switzerland, Finland or Ireland had an increase in monetary terms (US$ 4111, US$ 3640 and US$ 3600, per student, respectively). However, because they are countries with a well-developed education system, the returns on these investments grow slower, as they are close to ideal levels. In this way and analyzing the EFFCH, we noted that Finland and Switzerland had a management loss, and Ireland practically maintained its efficiency unchanged.

On the other hand, Brazil, Bulgaria, Estonia and Poland were the countries that increased the investments as a percentage terms. Still, these were the only countries that achieved improvements in their technical efficiency between these two periods. The relation opposite presented in the previous paragraph can explain this. These countries still have room for improvement in their educational outputs, and increased investment translates into educational outcomes more quickly.

4.3 Results of the second stage: regression with panel data

The regression model with panel data had as objective to know the intensities of the variations that can occur in the dependent variable and the explanatory variables. This premise is valid for variations over time (within variation), like the variations between individuals (variation between). The overall variance consists of the existing discrepancy of a certain country at an instant of time relative to all other data from the same variable for the complete base. These variations are shown in Table 5.

Table 5 - Description of variables and decomposition of variations between and whitin

Variable	Decomposition	Average	Standard deviation	Minimum	Maximum	Observations
COUNTRY	*overall*	22,17	12,46	1,00	43,00	N = 102
	between		12,56	1,00	43,00	n = 43
	within		0,00	22,17	22,17	T-bar = 2,37
YEAR	*overall*	2009,2	2,47	2006	2012	N = 102
	between		1,55	2009	2009	n = 43
	within		2,22	2006	2012	T-bar = 2,37
EFI	*overall*	0,96	0,04	0,84	1,00	N = 102
	between		0,04	0,84	1,00	n = 43
	within		0,02	0,90	1,04	T-bar = 2,37
CORR	*overall*	64,50	20,93	25,67	96,33	N = 101
	between		20,42	27,88	93,55	n = 42
	within		2,37	54,29	74,23	T-bar = 2,40
BACK	*overall*	-0,19	0,55	-1,80	0,78	N = 102
	between		0,56	-1,68	0,76	n = 43
	within		0,06	-0,37	0,00	T-bar = 2,37
COMP	*overall*	0,47	0,31	0,00	1,53	N = 100
	between		0,24	0,06	1,02	n = 43
	within		0,22	-0,17	1,04	T-bar = 2,32
PROF	*overall*	28781,17	14803,72	1828,80	74481,44	N = 71
	between		14373,32	1833,63	72943,56	n = 28
	within		1882,70	23449,50	33446,18	T-bar = 2,54
RECUR	*overall*	0,03	0,57	-1,05	1,64	N = 100
	between		0,57	-1,05	1,64	n = 43
	within		0,25	-0,96	0,78	T-bar =

Variable	Decomposition	Average	Standard deviation	Minimum	Maximum	Observations
						2,32
CURRIC	*overall*	0,00	0,62	-1,34	1,15	N = 100
	between		0,62	-1,34	1,11	n = 43
	within		0,19	-0,41	0,60	T-bar = 2,32
RAZA	*overall*	14,57	5,43	7,94	31,42	N = 100
	between		5,24	7,94	29,86	n = 43
	within		0,78	12,27	17,01	T-bar = 2,32
ALUN	*overall*	0,10	0,27	-0,33	0,91	N = 102
	between		0,27	-0,32	0,91	n = 43
	within		0,12	-0,27	0,40	T-bar = 2,37
DESEMP	*overall*	7,46	3,90	0,80	22,37	N = 102
	between		3,58	1,05	19,07	n = 43
	within		1,84	2,25	14,92	T-bar = 2,37
LNPIBPC	*overall*	10,19	0,58	8,92	11,64	N = 102
	between		0,60	9,00	11,64	n = 43
	within		0,10	9,93	10,42	T-bar = 2,37

Source: developed by the authors, based on the research data.

With the information in Table 5, it is possible to notice that the variable YEAR has variation between non-zero, and this reinforces that this is an unbalanced panel. Another detail is that all variables (with the exception of the YEAR variable) have a variation between greater than the within variation, reinforcing the thesis that the fixed effects model is not suitable for the regression of panel data in the present research. The number of observations (N) for each variable varies between 71 and 102 observations.

The Variance Inflation Factor (VIF) test did not detect multicollinearity problems among the independent variables. In addition, several alternative models were run in order to identify changes in the coefficient signals.

In order to know the best estimators for the panel data regression model, we used the Chow F, Brem-Pagan LM and the Hausman Test, which pointed to the random effects estimation as the best estimator, both for the specification of the model with the variable TEACHER as for the model without this variable.

That way, the data obtained through the regression model with unbalanced panel data and with random effects estimation can be visualized in Table 6. The dependent variable of the model was the EFI (efficiency) calculated by the DEA (RSV).

Table 6 - Model with random effects estimation

Dependent: EFI	Coefficient	Standard Error	z	Significance (*p-value*)
CORR	0,0008*	0,0005	1,6600	0,0980
BACK	0,0317*	0,0166	1,9000	0,0570
COMP	0,0117	0,0116	1,0100	0,3140
RECUR	-0,0143*	0,0080	-1,8000	0,0730
CURRIC	0,0362***	0,0083	4,3600	0,0000
RAZAP	-0,0009	0,0013	-0,6900	0,4920
ALUN	-0,0069	0,0155	-0,4400	0,6580
DESEMP	0,0017	0,0010	1,5800	0,1140
LNPIBPC	-0,0743***	0,0178	-4,1700	0,0000
CONSTANTE	1,6623***	0,1718	9,6700	0,0000
Observações:	99			
Wald chi2 (9)	43,19*** (0,0000)			
R^2 *within*	0,3269			
R^2 *between*	0,3650			
R^2 *overall*	0,3193			
Jarque Bera	2,328 (0,31227)			

Note: *, **, *** Correspond to 10%, 5% and 1% level of significance. P-values in square brackets.
Source: developed by the authors, based on the research data.

The R^2 overall indicates that 31.93% of the changes occurred in efficiency levels can be explained by the proposed model, which was significant at the 1% level, which indicates that at least one variable is significant to explain the variations. The Jarque-Bera tests indicated the normality of the residues of this model. Another important detail is that this model was run with 99 observations, and the countries that were part of the regression for each period can be visualized in Appendix H. It is believed that R^2 presented an acceptable value, and it is consistent with other studies about the subject, such as, for example, Agasisti (2014), who through his model was able to explain 32% of the variations in efficiency.

The regression brought other interesting information about a result already highlighted in the literature (Thanassoulis, 2001, Afonso, 2006, Giménez, Prior, Thieme, 2007, Alexander, Haug & Jaforullah, 2010, Diniz, 2010, Coco, Lagravinese, 2014) that the family background interferes with the efficiency of educational systems. In the present study, this variable was significant at the 10% level.

These results have already been demonstrated in New Zealand, with Alexander, Haug and Jaforullah (2010), and in Brazil, with Diniz (2012). Shutz, Usprung and Woessmann (2008) found a relation with the relative income of the population, which was understood as a family background variable. In this way,

public policies should be directed not only at schools, but also at the community in general, looking for improve the conditions of the lower income families.

The last significant variable (10%) appears frequently in academic studies (Coco & Lagravinese, 2014, Fonchamnyo & Sama, 2014), as important for the efficiency of educational systems: corruption. Although Coco and Lagravinese (2014) have used the CGI like an indicator to measure it, the CPI and CGI seek to measure corporate corruption rates, but have formulated through different methodologies.

The results of the present research demonstrate that the higher the CPI, the more efficient the nations will be. It is recalled that countries that have a better result in this index, have lower rates of corruption. These results support the findings of Reinikka and Svensson (2005).

In reference to the model, four variables did not present statistical significance: unemployment, number of computers per student, student/teacher ratio and student quality.

Recent research points out ways to overcome the efficiency problems encountered by education systems: more transparency, more accountability (Coco & Lagravinese, 2014, Fonchamnyo & Sama, 2014) and public policies aimed at students with socioeconomic disadvantages (Coco & Lagravinese, 2014).

Finally, the Table 7 presents a summary of the searching in this second stage of the research, showing the expected signs, signs found of the significant variables, as well as the values of each variable for Brazil.

Table 7 - Summary of results found in the second stage

Variable	Significance Level	Coefficient	Expected Sign	Found Sign	Brazilian value	Average
CURRIC	1%	0,0362	+	+	-0,21	0,00
LNPIBPC	1%	-0,0743	+	-	9,45	10,19
CORR	10%	0,0008	+	+	37,08	64,50
BACK	10%	0,0317	+	+	-1,15	-0,19
RECUR	10%	-0,0143	+	-	-0,43	0,03

Source: developed by the authors, based on the research data.

Therefore, it can be seen that the two-variable signal is not, a priori, as expected. However, it is not possible to state that these results indicate inconsistency, since much of what is discussed about the economic theory of education still lacks inferences that are more conclusive.

5 CONCLUSION

The objective of this study was to determine which independent variables affect the efficiency of public spending with secondary education from a cross-country perspective. Therefore, it was necessary to calculate the efficiency indices of each of the countries that performed the PISA examination through Data Envelopment Analysis (DEA). The calculated efficiency refers to the transformation of public expenditure into results in the PISA exam (quality of education) and the net attendance rate (number of adolescents being attended). The research universe was first made up of 65 countries that took the survey in 2012. For lack of data, only 38 countries had their efficiency ratios calculated for the most recent review period (2010-2012).

This research shows that Brazil is one of the most inefficient countries in the allocation of resources in secondary education. Even though it was spending more than the average of the emerging countries, the country obtained lower outputs than these nations. Another important point to note is that Brazil was the country that most expanded its resources during the period, and this may have contributed to its inefficiency, since investments in education take some time to transform into educational outcomes.

Besides Brazil, several emerging nations find themselves in a similar situation: they spend little and badly manage their resources. However, there are those who, even with a low investment, achieved good results in the PISA exam and / or the attendance rates, such as Poland and Serbia, which were efficient in the period 2010-2012. These countries could serve as a reference for Brazil to understand how their managers are organizing the education systems.

They benefit from the results found in this research, in addition to the managers, a portion of the Brazilian population that has interest and availability in overseeing public management. In addition, it is considered the current and pertinent theme to the national and international reality, given the budget constraint that Brazil will face in the short term and the austerity measures that are in vogue in several countries around the world. It is hoped that, with these results, the population will be able to put pressure on public management in order to make it more adequate and efficient.

Although the efficiency of the educational system is a topic that is being debated among academics, studies in a cross-country perspective and allow comparing the performance of the Brazilian system with other countries are still scarce, especially in national literature. Thus, this study joins the literature that has already addressed the theme, identifying important variables in the explanation of the efficiency of the education system, especially those related to governance characteristics in the school.

Of all the results found in the second stage of this research, two variables are in the direct control of these managers, which are the curricular autonomy and the financial autonomy. Thus, it is suggested that the public administrators of the educational system analyze if these would be plausible characteristics to be changed in the short term. However, given that the sign of financial autonomy was opposite to what was expected, and this variable was only significant at 10%, it is suggested that the focus of these managers should be curricular autonomy and that greater flexibility be given to education systems.

In addition, since some variables that are commonly highlighted in the media and academic circles (for example the classroom size) were not significant in the model, perhaps other characteristics, such as the student background of adolescents, deserve more attention. Political and cultural changes that could be more effective than decreasing the size of classrooms, at least for high school.

With regard to Accounting, it can be said that efficiency is still a subject rarely explored in the literature, and therefore the results of the research help to strengthen the theme within this area of study. Since the efficiency indicator is relatively easy to understand, results are believed to collaborate on issues such as accountability and transparency in public management.

Finally, it should be emphasized that the results and conclusions of the present research should be interpreted with caution, given the characteristics of the methodology used and the sample analyzed. When country educational systems are analyzed as a whole, many social and cultural characteristics are not taken into account and can therefore lead to distortions in results. However, since the DEA is a widely used tool in different sectors of the economy, it is believed that the results have contributed to a better understanding of how some factors inside and outside the education system can affect their efficiency levels.

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