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Allocation of Public Education Spending in Latin America and the Caribbean

Explaining Differences in Efficiency

by

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Abstract: Countries in Latin America and the Caribbean (LAC) have lagged behind in educational outcomes despite having on par levels of education spending given their level of development. This suggests that LAC suffers from poor efficiency of education spending which could be due to the high level of public investment in tertiary education. Hence this study looks at the relationship between efficiency and allocation of public education spending in LAC between 1970-2019 using quantitative methods. In a two-stage analysis, first country-efficiency scores are calculated for LAC countries using Data Envelopment Analysis. In the second stage, a fixed effects model is used to find how the share of tertiary education spending and the share of secondary education spending affect efficiency. The study finds that, on average, increasing tertiary education spending has increased efficiency of education spending but for high income inequality countries a higher share of tertiary education spending has been associated with inefficiency. The study also finds that in LAC increasing tertiary education spending has not come at the expense of decreasing spending at primary and secondary level. Furthermore, the study does not find evidence to support the claim that LAC countries would have moved to invest prematurely in tertiary education. Nevertheless, while increasing tertiary education spending has not had a negative impact on efficiency, increasing spending at secondary level has had a significantly larger positive effect on efficiency and thus LAC countries are likely to benefit from investing more at secondary level than at tertiary level.

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1 Introduction

Education of the masses is important for higher productivity and for the development of an economy (Salazar Cuellar, 2014). The fourth priority in the United Nations Sustainable Development Goals for 2030 is to ensure that "all boys and girls complete free, equitable and quality primary and secondary education" (UN, 2015). According to the latest statistics from 2018, Latin America and the Caribbean (LAC) had not reached this goal since the net primary school enrolment rate was 94% and only 85% of enrolled students reached the last grade of primary school (World Bank, 2021). The issue is even more pronounced at secondary level where 33% of secondary school aged children were not enrolled and completion rate of lower secondary stood below 80% (World Bank, 2021). The low educational attainment levels and high repetition rates also act as an indication of the poor quality of education in the region (Frankema, 2009). Furthermore, for the countries in LAC that have taken part, the OECD's Programme for International Student Assessment (PISA) illustrates that LAC education suffers from poor quality and equity. Though the comparison of PISA scores is not entirely fair since most other participating countries have higher income levels (Villar & Zoido, 2016), it is clear that there is a need for improvement in the education system in LAC.

Due to imperfect financial markets, households and individuals are unable to invest optimally in the education of their children (Lochner & Monge-Naranjo, 2012). Additionally, there are significant positive social externalities of education, which warrant governments to publicly provide and fund education (Benhabib & Spiegel, 1994). In the 20th century, LAC countries' education spending has been on par with their income levels, and yet the region has lagged behind in terms their of educational outcomes (Lindert, 2010). Thus, LAC seems to suffer from poor public education spending efficiency which motivates one to investigate how efficiency could be improved. Furthermore, in LAC government spending plays an important role in the economy as in recent years it has contributed roughly a quarter of GDP (World Bank, 2021). Thus public resources should be used as efficiently as possible (Herrera & Ouedraogo, 2018). Efficiency of public spending has been discussed recently to some extent in the context of developed countries (Azar Dufrechou, 2016; Mandl, 2007) but especially in developing country contexts (Afonso, Romero-Barrutieta & Monsalve, 2013; Afonso & St. Aubyn, 2006; Azar Dufrechou, 2016; Gupta & Verhoeven, 2001; Grigoli, 2015; Salazar Cuellar, 2014). A significant proportion of public spending goes to education (World Bank, 2021) and hence studying education spending efficiency also contributes to understanding overall efficiency of public spending.

Efficiency indicates whether resources are being used to get the best value for the money (Palmer & Torgerson, 1999). In this case the resource is public education funding with which the government (ideally) aims to accumulate as much human capital as possible. Technical efficiency refers to the physical relationship between inputs and outputs (Palmer & Torgerson, 1999) and has been the focus of economic research on public spending efficiency (See for example: Afonso & St. Aubyn, 2006; Curtin & Nelson, 1999; Salazar Cuellar, 2014;

Lavado & Cabanda, 2009; Herrera & Ouedraogo, 2018). Technical efficiency is a differentiation from productive efficiency and allocative efficiency of which the former is better suited for pedagogical scientists and the latter, although would also be of interest, will not be the focus of this research. Studying efficiency is especially important in developing regions where governments have more limited budgets and a high pressure to provide public services in order to further the country's development.

1.1 Research Problem

Inefficient allocation of education spending in LAC might be a possible reason for the conflicting evidence of on par levels of public investment in education on the one hand, and low enrolment rates and poor educational outcomes on the other. More specifically, LAC countries might have over-invested in tertiary education (Franklin, Ince & Hosein, 2014; Lindert, 2010). For example, Lindert (2010) shows that Latin American countries spend less than half as much on a primary school child compared to a student in higher education. In several LAC countries students in tertiary education pay very small or no fees even though they could afford to pay more (Brown & Hunter, 2004). Psacharopoulos (1996) argues that before all children in developing regions are able to finish basic education, that is primary and secondary education, investments in higher education, or tertiary education, will by default only benefit a limited proportion of the population. This argument is supported by Franklin, Ince and Hosein (2014) and Winkler (1990) who show that investing in higher education in LAC has usually disproportionally benefitted children of the middle- and upper-class, and thus contributed to persisting or possibly even increasing inequality. Therefore, in order for tertiary education spending to be efficient, developing countries might have to first ensure that their primary and eventually secondary education is reaching all and is of high enough quality. In other words, the high inequality and government policies might be biased towards serving the interest of the middle- and upper classes in LAC causing a premature diversion of resources to higher education and lower overall human capital accumulation.

Also, the private returns from tertiary education are generally higher compared to those who have only completed basic education, which means that investment in tertiary education at the expense of investing in basic education has a negative effect on intergenerational mobility and increases income inequality (Sanroman, 2006). If education expenditure is not going into improving educational outcomes of the general population and the government is spending disproportionally on tertiary education, spending on education could be less useful for economic development and less efficient (Castillo Caicedo, Monroy del Castillo & Cardona Ceballos, 2015; Lustig, 2014; Méndez, 2020). Explanations for the low educational attainment in the region have been linked to poor institutional development. In their influential paper, Engerman and Sokoloff (2005) argue that the reason for poor institutional development and economic stagnation in Latin America stems from factor endowments such as land and amount of labour relative to land. These factors can be linked to the unequal distribution of wealth during the colonial period. According to the theory, high initial

inequality levels in Latin America caused institutions to be built in a way that was not conducive for growth. The poor and inequitable education system can be seen as evidence of a bad institutional set up which favours the elite (Engerman, Mariscal & Sokoloff, 2009).

Nevertheless, since the 1990's in Latin America, there have been significant improvements in the efficiency on public spending (Azar Dufrechou, 2016). Some 17 countries in the region have also implemented anti-poverty programs in the form of conditional cash transfers (CCT) that specifically aim to increase enrolment in schools (Robles, Rubio & Stampini, 2019). This is an indication of more redistributive policy sentiments in the region and shows that education has been recognised as an important tool for development in the countries. Therefore, it could be that a misallocation of education is no longer an issue in LAC and the high rates of tertiary education spending are warranted given the positive effects it can have. Funding tertiary level education might have positive effects on growth and thus as a result of research, innovation and technological development, the demand for skill might increase (Birdsall, 1996). This would induce higher incentives for individuals to become educated which would possibly increase efficiency of public education. Furthermore, there could be large differences in how public funds are used at tertiary level. For example, if public funds are used to help students from low-income backgrounds overcome financial barriers to higher education, this would increase intergenerational mobility and lower inequality (Winkler, 1990).

In all, it is not clear what the relationship between tertiary education spending and efficiency is since previous research has not quantitatively investigated whether inefficiencies in human capital accumulation in LAC could be due to the composition of education spending. Thus, this thesis will contribute to the literature on education spending efficiency in LAC by investigating how allocation of education spending has impacted efficiency.

1.2 Aim and Scope

The purpose of this research is to study how allocation of education spending is related to the efficiency of total public education spending in LAC. This is done to provide quantitative evidence on how to best allocate education spending to increase efficiency. Hence, the research question is: *What has been the relationship between the composition and efficiency of public education spending in Latin America and the Caribbean between 1970-2019?* The main hypothesis of this paper is that a high share of tertiary education has been less efficient than investing in basic education. Additionally, there are three factors which are expected to cause heterogenous effects on efficiency of increasing spending at tertiary level. The three hypothesises related to these factors which together help to explain the main results are as follows:

1) **Inequality**: The effect of increasing the share of tertiary education spending on efficiency depends on the level of inequality in the economy so that when inequality is high, increasing the share of tertiary education has a lower or a negative effect on efficiency. This is called the institutional hypothesis since it is based on the idea that

high inequality leads to a bad institutional set up and misallocation of public resources.

2) **Overall education spending patterns:** The effect of increasing the share of tertiary education spending on efficiency depends on whether it increases overall education spending or if it is increased at the expense of spending at primary or secondary level.
3) **Initial educational level:** The effect of increasing the share of tertiary education spending on efficiency depends on the initial average level of schooling in the economy, where an economy with higher educational attainment levels will experience lower efficiency losses or higher efficiency gains from increasing the share of tertiary education spending.

The aim of this study is to first conduct a data envelopment analysis (DEA) with a panel dataset of LAC countries to find, relative to other countries in other time periods, how well countries have been able to maximise educational output with their level of education spending. The DEA calculations will give efficiency scores for each observation in the dataset, which are used in regression analysis to find how different factors, including the allocation of education spending, are related to efficiency. The thesis will focus on a selection of 25 LAC countries (based on data availability) in the time period between 1970-2019. The focus is specifically on LAC because of the previously found issues with inefficiency of education spending as well as the regions other characteristics such as high inequality and relatively high tertiary education spending. Nevertheless, by limiting the sample to only LAC, the efficiencies and inefficiencies will only be determined in relation to other LAC countries within the time period in question.

The research in this paper also only focuses on the overall accumulation of human capital or more specifically the average educational attainment level of the country. This means that the same value is put on a year of primary education as a year of tertiary education, even though their value in the economy or to the individual are very different. Thus, the paper is also unable to comment on the consequences on equitability of allocation of education spending despite this being a legitimate concern and issue in the region.

1.3 Context

LAC is comprised of 41 countries and can be divided into the sub-regions the Caribbean, Central America and South America. While the region is vastly heterogenous, there are some common trends which have impacted the development of human capital in the region. LAC has a deep colonial past starting from the late 15th century and ending in the early 19th century when most countries gained independence. In the 19th century, education was not widespread, and educational inequality was high and increasing (Baten & Mumme, 2010). Higher education was originally set up to educate and serve the political and technical elite (Winkler, 1990). Nevertheless, equity in education improved in the early 20th century (Baten & Mumme, 2010). However, the spread of mass education in LAC started catching up with other regions in the post-war period but the increase in enrolments was also met with a reduction in the quality of education (Frankema, 2009). LAC suffered from low political

stability before the mid-1980s when governments were able to restore democratic institutions. Nevertheless, education spending was especially limited in the 1980's and 1990s due to economic instability and the Washington Consensus with its strict fiscal constraints which were imposed on LAC governments (Winkler, 1990). Regardless, enrolment at universities increased by tenfold between 1960-1985 (Winkler, 1990). Since 1990s many LAC governments have been able to make large strides in expanding basic education as well and decrease educational inequality along with it (Cruces, García Domench & Gasparini, 2014). Many LAC countries have also implemented more pro-poor policies since the 1990's including conditional cash transfer programs of which education has been an important part of. Income inequality also started to fall consistently in the 2000s in almost all Latin American countries (Gasparini, Cruces, Tornarolli & Mejía, 2011). Nowadays LAC government invest on average roughly the same proportion of their GDP on education as high income countries (World Bank, 2021).

1.4 Outline of the Thesis

Section 2 discusses the theoretical approach on allocation of education spending in relation to efficiency and the empirical research on efficiency of government expenditure. Section 3 describes the sources for the data and the dataset used for the quantitative analysis as well as some descriptive statistics. Section 4 provides a description of the methodology used to calculate the efficiency scores and the second-stage analysis used to explore the determinants of efficiency. Section 5 shows the results from the first stage analysis of efficiency, followed by the results from the regression analysis explaining causes of efficiency in public education spending. In this section the results are also checked for robustness and discussed in relation to the hypothesises and previous literature. Finally, section 6 concludes, discusses policy implications and limitations as well as identifies topics for further research.

2 Literature Review

This section critically discusses the previous literature by first looking at the theoretical approach on allocation of education spending in relation to efficiency, and then assesses the empirical findings of public spending efficiency literature to identify important variables affecting efficiency.

2.1 Theoretical Approach on Allocation of Education Spending and Efficiency

While human capital consists of multiple factors, the most relevant for government spending is formal education. Human capital is good for growth and economic development (Gomez Meneses & Zarate Camelo, 2011; Hanushek & Kimko, 2000; Krueger & Lindahl, 2001). There are multiple channels on a micro and macro level through which human capital increases output and the rate of growth. On a macro level, human capital increases productivity of labour (Backman, 2014). Human capital also enables a more effective adaption of technologies (Benhabib & Spiegel, 2005). Finally, human capital increases innovation and improves the level of research and development (Marozau, Guerrero & Urbano, 2021). On a micro level, education explains the largest share of people's income levels (Mincer, 1974). Education also acts as an effective antipoverty measure and increases the health of people (Curtin & Nelson, 1999). Due to the positive social externalities of education and imperfect financial markets, it makes sense for governments to publicly fund education.

However, government resources are limited and should be allocated between different education levels as effectively as possible to accumulate the most human capital. In fact, Lindert (2010) and Frankema (2009) suggest that poor efficiency in human capital development in LAC is due to overinvestment in tertiary education. When comparing Latin American countries' education spending to other regions in the 20th century, the former spent the same amount of money on education, relative to the countries' income levels (Lindert, 2010). However, their secondary school enrolment levels, literacy scores and math scores have not been in line with how much they are spending (Lindert, 2010). Frankema (2009) shows further that gross enrolment figures overestimate the actual human capital development due to high repetition rates. Furthermore, Judson (1998) finds that inefficient allocation of education spending reduced the positive impact on growth of human capital. Therefore, it is vital to study, the composition of public education spending and the effects this has on the efficiency of human capital accumulation.

Generally, micro-economists have discussed the allocation of education resources in terms of maximising the rates of returns to education. Psacharopoulos (1996) argues that for developing and emerging economies it is more important to invest in primary education and secondary. His argument is based on the evidence he finds on the returns to secondary education which are generally higher than the returns to higher education (Psacharopoulos, 2003; Psacharopoulos, Tan & Jimenez, 1986). However, basing government education spending on micro-level rates of returns are not ideal as it does not give information about the marginal social rates of return on public investment (Judson, 1998). This is because the rate of return to education is related to both the relative supply and demand of skills and will thus respond to changes in the allocation of education spending as well as to changes in the labour market and technology (Arrow, 1973; Goldin & Katz, 2007).

There are multiple different channels through which the allocation of public education spending could influence efficiency. First, in Latin America high inequality and the consequent poor institutional development could cause low education spending efficiency due to intentional misallocation of education spending. Engerman and Sokoloff (2005) argue that high initial inequality has a negative effect on institutional development. One of the channels through which this occurs is the suboptimal human capital development (Engerman, Mariscal & Sokoloff, 2009). Furthermore, according to Acemoglu, Johnson and Robinson (2005) high inequality and extractive institutions will lead to path dependency, where the elite will have an interest in keeping the unequal status quo. Therefore, not only would government funding be diverted towards higher education, but it is also likely that there would be suboptimal spending at primary and secondary level. Since education inequality in Latin America is closely related to income inequality (Cruces, García Domench & Gasparini, 2014), mass education would help to reduce inequality and even out the economic power in the society. Yet, increased economic power of the masses could threaten the political power of the elite and thus they have an interest to maintain their economic and political power (Acemoglu, Johnson & Robinson, 2005). There is some evidence of institutional issues being related to a diversion of spending to higher education in Latin America. Brown and Hunter (2004) find that in late 20th century Latin America less democratic countries spent a smaller share of their education spending on primary education and that education spending was lower overall. One of the explanations that Brown and Hunter (2004) offer to explain the phenomena is that democratic countries depend on the support of the general population and thus governments have a higher interest in providing education to the masses through investment in basic education. On the other hand, in less democratic countries interest groups are likely to have more power and since the higher education lobby is more organised than supporters of basic education, they have more control. Furthermore, universities have better connections to the government since ministers are often affiliated with higher education institution themselves (Winkler, 1990). Thus, according to an institutional framework, low efficiency of public education spending can be explained by a diversion of education spending to higher education instead of primary and secondary. According to this framework, increasing share of tertiary education spending would create inefficiencies in a context of high inequality and low institutional quality.

Second, education spending efficiency can also be thought of in terms of a public good framework. Education can often be considered to be a public good, though it does not strictly fulfil the criteria as it is excludable (Franklin, Ince & Hosein, 2014). Moreover, tertiary

education is somewhat different to primary and secondary education. Tertiary education fulfils three different functions: the teaching function, the research function and the service function (Naert, 2004). Tertiary education in its teaching function is a "quasi-public good" as there are significant private returns but also public returns in terms of increased productivity. However, the research function is largely a public good and there is an argument for public investment due to the positive effect of universities on growth through their research and development function (Birdsall, 1996). Though the difficulty in separating investment between tertiary education for students and researchers brings this line of argument into question (Psacharopoulos, 1996). Nevertheless, due to the high private returns of tertiary education, the market might be better able to sufficiently provide the right level of higher education and thus publicly funding higher education might cause inefficiencies. According to the public good framework, this relationship would be constant. Therefore, when it comes to public funding of education in a development setting, basic education is usually emphasised (Curtin & Nelson, 1999; Bennell, 1996; Psacharopoulos, 2003). The argument for publicly funding basic education comes from the high social returns of education at the lower levels (Psacharopoulos, 2003). Furthermore, Psacharopoulos (1996) argues that as developing countries are building their education system, it is better for developing countries to concentrate their limited spending first on primary education, then secondary education and eventually tertiary education. Winkler (1990) also argues that LAC governments are better able to support the educational development of children from lower income households by first assuring quality basic education before investing heavily in tertiary education. This is because investment at higher levels of education do not help children from lower income families if they have not been able to complete basic education or if the quality of basic education has not been of high enough quality to prepare them for further studies. Still, above a certain levels of average educational attainment, it also becomes necessary for countries to invest increasingly in tertiary education to increase educational attainment levels and efficiency (Judson, 1998). Consequently, the composition of education spending should respond to the educational attainment levels of the economy to maximise efficiency.

Third, there are several reasons that would suggest spending at tertiary level is more inefficient than at primary and secondary level in LAC. Winkler (1990) has found that in LAC, the social returns to higher education decreased in LAC towards the 1980s. This is mostly a result from the fact that spending at tertiary level has not been allocated in a redistributive way and has benefited people from the middle and upper class. Thus, the inefficiency of public spending at tertiary level could be explained by the fact that in the absence of heavy public subsidies for higher education, students would be able to substitute public investment with private investment (Brown & Hunter, 2004). The same is true of course for all levels but at the tertiary level, this phenomenon is likely to be stronger due intergenerational transfer of educational outcomes (Daude & Robano, 2015). However, in order to improve intergenerational mobility, equity and equality in in tertiary education it is important that funding for students from low-income backgrounds are financially supported through public funds (Winkler, 1990). This would help to increase efficiency within the tertiary level spending as funds are directed to those who need them. Therefore, the efficiency of tertiary education spending would depend on the equitability of investment. Contrastingly, there are larger financial market constraints for primary and secondary level education due to the uncertainty of returns to education which could mean that public investments at tertiary

level are always going to be less efficient. Judson (1998) argues that talent has not been revealed before going to school which makes investments in children risky. However, by the time a child is entering higher education, ability is more apparent to the child and their family and thus investment choices are not as risky. Therefore, families are not as credit constraint when it comes to investing in education at tertiary level. In this case, there would be efficiency gains from decreasing public education spending at tertiary level. Alternatively, increasing the efficiency and redistribution of tertiary spending could also help (Winkler, 1990; Birdsall, 1996). According to this line of argument private funding at tertiary level would increase with decreasing public funding and efficiency of public spending would increase. However, in reality this is hard to quantitatively observe since data private investment is hard to find.

Fourth, an argument for increasing efficiency by reducing spending at tertiary level, is the fact that spending at primary and secondary level is complementary to spending at tertiary level. Increasing spending at tertiary level does not increase the output at tertiary level if there is not a sufficient pool of students who have graduated primary and secondary school. Additionally, if the quality of primary and secondary is poor, it is less efficient to fill in the knowledge gaps at tertiary level. If the pool of secondary school graduates remains the same but there is an increase in tertiary education students, then the average ability level of tertiary education is likely to decrease. Therefore, if primary and secondary level education is underfunded or if increasing spending at tertiary level is done at the expense of funding at pre-tertiary levels, then this would be harmful for overall efficiency because a larger share of resources will benefit a smaller group of people. However, Winkler (1990) argues that education spending between basic education and higher education are not in competition with one another. He points out that in Latin American governments, generally, the basic education budgets are determined separately from higher education and are not allocated between different levels within the education ministry. Therefore, increased spending at tertiary level would not necessarily mean that there would be less spending at secondary or primary level just that the overall education spending would increase. In this case the relationship between the share of tertiary education spending and efficiency would be more positive since increases at tertiary level would not decrease output at lower levels but would increase output at tertiary education level.

Increasing the share of tertiary education could also be beneficial for efficiency by increasing the demand for education. There are multiple reasons to suggest that increasing spending at tertiary level would increase efficiency of education spending. If there is an increase in spending at tertiary level, this could increase research, innovation and technological adaption in the country. This might create a higher demand for education, and efficiency of education spending would increase. The evidence for this channel is mixed. Krueger and Lindahl (2001) found that for low- and middle-income countries, higher educational attainment levels at primary and secondary level have positive effects on growth whereas higher tertiary education attainment only had positive effects on growth in OECD countries. Contrastingly, Marozau, Guerrero and Urbano (2021) found that universities have a positive effect on development at all development stages, and at lower stages specifically the educational aspect of universities plays the most important role. Higher growth is related to better employment opportunities and thus demand for skill. However, solving the demand side of education might not be enough in LAC. In several Latin American countries, demand for education has recently been

addressed through conditional cash transfer (CCT) programs (Behrman, Parker & Todd, 2005). In these anti-poverty schemes, areas and families in need are targeted and given cash transfers usually conditional on school attendance of the children in the family and the consumption of health care. While the programs have successfully increased school enrolment, there is reason to believe that the long-term impacts, in terms of educational outcomes, might not be as positive; studies looking at test scores show that participation in the program did not improve cognitive abilities (Behrman, Parker & Todd, 2005). This might be an indication of the poor quality of schools. Therefore, addressing only the demand side of education is not sufficient if there is not enough investment on the supply side. Investment at tertiary level could also help with the supply side since teachers for basic education would be trained through post-secondary education (Birdsall, 1996). Therefore, increasing spending at tertiary level for teacher training would increase the quality of pre-tertiary education as well. This would increase the attainment levels in basic education as a result of decreasing repetition rates and help on the supply side of education.

Simply put, the relationship between the share of higher education spending of overall education spending and the efficiency of education spending is unknown since there could be both positive and negative effect on efficiency of increasing the share of tertiary education spending and the effects will depend on the context. Therefore, whether a larger share of tertiary spending has a negative effect or a positive effect on efficiency will shed a light on whether there has been a premature or timely increase in tertiary education spending in Latin America. The literature offers arguments for both efficiency gains and losses from increasing allocation to tertiary spending and this paper will be able to provide some evidence on which effects are stronger in Latin America. It is possible that the optimal composition of education spending is related to the inequality level, educational level or the ways of allocating education spending. Therefore, this paper will also be able to shed some light on which of the channels mentioned above are relevant for LAC.

2.2 Empirical Evidence on Efficiency

2.2.1 Calculating Efficiency

Efficiency measures whether resources are being used to get the best value for the money (Palmer & Torgerson, 1999). The research on public spending efficiency has been investigated mostly in terms of technical efficiency (See for example: Afonso & St. Aubyn, 2006; Curtin & Nelson, 1999; Salazar Cuellar, 2014; Gupta & Verhoeven, 2001; Lavado & Cabanda, 2009; Azar Dufrechou, 2016; Herrera & Ouedraogo, 2018), which refers to the physical relationship between inputs and outputs (Palmer & Torgerson, 1999). This is a differentiation from productive efficiency and allocative efficiency. The former allows one to compare different methods to achieve a certain goal (Palmer & Torgerson, 1999), for example different pedagogical methods to increase literacy. Allocative efficiency refers to how well an economy is able to maximise the welfare of a community with its given resources (Drummond, 1989). This paper focuses on technical efficiency since in this case the resources are public education funding with which the government (ideally) aims to get the highest

possible education level in the country. Investigating efficiency of education spending in LAC, instead of focusing on output, is motivated by previous research which has found that education spending in LAC is not lacking, yet when looking at the quantity and quality of schooling, their human capital attainment levels are lower relative to the amount of public spending on education. Therefore, it is important to study where the money is going and what could be the reason that explains the mismatch between spending and educational output in LAC.

There are a few ways previous literature has approached efficiency of public spending. Judson (1998) builds a model of efficiency in terms of maximising returns to education. Her model assumes that the returns to education only respond to the relative supply of skill at different education levels. However, previous research has shown that the return to skill is more dynamic and responds to both demand and supply of skills (Goldin & Katz, 2007; Manacorda, Sanchez-Paramo & Schady, 2010). The most commonly used methods to measure efficiency of public spending are Data Envelopment Analysis (DEA) (Gupta, Schwartz, Tareq, Allen, Adenauer, Fletcher & Last, 2007; Herrera & Pang, 2006; Afonso, Romero-Barrutieta & Monsalve, 2013; Azar Dufrechou, 2016; Afonso & St. Aubyn, 2006) and Stochastic Frontier Analysis (SFA) (Jayasuriya & Wodon, 2003). DEA is a nonparametric method where input data on a single or multiple variables are compared to output data and an efficiency frontier is determined either as output oriented or input oriented (Farrell, 1957). The issue with the nonparametric method is that it does not account for statistical noise or measurement error. Furthermore, it does not allow for exogenous variables to be taken into account and a second-stage analysis is needed to reduce the bias in efficiency estimates. While SFA is able to take into account statistical errors, in practice the approach has not been able to determine statistically significant relationships. Wagstaff and Wang (2011) also develop a hybrid method which takes into account the statistical noise similarly to SFA and allows for a calculation of efficiency scores based on development level. However, the weakness with the hybrid model is that by creating different efficiency scores based on development level, it is not possible to see what the relationship between development and efficiency is, but instead a lot is assumed of the relationship between development and efficiency.

Nevertheless, to calculate efficiency of education spending different input and output measures have been used. The most common input measure is the amount of public expenditure on education, usually in real PPP terms (Herrera & Pang, 2006; Gupta et al., 2007; Azar Dufrechou, 2016; Gupta & Verhoeven, 2001; Judson, 1998) but other measures are also used. For example, Afonso and St. Aubyn (2006) use the student-teacher ratio and the intended instruction time and Afonso, Romero-Barrutieta and Monsalve (2013) use the spending to GDP ratio. The use of output variables varies more and depends on the focus of the research. When studying efficiency of basic education in recent times and in relatively more developed country sample, PISA test scores have been used to appropriately capture the schooling output (Afonso & St. Aubyn, 2006). Since PISA test scores only measure education outcomes at secondary level and for a limited number of mostly developed countries and only since 2000, the sample that can be used for such studies is limited. Therefore, studies focusing on developing regions at a given level of education, output has been measured in terms of enrolment rates (Mandl, 2007). However, studies which use enrolment rates as the output variable are not ideal as research on efficiency should aim to measure the final or target output to the highest extent possible (Palmer & Torgerson, 1999). Enrolment figures are only

intermediate outcome goals that often do not accurately capture learning and are biased by grade repetition (Azar Dufrechou, 2016; Frankema, 2009). Finally, in the absence of data on skills acquired in school, an easily comparable estimate across countries and times periods for educational output that has been used is educational attainment or completion rates (Azar Dufrechou, 2016; Herrera & Pang, 2006).

Overall, studies find that there are differences in efficiency and that educational outcomes could be improved significantly with higher efficiency. In LAC for overall public spending Afonso, Romero-Barrutieta and Monsalve (2013) find that, on average, countries could increase their output by 19% with the given inputs. The results for education spending efficiency are very similar in Azar Dufrechou (2016), who finds that LAC countries between 1970-2010 could improve their efficiency by 21%. She also finds that efficiency has increased over time in LAC and that LAC have higher efficiency compared to high income countries. However, this results might be biased by the inability of the study to properly account for quality. Afonso and St. Aubyn (2006), who account for quality by using PISA scores, are only able to include one LAC country, Uruguay and they find it to be the least efficient. Herrera and Pang (2006) actually find Uruguay (along with Bahamas) to be among the most efficient in basic education output terms in the developing world. However, Herrera and Pang (2006) also find that for efficiency in achieving average years of schooling, LAC performs on average lower than two of the comparison regions: East Asia and the Pacific as well as Eastern Europe and Central Asia. Furthermore, Grigoli (2015) finds that in the world, less developing countries generally have lower efficiency scores than developed countries. However, the studies on education spending efficiency in LAC are fairly limited as Azar Dufrechou (2016) only includes 11 countries from 49 countries in the region in her study and the focus in Afonso, Romero-Barrutieta and Monsalve (2013) is on overall public spending efficiency and not education spending.

2.2.2 Determinants of Efficiency

There are several confounding factors that affect the relationship between the composition of education spending and the efficiency of public spending. Therefore, it is important to investigate what previous research has found as the main contributors and hindrances to public education spending efficiency. Some of the research on efficiency simply looks at correlations between different factors such as development or inequality instead of attempting to find causal relationships (Judson, 1998). The findings of these studies would suggest that neither of these factors are related to efficiency. However, Azar Dufrechou (2016) finds, for example, that that there is a quadratic relationship between development and efficiency and thus a simple correlational studies are likely to miss important trends in efficiency of public spending. Since efficiency scores are determined within a limit of values - usually between 0 and 1 - previous research often uses truncated or censored regression models to estimate the size and sign of determinants of efficiency (Afonso & St. Aubyn, 2006; Azar Dufrechou, 2016; Afonso, Romero-Barrutieta & Monsalve, 2013; Grigoli, 2015; Herrera & Pang, 2006). Depending on the amount of time periods available in the data set fixed effects (with multiple time periods) (Azar Dufrechou, 2016) or random effects (with 2 time periods) (Herrera &

Pang, 2006) have been used. To tackle endogeneity issues, some studies have lagged their control variables (Azar Dufrechou, 2016).

Nevertheless, previous research has looked at various cofounding factors and has found at times conflicting results. Grigoli (2015) finds that student-to-teacher ratios and governance effectiveness have an impact on efficiency as well as the share or rural population, inequality, population density, and the level of adult literacy. He controls for government wage bill arguing that an increasing wage bill decreases efficiency by pushing away from other inputs such as teaching equipment. However, he ignores the fact that increasing wage bill can also be an indication of higher quality of teaching (Birdsall, 1996). Afonso and St. Aubyn (2006) find that GDP per capita and adult educational attainment are the most significant determinants of higher efficiency of public spending in basic education. For developing countries, Gupta and Verhoeven (2001) find that while expenditure has an effect on efficiency, this effect is lowered or cancelled out when adding GDP per capita into the model. Azar Dufrechou (2016) finds that GDP per capita, economic globalization and democracy have an impact on efficiency. She also finds that inefficiency decreases more significantly at higher income per capital levels. She also looks at the effect of government size, interest paid on debt, inequality and household gross income as factors of efficiency. However, she fails to account for the fact that public spending is also used on tertiary education and in LAC this proportion is higher than in other countries with similar income levels (Lindert, 2010) and thus should also ideally translate into significant output at tertiary level. This means that the estimates in Azar Dufrechou (2016) would be biased. Studies that include inequality in the models, find it to be negatively associated with efficiency (Grigoli, 2015; Azar Dufrechou, 2016) which supports the institutional hypothesis and thus deserves to be inspected more closely.

However, previous literature does not investigate whether inefficiencies in general or at pre-tertiary level are due to misallocation of educational spending. Nevertheless, Afonso, Romero-Barrutieta and Monsalve (2013) find that Guatemala and Peru are some of the most efficient in education spending in LAC. These countries also tend to spend smaller shares of their education budget on tertiary education compared to other LAC countries (World Bank, 2021). Yet, such correlations do not reveal much without investigating whether there is a causal relationship. Therefore, this study contributes to the discussion on the determinants of inefficiency by looking at the role of composition of education spending on overall educational attainment levels. More specifically, while scholars such as Lindert (2010) and Frankema (2009) have previously argued that part of the reason for low human capital levels in LAC in the 20th century might be related to high spending on tertiary education, this thesis will quantitatively investigate the extent to which this is true and if this is still the case. Through a regression analysis, it is also possible to discover what the relationship between different determinants of efficiency and the composition of education spending is. Inequality, development level and initial educational level has been found to be significant determinants of efficiency, but it is not yet known how these determinants interact and are related to the composition of education spending. Furthermore, previous literature that has looked at efficiency in education spending in LAC has focused on a specific educational level but looking at overall education spending will provide evidence on overall human capital accumulation in the economy. In the larger context, this thesis is exploring the mechanisms that can explain lower efficiency in public spending in developing and emerging economies.

3 Data

To investigate the efficiency of public education spending, data on educational inputs and outputs is required. Efficiency in this study is determined by the human capital output that a government is trying to maximise with a given level of education spending inputs. Education spending will be measured in terms of constant US dollars adjusted at purchasing power parity. To allow for an easy comparison across countries spending will be calculated per population under the age of 25. By dividing the total amount of education spending by the size of the youth population, the amount is scaled not only to the size of the country but also directly to the size of the school aged population. Spending per enrolled student would be preferred as not all under the age of 25 are enrolled and there could be individuals above the age of 25 who are completing their tertiary education studies or participating in adult and life-long learning. However, reliable enrolment figures are not readily available. Furthermore, since formal adult training continues to not be widespread in the region, it is unlikely to cause major concern (OECD, 2020). The data for education spending is collected from The UNESCO Institute for Statistics (UIS). Gaps in data availability for the amount of education spending, especially for earlier years, are supplemented with estimations of education spending using education spending as a share of GDP from UIS and GDP data from Penn World Tables (PWT, 10.0). The benefit of using UIS data on education spending is that it provides a comparable data set for a wide set of countries for a long time period.

The main output variable is the average years of schooling for which data can be found from the Barro and Lee (2013) data set and missing data (mostly from after 2010) has been supplemented with data from UIS. While combining information from the two datasets increases the number of observations for the study, data on average years of schooling does not completely match between the datasets, which could cause errors in estimation. The main weakness with using average years of schooling as the output variable is the fact that it does not measure immediate output and it includes the output created in earlier periods. Thus, there is an assumption that the average years of schooling changes with the inputs rather than due to demographic changes. To better capture current output, previous literature has often used enrolment figures but using attainment instead of enrolment as the output variable is most appropriate for several reasons. For one, enrolment levels in basic education in LAC are relatively high for the period in question and differences are going to be marginal. Thus, increased basic education spending is likely to be observed as an increase in the quality of education and increases completion rates that cannot be observed when enrolment rates are very high or at 100%. For LAC issues in education are more prominent in terms of dropout, repetition and quality which bring down the completion rates (Salazar Cuellar, 2014). Secondly, enrolment figures can be distorted by high repetition rates since students stay in school for longer without learning more (Frankema, 2009). Finally, attainment levels give a better understanding of the differences in quality of education. While educational attainment is not a perfect measure of the quantity of human capital level achieved in a country, it does still to an extent reflect the quality of education. This is because poor quality of education is

closely related to high grade repetition rates (Frankema, 2009; Wolff, Schiefelbein & Schiefelbein, 2002) which has widely been reported to predict high dropout rates and low attainment levels (Manacorda, 2012; Jacob & Lefgren, 2009; Gomes-Neto & Hanushek, 1994). Furthermore, for the individual, attainment is likely to be more important than enrolment due to the signalling effect on the labour market (Arrow, 1973; Manacorda, Sanchez-Paramo & Schady, 2010). Therefore, average years of education should capture educational output to a satisfactory extent.

For the second stage, data is needed on the determinants of efficiency. Data for measuring the allocation of education spending is taken from UIS. To calculate the share of tertiary education spending, tertiary education spending as a share of GDP is divided by education spending as a share of GDP. The same is done for calculating the share of primary and secondary education spending, respectively. These are the interest variables that are needed to see what the effect of the allocation of education spending has on efficiency. Additionally, there are other factors that could have an impact on efficiency directly and could reveal heterogenous effects when interacted with the share of tertiary education spending. The first of these is inequality for which data has been collected from The Standardized World Income Inequality Database (SWIID9). Inequality is measured by the Gini coefficient in equivalised household disposable income. To ease the interpretation of the interaction term, the Gini coefficient has been made into a dummy variable where 1 indicates that a country is highly unequal and 0 otherwise. The break-off point between high and low inequality is defined around the 75^{th} percentile of the Gini coefficient, at 0.50. Since the cut-off point is somewhat arbitrary, alternative definitions of the inequality measure are used for robustness check. Inequality is expected to negatively affect efficiency (Grigoli, 2015; Azar Dufrechou, 2016). In a country with more equally distributed income, a larger share of the population can afford to go to school (Grigoli, 2015). Also, inequality is likely to impact how education funds are allocated and thus highly unequal societies might allocate funds in a less redistributive fashion which could lead to inefficiency (Lindert, 2010; Brown & Hunter, 2004).

The two control variables are the share of rural population and development level which are collected from UIS and PWT, respectively. A large share of rural population is believed to be a significant hindrance to efficiency (Grigoli, 2015). Students are likely to have more challenges in accessing and attending schooling and there could be less demand as there is more need for skilled labour in urban areas (Herrera & Pang, 2006). Development is captured by GDP per capita at constant national prices (2017US$). While the exact effect of development on efficiency is ambiguous as there is conflicting evidence on it (Azar Dufrechou, 2016; Grigoli, 2015), it is still likely to be linked to efficiency through its effect on a governments ability to fund schooling (Lindert, 2010) and the demand for schooling (Glewwe & Jacoby, 2004). For the regressions, the log of GDP per capita is used to account for the non-linear relationship (Azar Dufrechou, 2016) as well as to ease the interpretation on the coefficient.

The unbalanced panel data set covers the years between 1975-2019. The data analysis is done in 5-year intervals between 1975-2019, totalling 10 time periods. The data set is structured at 5-year intervals as per previous research (Azar Dufrechou, 2016; Judson, 1998) and for a few reasons. First, the Barro and Lee (2013) data as is compiled at five-year intervals. Second, for other variables, data is often measured every few years and thus compiling five-year averages

with existing data allows for more variables to be observed for a country in a given five-year period compared to in five individual years within that period. Third, the effect of educational inputs take some time to have an effect and a five-year interval is a good compromise. Full count of available variables for each country and time span is shown in Appendix A. Sufficient data for DEA can be found for 25 countries which represents just under two thirds of the countries in the region. There are only two countries, Argentina and Chile, which have data for all 10 time periods. There also only two countries, Bahamas and Saint Vincent and The Grenadines, which have data only for 1 time period. The advantage of this dataset is the long time period it covers. This allows for a more long-term investigation into efficiency in education spending compared to most previous studies in LAC (Afonso, Romero-Barrutieta & Monsalve, 2013; Salazar Cuellar, 2014). Having multiple time periods in the data set also enables the use of a fixed effects regression analysis to control for time invariant country characteristics. Furthermore, the data set is more representative of the area since it includes more countries from the region compared to, for example, the study by Azar Dufrechou (2016).

3.1 Descriptive Statistics

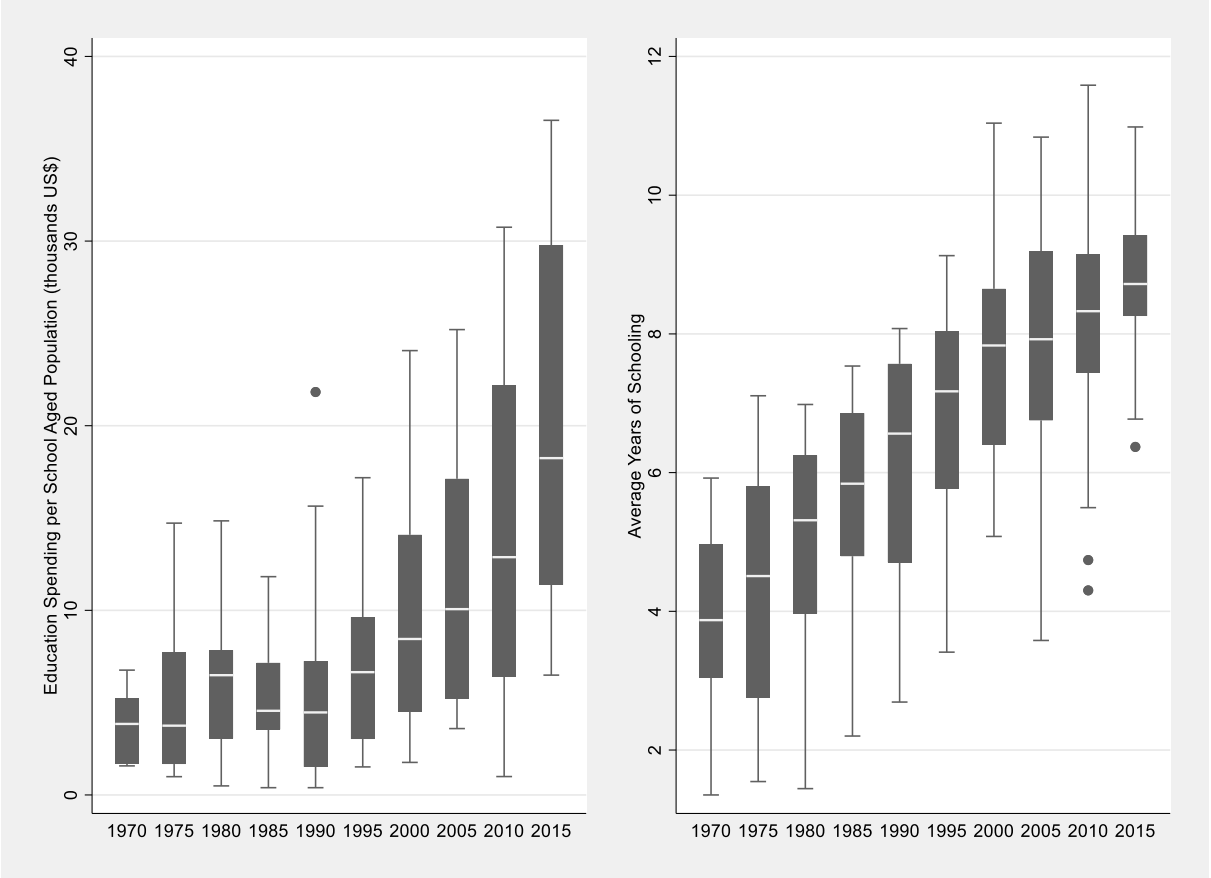


Figure 1 Time trends in Education Spending and Average Years of Schooling

Summary statistics for all variables in the data set are presented in Appendix B. Figure 1 shows that generally education spending, and average years of schooling along with it, has

increased. However, in the late 1980s and early 1990s median education spending takes a dip that doesn't recover to early 1980's level till late 1990s. The decrease in education spending can be explained by general trends to decrease public spending due to the financial crisis in the 80s and the market-oriented policies that followed in the 90s. This is likely to cause some systematic effects that are related to the time period. Furthermore, since education spending decreased in the 90s, but this did not have a negative effect on educational attainment levels which have continuously increased in the region, efficiency is likely to be relatively high in this period. Nevertheless, when looking at aggregate time trends in the data, it is important to remember that the sample of countries differs from year to year due to data availability, and thus differences in averages are also caused by differences in the sample.

Table 1 Correlation between allocation of education spending and interest variables

Correlation coefficients	Share of primary education spending	Share of secondary education spending	Share of tertiary education spending
Average years of schooling	-0.39	0.53	0.06
Gini	0.38	-0.17	-0.25
GDP per capita	-0.51	0.42	0.24

Source: Author's own calculations

Table 1 shows how allocation of education spending is related to average years of schooling, inequality, and the development level. The signs of the correlation coefficients are opposite for the share of primary spending compared to tertiary and secondary spending. As the educational level of the country increases, the share of primary education decreases, and the share of secondary education increases significantly. Higher educational level is also associated with higher share of tertiary education spending but not to the same extent as secondary education spending. Inequality is positively associated with the share of primary education spending and negatively associated with the share of secondary and tertiary education spending. This is somewhat surprising but could also reflect the fact that inequality and average years of schooling are negatively associated in the sample and this is reflected in the correlation coefficients with the Gini coefficient and the allocation of education spending. Unsurprisingly, development is negatively associated with primary education spending and positively associated with secondary and tertiary education spending. This is likely to be a reflection of the government's better ability to fund schooling as the country develops and the higher relative cost of secondary and tertiary education compared to primary education. Similarly to the correlation coefficient on average years of schooling, this is not likely to reflect a decrease in the amount of primary education spending.

4 Methods

In the first stage data envelopment analysis (DEA) is conducted to calculate the efficiency ranking and efficiency scores. In the second stage, a fixed effects regression is run to find the determinants of efficiency and to see how allocation of education spending is related to overall efficiency. The following two sections describe these methods in detail.

4.1 First-Stage: Data Envelopment Analysis

DEA analysis, originating from and popularised by Farrell (1957) and Charnes, Cooper and Rhodes (1978) assumes a convex production frontier. An output-oriented DEA aims to uncover by how much a decision-making unit, in this case the government or the education ministry, can increase its output without increasing the inputs. The output-oriented method is the most appropriate for this study since it is assumed that governments have a given budget for education and they aim to maximise the accumulated human capital with the given budget. It is also assumed that there are variable returns to scale as per other education spending literature (Afonso & St. Aubyn, 2006; Azar Dufrechou, 2016).

In mathematical form DEA can be described as follows (Lee & Ji, 2009; Afonso & St. Aubyn, 2006). First, there are S inputs and H outputs for each of N countries at different times, called a decision-making unit (DMU). In this case, as is usual for DEA analysis in education spending efficiency, there is only one input variable and one output variable. For the *j*-th DMU the data on inputs and outputs are represented by the vector x_j and y_j, respectively. The S×N input matrix, X, and the H×N output matrix, Y, represent the data of all N DMUs. With the data using DEA, we can then find the efficiency frontier such that on a production function no points lie above the frontier.

$$
\begin{aligned}
&Max_{\lambda,\theta_j}\,\theta_j \\
&s.to \quad \theta_j y_j \le Y\lambda \\
&\qquad X\lambda \le x_j \\
&\qquad n1\lambda = 1 \\
&\qquad \lambda \ge 0
\end{aligned}
\tag{1.1}
$$

In problem (1.1), θ_j represents the efficiency score which is ≤ 1 and measures the distance of *j* from the efficiency frontier. An efficient unit is indicated by $\theta_j=1$. The vector λ is a $(n \times 1)$ vector of constants and it is used to calculate the potential location on the efficiency frontier of an inefficient DMU. In particular, λ measures the weights between the efficient peers used to calculate the distance to efficiency frontier for *j*. The peers are the DMUs that are defining

the relevant efficiency frontier for j. The third restriction, $n1'\lambda = 1$, where $n1$ is a n-dimensional vector of ones, imposes a convex frontier. This restriction is needed to account for the variable returns to scale. The problem is solved for each DMU to obtain n efficiency scores. Figure 2 illustrates the efficiency frontier with variable returns to scale and how efficiency scores are calculated. Points A, B and C are on the efficiency frontier and their efficiency score, θ, would be 1. D is not an efficient unit and thus the efficiency score $[d_2/(d_1 + d_2)]$ would have a value between 0 and 1. In this case the input variable is education spending per school aged population and output is measured in average years of schooling.

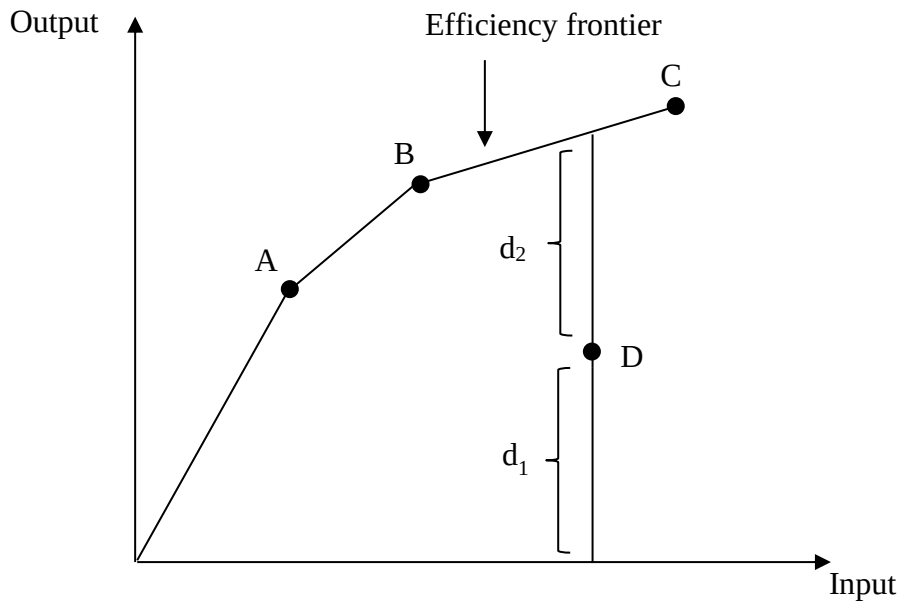


Figure 2 DEA Efficiency frontier with one input and output

In most of the efficiency literature, DEA has been used to find technical efficiency or how to maximize the output with the given inputs. DEA is not able to answer questions relating to allocative efficiency or how to optimize the relative proportions of inputs given their prices. While this study is interested in the allocation of the inputs, this is taken as a factor that influences technical efficiency. Since this study is comparing countries' spending in real PPP terms, it is assumed that the costs faced by different countries of accumulating the same amount of human capital are the same. Thus, differences in overall economic efficiency would only be explained by differences in technical efficiency. This is a strong assumption though and could cause biased estimates. However, it is less likely that the ratio between the relative cost of accumulating human capital at different levels would differ too drastically. Since spending at different levels is measured as shares of overall education spending, instead of measuring them in absolute terms, the bias is reduced in the second stage. Furthermore, adding control variables in the second stage helps to control for factors that are likely to have an impact on the relative costs of education.

4.2 Second-Stage Model: Fixed Effects Regression

The role of the second stage is to find which factors influence efficiency of public education spending in Latin America, and more specifically to find what the relationship between the composition of education spending and efficiency is. There are different kinds of factors which influence the efficiency of countries. First, there are time variant and time invariant characteristics of which the latter are usually out of the control of the countries governments since they stay fixed. Of these characteristics, some of the most important ones for efficiency in education spending are likely to be geographical area, ethnic and linguistic diversity (Alfred, Robinson & Alfred, 2011) as well as history. Especially the last of these is something which is hard to observe statistically and capture in data but is likely to have an impact on how education is viewed and thus the demand but also governments capability and knowledge to supply quality education. Therefore, a fixed effects model should be used to control for the time invariant characteristics. To use the fixed effects model and to find the effect of educational composition on efficiency, the time variant part of the error term εit must be unrelated to efficiency. However, there are likely to be a significant number of time-variant factors which affect efficiency and thus it is important to control for these. Another assumption that must hold for the FE model, is that the error term ε_{it} must be uncorrelated with the time variable. This assumptions is unlikely to hold since Latin American economies and thus government budgets are connected to each other. Thus, there could be common shocks that would significantly affect the variables of interest. The fixed effects model is only looking at within country trends and it could be that there is not enough variation within countries to capture the predicted trends.

There are several time variant characteristics that have an impact on efficiency and some of which governments are unable to have direct control over. Such characteristics include the share of rural population and the economic development level. These aspects should be controlled for to reduce omitted variable bias. The other variables are non-discretionary inputs or environmental variables that the government cannot directly control, while the composition of education spending is a discretionary input. The aim of the second stage analysis is to sufficiently control for environmental effects to see if allocation is contributing to inefficiency in education spending. Therefore, to estimate the effect of the composition of public education spending on efficiency of education spending, the following population model can be used:

$$\hat{\theta}_{jt} = \alpha + \beta_1 \frac{TER}{EDU}_{jt} + \beta_2 \frac{SEC}{EDU}_{jt} + \beta_3 RuralPop_{jt} + \beta_4 \ln GDPpc_{jt} + \eta_j + \varepsilon_{jt} \quad (1.2)$$

where $\hat{\theta}$ represents the efficiency score of country *j* in time period *t*. On the rights hand side of the equation, α represents the constant, $\frac{TER}{EDU}$ and $\frac{SEC}{EDU}$ represent the share of tertiary and secondary education spending of overall education spending, RuralPop represents the share of rural population, lnGDPpc is the log of real GDP per capita (US$ 2017), η includes all time-invariant characteristics that affect efficiency that are controlled for in the fixed effects model,

and finally ε is the error term and includes all unobserved time variant characteristics. The share of primary education spending is omitted to avoid perfect collinearity with the other compositional variables. If β_1 is positive, this would mean that increasing the share of tertiary education increases efficiency given that the share of secondary education spending stays the same. Since the share of primary education spending is the omitted category, a positive coefficient on the share of tertiary education spending would also signify that decreasing the share of primary education spending would increase efficiency. Whether β_1 or β_1 are positive, negative or close to zero is unknown and is the main result of interest for this study. The coefficient on the share of rural population is likely to be negative since providing access to education for a population that is more scattered is likely to be less cost efficient. The sign of β_1 is also unknown but a positive coefficient would suggest that more developed countries are more efficient.

In an alternative specification, the share of tertiary spending of overall education spending is interacted with an inequality dummy, *Gini*, to test for the institutional hypothesis. This specification is shown in Equation (1.3).

$$\hat{\theta}_{jt} = \alpha + \beta_1 \frac{TER}{EDU}_{jt} + \beta_2 \frac{SEC}{EDU}_{jt} + \beta_3 Gini_{jt} + \beta_4 Gini_{jt} \times \frac{TER}{EDU}_{jt} + \beta_5 \mathrm{X}_{jt} + \varepsilon_{jt} \tag{1.3}$$

In this specification the interpretation of β_1 changes, as it shows what the effect of increasing the share of tertiary education spending has on efficiency in a low inequality country. β_3 estimates the difference in efficiency between a highly unequal country and a more equal country if these countries were not spending any money on tertiary education. While the strict interpretation of the coefficient is not very meaningful, according to the hypothesis, the coefficient for Gini should be negative since unequal countries should be less efficient. The coefficient of interest for this hypothesis is β_4 which indicates whether highly unequal countries experience efficiency gains or losses with an increasing share of tertiary education spending. The hypothesis suggests that the coefficient on the interaction term is negative. The ***X*** term captures the effect of the two control variables, share of rural population and logged GDP per capita.

In the third specification, the share of tertiary spending of overall education spending will be interacted with overall education spending, *EduSpend*, as shown in Equation (1.4).

$$\hat{\theta}_{jt} = \alpha + \beta_1 \frac{TER}{EDU}_{jt} + \beta_2 \frac{SEC}{EDU}_{jt} + \beta_3 EduSpend_{jt} + \beta_4 EduSpend_{jt} \times \frac{TER}{EDU}_{jt} + \beta_5 \mathrm{X}_{jt} + \varepsilon_{jt} \tag{1.4}$$

This model is estimated to explain the results of the base model to see if the coefficient on the share of tertiary education spending can be explained by the changes in overall education spending that are associated with changes in the tertiary education spending. Since both of the variables in the interaction term are continuous the interpretation of the β_1 and β_1 are not very meaningful but once again the interaction term is the coefficient of interest. If in the base model, (1.2), the coefficient on β_1 is positive, a positive coefficient on the interaction term in (1.4) would suggest that this is explained by increases in tertiary education spending being generally associated with increases in overall education spending. If in turn in the base model,

(1.2), the coefficient on β_1 is negative, but there is a positive coefficient on the interaction term in (1.4), this would suggest that, on average, tertiary education spending has increased at the expense of primary and secondary education spending. It would also provide evidence suggesting that when countries increase the amount of tertiary education spending by increasing overall education spending, this has a positive effect on efficiency. If the interaction term is close to zero, then this would imply that increasing tertiary education spending without increasing spending at primary and secondary level does not provide efficiency gains.

The fourth specification attempts to capture heterogenous effects with varying initial levels of education by interacting the average years of schooling, *AvgYrsSch*, of the previous period with the share of tertiary education spending, as shown in Equation (1.5).

$$\hat{\theta}_{jt} = \alpha + \beta_1 \frac{TER}{EDU}_{jt} + \beta_2 \frac{SEC}{EDU}_{jt} + \beta_3 AvgYrsSch_{jt-1} + \beta_4 AvgYrsSch_{jt-1} \times \frac{TER}{EDU}_{jt} + \beta_5 \mathrm{X}_{jt} + \varepsilon_{jt} \tag{1.5}$$

Once again, the variables in the interaction term are continuous and unlikely to be zero and thus the interpretation of the coefficients on β_1 and β_3 are not very meaningful. The coefficient of interest in this specification is β_4 which when positive would suggest that increasing the share of tertiary education with increasing levels of initial education levels in the country has a positive effect on efficiency. When the coefficient on the share of tertiary education from the base model, (1.2), is also positive, together these results would suggest that countries have on average increased the share of tertiary education spending in accordance with the needs to further educate people. On the other hand, if the β_1 from (1.2) is negative and the interaction term in (1.5) remains positive, then this would imply that countries have on average moved too early to invest in tertiary education. If the coefficient on the interaction term is close to zero or negative this would mean that increasing the share of tertiary education spending regardless, of the initial education level, has a no effect or has a negative effect on efficiency.

To account for the effects of inequality, overall education spending and initial level of education, a full population model will be specified as follows:

$$\hat{\theta}_{jt} = \alpha + \beta_1 \frac{TER}{EDU}_{jt} + \beta_2 \frac{SEC}{EDU}_{jt} + \beta_3 Gini_{jt} + \beta_4 EduSpend_{jt} + \beta_5 AvgYrsSch_{jt-1} + \beta_6 \mathrm{X}_{jt} + \varepsilon_{jt} \tag{1.6}$$

In this specification, β_2 is predicted to be larger than β_1, β_3 is predicted to be negative, β_4 and β_3 are predicted to be positive. All of the specifications above are run with a fixed effect model with robust standard errors to account for heteroscedasticity, using an unbalanced panel data set.

5 Empirical Analysis

5.1 First-stage: Data Envelopment Results

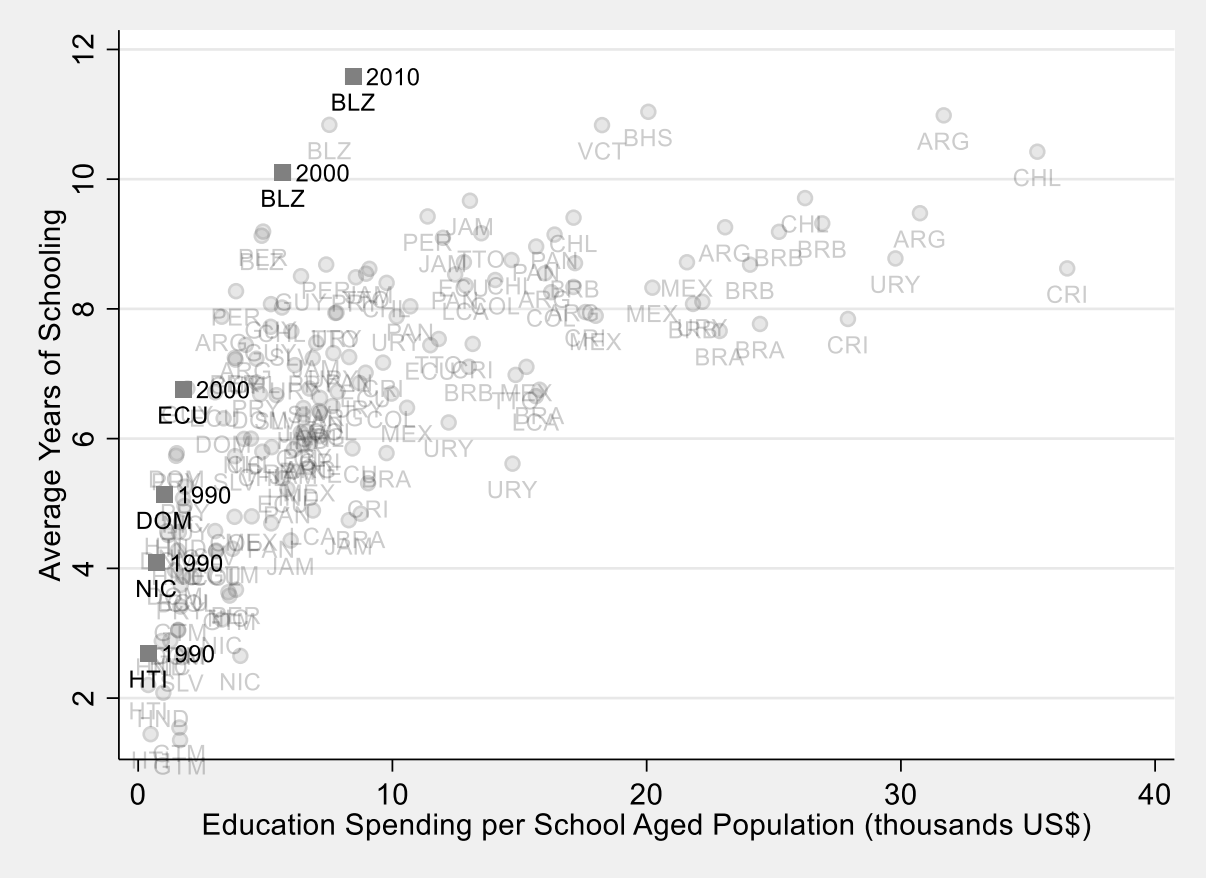


Figure 3 Education Spending and Schooling outcomes with Efficiency Frontier Highlighted

Figure 3 illustrates the observations used to calculate the efficiency scores and the efficiency frontier is indicated by the highlighted markers labelled with the country[1] and the year of observation. The full results from DEA can be seen in Appendix D, where each time period is marked with the first year of the 5-year time span. There are 25 countries for which data on years of schooling and average years of schooling are available for at least one time period,

[1] Country abbreviations are explained in Appendix C.

and many countries only have data for a limited amount of the time periods. In total there are 159 observations.

Table 2 Summary statistics for DEA efficiency scores

Variable		Mean	Std. Dev.	Min	Max	Observations
Efficiency Score	overall	0.68	0.16	0.21	1.00	N = 159
	between		0.13	0.40	0.99	n = 25
	within		0.12	0.31	1.08	T -bar = 6.36

Source: Author's own calculations

Table 2 shows that the average efficiency score throughout the sample is 0.68, meaning that on average LAC countries could have increased their average years of schooling by 32% with their given inputs between 1970-2019. For the time period, the average for years of schooling in the sample was 6.63 years and thus if the economies would have been efficient the average would have increased by 2.12 years up to 8.75 years, a significant improvement. The overall average efficiency score for the Caribbean, South America and Central America are 0.72, 0.70 and 0.62, respectively. While it seems that the Central America is least efficient, it could also be due to data selection issues. It is also hard to comment on any cross-country time trends in the period since there is a different sample of countries for each time period, but generally the trend seems to be positive. Efficiency was much lower before the mid-1980s than it was after. Furthermore, where data is available for more than one time period, each country improved in efficiency from first time period to the last one. However, as illustrated in Figure 3, the efficiency frontier is defined by six observations, of which half are from 1990. In fact, many of the countries have higher efficiency scores in the 90s than in their most recent observation. Shown in Table 2, the size of variation between countries and within countries are quite similar. The factors contributing to the variance will be dealt with in the second stage analysis. From country overall averages, the most efficient countries are Belize, Bahamas, and Saint Vincent and the Grenadines. These are all small countries with a population of less than half a million, and as seen from Figure 3, these countries stand out from the rest of the data as outliers. There is also no data for these countries before 1995 which could create an upward bias on the efficiency scores for them. The three least efficient countries are Guatemala, Brazil and Saint Lucia. Nevertheless, even these countries made significant improvements in efficiency.

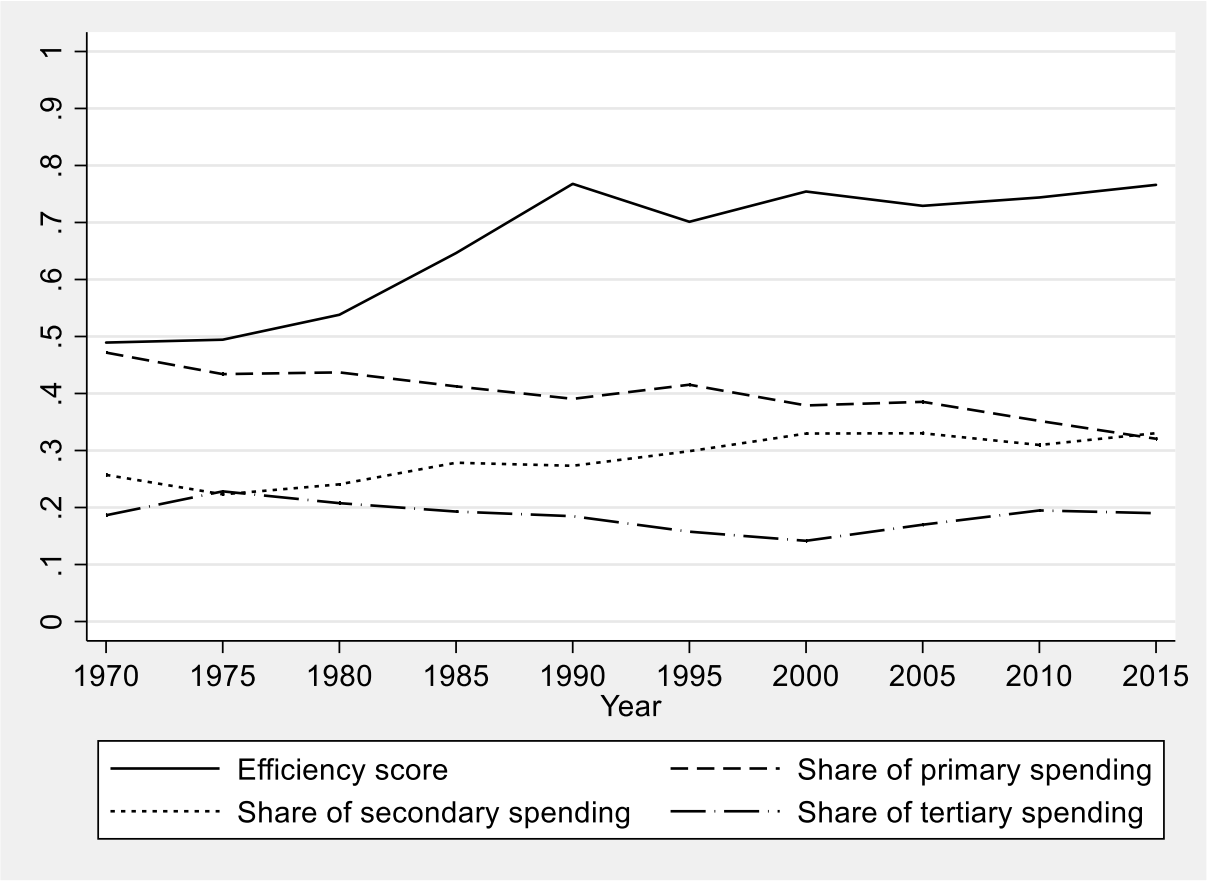


Figure 4 Trends in Effiicency Scores and Allocation of Education Spending (Averages)

Figure 4 shows that there is no clear relationship between average efficiency scores and the average share of tertiary spending. While the share of tertiary spending decreases steadily along with a general increasing trend in the efficiency scores between 1975-2000, the increase in tertiary education spending between 2000 and 2010 is not shown to be negatively reflected in efficiency. Furthermore, the dip in efficiency scores in 1995 cannot be explained by changes in the share of tertiary education spending. Trends in the share of primary and secondary education spending generally run opposite of one another and are relatively smooth. The share of primary education seems to best fit with the trends of efficiency scores. When the share of primary education spending has decreased, efficiency has increased and vice versa. This is most visible from 1990 onwards and a somewhat surprising finding which could be explained by issues of sample selection for each year as well as collinear factors between efficiency and the share of primary education spending. To get a better idea of the causal relationship between the two, regression analysis is needed. Furthermore, the steep increase in efficiency between 1970 and 1990 seems to be explained by something else than the composition of education spending. One of these explanations could be the observed decrease in education spending seen in Figure 1, which did not have an observable negative effect in average years of education.

Two of the points on the efficiency frontier are determined by Belize and the other two of the top three efficient countries are also relatively small nations with a population of less than 400 000 and are outliers from the rest of the data. Therefore, another set of efficiency scores have been calculated with and without countries with a population of less than half a million.

The full results are shown in Appendix E and summarised in graphical form in Appendix F. A regression analysis is conducted with both samples to check the robustness of the results.

5.2 Second-stage: Results from the Regression Analysis

Table 3 Results of a Fixed Effects Regression

	Country Fixed Effects				
	(1)	(2)	(3)	(4)	(5)
	FEbase	FEineq	FEspend	FEedulvl	FEfull
VARIABLES	Theta	Theta	Theta	Theta	Theta
Tertiary spending	0.278	0.222	-0.092	-1.284	0.180
	(0.270)	(0.244)	(0.526)	(0.983)	(0.270)
Secondary spending	0.392*	0.735**	0.489*	0.407**	0.701**
	(0.210)	(0.312)	(0.256)	(0.183)	(0.304)
Rural pop	-0.815***	-0.163	-0.854***	0.085	0.421
	(0.274)	(0.305)	(0.284)	(0.320)	(0.428)
$lnGDPpc_{t-1}$	0.044	0.076	0.023	-0.161***	-0.115*
	(0.069)	(0.058)	(0.101)	(0.054)	(0.062)
Gini (0.50=high)		0.038			0.012
		(0.181)			(0.029)
Tertiary spending × Gini		-0.135			
		(0.817)			
Edu spending			-0.012		0.002
			(0.011)		(0.002)
Tertiary spending × Edu spending			0.053		
			(0.044)		
Yrs of Sch_{t-1}				0.025	0.051***
				(0.024)	(0.014)
Tertiary spending × Yrs of Sch_{t-1}				0.221	
				(0.138)	
Constant	0.429	-0.198	0.684	1.819***	1.007
	(0.676)	(0.540)	(0.941)	(0.509)	(0.598)
Observations	133	112	133	130	111
R-squared	0.286	0.292	0.310	0.460	0.416
Number of countries	23	22	23	22	21

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3 shows the results for the regression analysis explaining the determinants of efficiency using a country fixed effects model with robust standard errors. The first columns shows the base model with 133 observations, where efficiency scores have been regressed on the variables of interest, share of tertiary education spending and share of secondary education spending, as well as some time variant control variables: share of rural population and lagged

log of GDP per capita. Using a country fixed effects model ensures that all time invariant characteristics such as the size of the country, ethnic diversity and culture are controlled for. The base model shows that on average in LAC between 1970-2019, when the share of secondary education spending is kept constant, increasing the share of tertiary education spending increased efficiency. The overall effect of the share of tertiary education spending is fairly small since on average a 10%-point increase in tertiary education spending increases the efficiency score by 0.03 units which translates to a 4% increase in the average efficiency score. Increasing the share of secondary education has a larger positive effect on efficiency than increasing tertiary education spending. The size of the coefficient on secondary education spending is 40% larger than on tertiary spending. Since the coefficients on tertiary and secondary education spending are positive, this implies that increasing spending at primary level decreases efficiency. As expected, the share of the rural population is negatively associated with efficiency and the effect is statistically significant. Furthermore, the development level of a country is positively associated with efficiency, though not statistically significant.

The second column explores the relationship between education and inequality. In this model, share of tertiary education has been interacted with an inequality dummy variable. Due to data unavailability, the number of observations falls significantly from the previous models to 112. This could create further issues with finding statistically significant results and could bias the results. Nevertheless, the coefficient on tertiary education spending indicates that for countries with a Gini coefficient that is below 0.5, increasing the share of tertiary education spending increases efficiency. For countries with a high level of inequality, the effect is opposite and thus providing evidence to support the institutional hypothesis. However, the coefficient on the interaction term is smaller than on the share of tertiary education spending and the result is highly statistically insignificant. Interestingly, although the coefficient on inequality is very small and the p-value on the coefficient is very large, the coefficient is still positive and not negative as has been found in the previous literature (Grigoli, 2015; Azar Dufrechou, 2016). Nevertheless, when inequality is controlled for the coefficient of secondary education becomes very large and highly statistically significant.

In the third column, education spending is interacted with the share of tertiary education spending to see whether increases in tertiary education spending are associated with increases in overall education spending which would explain the positive overall relationship between efficiency and increasing the share of tertiary education spending. The interaction term is positive, meaning that increasing education spending in association with increasing tertiary education spending has a positive effect on efficiency. Since the overall effect of increasing tertiary education spending in the base model was positive, this suggests that generally tertiary education spending does in fact not compete with the share of primary and secondary education spending but rather comes from a “separate pot”. When controlling for education spending, the positive coefficient on the share of secondary education spending becomes larger, compared to the base model.

In the fourth column, tertiary education spending has been interacted with average years of schooling form the previous period to see if the composition of education spending should change in accordance with the education level of the country. Due to missing data on years of schooling for all time periods, the number of observations falls by three from the base model.

The interaction coefficient is positive and statistically significant at the 15% significance level, meaning that the efficiency gains of increasing tertiary education grow with higher average levels of education attainment. This suggests that in LAC, the positive relationship between efficiency and the share of tertiary education spending in the base model can be explained by the governments having increased tertiary education spending when this has been needed to increase overall educational attainment. Once again, the positive effect on efficiency of increasing secondary education spending is larger than in the base model. In the fourth model the sign on both of the control variables change sign. This could be because average years of schooling is likely to be correlated with economic development and the share of rural population and thus the individual effect of the different determinants become hard to separate. The negative sign on GDP could also be explained by the fact in a situation where two countries have the same level of education but the other one has a higher level of GDP, it is likely to be a resource rich country. This could lead to less demand for education and thus lower efficiency. Overall, the results from the third and fourth model support one another as they show that LAC governments have increased spending on tertiary education when the educational attainment in the countries has been high enough and that the increase in the share of tertiary education spending has come with an increase in overall education spending and thus has been positive for overall efficiency.

In the last column, education spending, average years of schooling and inequality have been added as controls to the base model. In this model the number of observations decreases to 111 and the number of countries drops down by two to 21. Compared to the base model, the coefficient on tertiary education is significantly smaller and the coefficient on the share of secondary education is much larger and statistically significant. Since the coefficient on secondary education has been consistently positive and statistically significant, it seems that increasing the share of secondary education spending is better for efficiency than increasing the share of tertiary education spending. Together the positive coefficients on tertiary education and secondary education suggest that, on average, LAC governments have overinvested in primary education or more likely that investments at primary level have been the most inefficient. For the share of rural population and GDP, the sign of the coefficients have changed from the base model due to average years of schooling being added as a control. As discussed previously, this is observed most likely because average years of education in the previous period captures a large part of the effect of development on efficiency. Increasing overall education spending and higher inequality is positively associated with efficiency, though the p-value on the latter is very large and the effect is fairly small. Nevertheless, the positive coefficient on the dummy variable for Gini is somewhat surprising.

5.3 Robustness check

As noted from the DEA results, the most efficient observations seem to be concentrated among the small, mostly Caribbean countries and outliers. Despite the fixed effects model controlling for characteristics such as population size, it is important to ensure that the results are not biased since these countries have a somewhat special context. Therefore, within country trends could be different and not very applicable to other countries or regions.

Appendix G shows the results of the base model and the full model where columns 1 and 4 have the full sample, columns 2 and 5 the Caribbean countries omitted and columns 3 and 6 without countries with a population of less than 0.5 million. There are six Caribbean countries in the original sample and three countries are removed in the third sample specification. Generally, the results remain the same throughout different sample specifications. The sign on all coefficients are of the same sign when compared to the original sample. The coefficient on tertiary education becomes slightly larger in the sample without Caribbean countries whereas it decreases slightly in the sample without small countries and the new efficiency scores. However, the same happens for the coefficient on the share of secondary education spending as well which suggests that the change is more due to statistical issues rather than revealing true differences in the relationship. In the base model without small countries, the coefficient on secondary education spending becomes insignificant due to relatively higher variance. However, the positive effect of secondary spending is still larger than the effect of tertiary spending.

In order to create an easy interpretation of the interaction term between the Gini coefficient and the share of tertiary education spending, the information of the Gini coefficient was summarised by a dummy variable. Drawing the line between high and low inequality is somewhat arbitrary and so it could be that the results are biased by the specific definition of the Gini coefficient. It is especially vital to see how different specifications of the Gini coefficient impact the results since the sign of the coefficient on inequality conflicts with findings from previous literature (Azar Dufrechou, 2016; Grigoli, 2015). Three different inequality variables have been used to confirm the results on the relationship between inequality and efficiency as well as the interaction between inequality and tertiary education (Appendix H). The first modification to the initial inequality dummy is to change the cut-off point at 0.45, which is roughly at the median. When the new dummy is interacted with the share of tertiary education spending the coefficient on tertiary spending is slightly larger than with the higher cut-off point and statistically significant. The interaction term is still negative and significantly further from zero. Therefore, it seems that the difference in the effect of share of tertiary education on efficiency is more pronounced when the restriction on high inequality is lowered. In the full model where inequality is added as a control but not interacted with the share of tertiary education spending, there is no considerable change between having the dummy cut-off point at the median or at the 75th percentile. In the second modification, the Gini coefficient has been added and interacted as a continuous variable. The results also remain similar when the Gini coefficient is added into the model as a continuous variable. In the full model, having the Gini coefficient as a continuous variable gives a very large positive coefficient that is statistically significant. Therefore, these results provide further proof that inequality is positively associated with efficiency.

Finally, the efficiency scores are not normally distributed since there is a maximum value of 1 for theta. Therefore, previous research has used censored regression models where this has been taken into account. As per Azar Dufrechou (2016), a truncated regression model with bootstrapped standard errors is run to see if the non-normal distribution of the efficiency scores is causing biased results. Appendix I shows for comparison the original results in columns 1 and 4 and the estimations for the truncated regression model where the upper limit has been set as 1 and thus the efficiency frontier is omitted from the regression analysis. The main results from the fixed effects model hold in the truncated model. In the second and firth

column country fixed effects are not controlled for whereas in the third and last column country variable has been added as a categorical control variable with one category is omitted[2]. The size of the coefficients are very different in the model where country fixed effects are not controlled for since the model suffers from a high degree of omitted variable bias. However, the sign on the coefficients for the compositional variables are the same as in the original results for both the base and the full model. In fact, the only significant change in the truncated regression can be seen in the full model without country fixed effects for the share of rural population and inequality for which the sign of the coefficient become negative. Overall, the results from the truncated model and other robustness checks suggest that the original results are accurately capturing the effect of the composition of education spending on public education spending.

5.4 Discussion

As illustrated by Figure 4, efficiency of education spending is not directly associated with a low share of tertiary education spending. Instead, primary education seems to be negatively associated with efficiency. Looking at the correlation between the efficiency scores and the share of tertiary education spending is not yet enough to comment on the hypothesis but it is important to compare the finding to previous literature to see if the results are plausible. Comparing efficiency rankings with previous studies is difficult since efficiency ranking will always be in relation to the chosen sample and there are no studies with the same sample as has been used in this paper. Nevertheless, since Azar Dufrechou (2016) studies 11 Latin American countries between 1970-2010 and thus provides the closest comparison to this study. When comparing average efficiency scores, her estimations are consistently higher, meaning that the countries are relatively more efficient in relation to the most efficient country in the sample. Furthermore, the time trends in efficiency scores are similar but comparing efficiency scores at country level as an average across time yields very different results. The differences between the results in Azar Dufrechou (2016) and this paper are reasonable since her sample is smaller which can be seen also reflected in the smaller between country variation relative to within country variation. Azar Dufrechou's sample is also biased towards countries that are found in this paper to be less efficient which explains why the average efficiency score in the paper would be lower. Another comparison can be made with Afonso, Romero-Barrutieta and Monsalve (2013) who look at overall public spending efficiency in LAC between 2001-2010. It seems that overall public spending efficiency and education spending efficiency are not strongly correlated since for 2010 Guatemala has been shown to have the lowest efficiency rating in this paper while for Afonso, Romero-Barrutieta and Monsalve (2013) Guatemala is on the efficiency frontier. However, in both analyses

[2] The statistical software Stata which is used for the regression analysis does not allow for truncated panel data models. Hence, country fixed effects must be controlled for manually.

Chile is found to be relatively efficient. The average and minimum efficiency score are slightly higher for overall public spending efficiency compared to education spending efficiency. The regression results provide partial evidence to support the main hypothesis since the coefficient on the share of secondary education spending is positive and larger than on the share of tertiary education spending. However, increasing the share of primary education spending is less efficient than increasing tertiary education spending and thus this result goes against the main hypothesis. It seems that funding tertiary education in LAC is beneficial for increasing overall educational attainment in the region and students are not funding their university studies to the same extent in the absence of public funding. The results also support the three hypothesises on heterogenous effects. The results suggest that the institutional hypothesis is correct in the sense that highly unequal countries have diverted funds to tertiary education in an inefficient way, but the main results show that on average this has not been the case in LAC. Furthermore, there is some doubt to the extent that inequality in itself is related to misallocation of education spending since the relationship between inequality and efficiency is not negative. The results provide evidence to support the hypothesis that tertiary education spending does not increase at the expense of primary and secondary education spending but rather that the resources come from separate funds. Furthermore, the results on initial educational level imply that countries are more efficient with their education spending when the share of tertiary education spending is increased in accordance with the initial level of schooling in the country. Together the last two hypothesises help to explain why increasing the share of tertiary education spending in LAC has generally increased efficiency. Since there are heterogenous effects of increasing tertiary education spending, the relationship between increasing the share of tertiary education spending and efficiency is not always going to be positive.

When comparing the regression results to previous literature, the results for efficiency of the composition of education spending are not aligned with the results in measuring efficiency in terms of returns to education. Judson (1998) finds that the enrolment rate for primary is too low, but it seems that in recent times in LAC increasing education spending at primary level has been the least efficient. Furthermore, Judson (1998) finds that secondary enrolment levels are too high, whereas the results above based on educational attainment show that increasing spending at secondary education is the largest contributor to improving efficiency in LAC between 1970-2019. For tertiary education, the results are similar to Judson (1998) since her research also suggests that countries would benefit from increasing tertiary education spending. This conclusion contradicts the suggestion by Lindert (2010) that LAC counties have overinvested in tertiary education. The contradictions between the studies could be due to the different time periods in question. Judson (1998) and Lindert (2010) look at educational spending and outcomes in the 20th century only, when education attainment levels in LAC where much lower on average. Therefore, these results suggest that overinvestment in tertiary education has not, on average, been an issue in the region anymore even though it might have been earlier.

Previous research has found that inequality has a negative effect on efficiency (Azar Dufrechou, 2016; Grigoli, 2015). However, the results above show that inequality would have a positive effect on efficiency and these results hold up to robustness checks. Similarly, the share of rural population is shown to be positively related with efficiency despite previous research suggesting otherwise (Grigoli, 2015). Some level of bias might be caused by the

measurement of the output variable. This can be seen by the increase in efficiency in the 1990s that is likely to be caused by the fact that governments reduced their spending on education in this period, yet this did not have a significant negative effect on the average years of schooling in the countries since those that were already out of the schooling system were not affected by the changes in spending patterns. This is something that should be addressed in future research and a variable which captures immediate schooling outcomes would need to be used to avoid such bias.

6 Conclusion

This paper has analysed public education spending efficiency in LAC between 1970-2019. The paper provided evidence on how the allocation of education spending and specifically increasing tertiary education spending has affected the efficiency of education spending. First efficiency scores were calculated for the countries in five-year time spans and trends between efficiency and allocation revealed that there is no direct correlation between tertiary education spending and efficiency. However, trends in primary education spending are reflected in average efficiency scores especially since the 1990s. Then the efficiency scores were regressed on the share of tertiary education spending and the share of secondary education spending as well as different explanatory variables based on previous literature. The results are somewhat in line with the hypothesis of this paper since investing in secondary education seems to be more efficient than investments at tertiary level. However, the finding that investing in tertiary education would be more beneficial for efficiency than increasing investing at primary level contradicts the original hypothesis. The base results showed that while increasing tertiary education spending increased efficiency, increasing secondary education spending increased efficiency more and the coefficient on secondary education were consistently statistically significant. The positive average effect of increasing tertiary education spending can be explained through different channels. First, there is reason to believe that tertiary education spending is not in competition with basic education spending since there are increasing efficiency gains when the share of tertiary education spending increases along with education spending. Second, countries in LAC have increased their education spending at tertiary level based on the existing average educational attainment level in the country. This can be seen from the growing efficiency gains of increasing tertiary education spending with higher existing educational attainment level. The paper also explored whether inefficiencies in LAC could be explained by highly unequal economies misallocating their spending to tertiary education. The results for this are mixed since the interaction term with an inequality dummy is negative, but the effect of inequality on efficiency is found to be positive. Nevertheless, the results can be used to provide an explanation on how inequality can be harmful for efficiency. The results hold up to robustness checks but the coefficient on tertiary education or the interaction terms are not statistically significant.

Overall, the evidence presented contradicts some of the claims made by Lindert (2010) who argues that high shares of tertiary education spending would be the reason for the low inefficiency in public education spending in LAC. Yet, the results do align with the institutional story of human capital development in LAC told most prominently by Engerman, Mariscal and Sokoloff (2009). The evidence contradicts also the concerns by Psacharopoulos (1996) that developing countries are investing too much in tertiary education.

6.1 Practical Implications

Efficiency gains were largest and consistently significant for secondary education spending, and thus it is likely that a higher share of secondary education spending would increase the efficiency of education spending. Since the positive coefficient on tertiary and secondary education spending suggests that there are efficiency losses of increasing primary education spending, there could be significant sources for improvement in internal efficiency at primary level. It is unlikely to be beneficial for countries to reduce the amount of primary education spending. Since there are heterogenous effects of tertiary education spending based on the educational level of the country and education spending, increasing the share of tertiary education spending depends on the context. Furthermore, it seems that in LAC countries tertiary education budgets are determined independently from basic education budgets which has been successful in terms of increasing efficiency. Therefore, having high spending on tertiary education in itself is not a cause for concern. This does motivate future research on education spending to focus more closely on specifically basic education spending in developing countries rather than looking at overall education spending. Finally, it seems that countries in LAC have successfully been able to adjust the level of tertiary education spending to their educational attainment level. Therefore, countries with very low average education should not necessarily increase tertiary education. However, the results above can only provide recommendations for the composition of education spending on grounds of efficiency. There could be, for example, reasons for decreasing spending at tertiary level on equitability grounds (Lustig, 2014). Furthermore, the recommendations are based on the assumption that the goal of the government is to increase the overall human capital and not, for example, to maximise the returns on their investments in education.

6.2 Limitations and Future Research

There are some limitations to the results which warrant further research. Measuring the educational output of the inputs in the right time period is difficult. The consequences of this are seen by the high efficiency scores in the 1990s when education spending decreased as a results of strict fiscal policies. Yet, the effects of this are not reflected in the output measure since it is highly biased by individuals who have already completed schooling. It is hard to capture the output of education spending in the correct time period as the output level will also differ depending on the context. For example, the output of primary school investments are only seen once the students complete their full education which for some will be directly after or even before completing primary school, but for some after completing 15 years of schooling. However, the effects of investment on tertiary education are experienced usually after three or five years. This could also be one of the reasons why the results are biased away from supporting investments in primary education. Furthermore, it is very likely that the people who were in primary school in the 1990s suffered the most, as the quality of teaching likely decreased as a result of less spending per pupil. However, without an output measure, such as test scores, which measure the educational output consistently throughout the

education system, it is hard to observe such phenomena in the data. Comparable test scores would also give a better indication of the quality of education which attainment levels are not able to capture. Since data on comparable ability tests are hard to collect, especially from earlier periods, more data on other quality indicators such as student-teacher ratio would also help to capture the human capital output (Afonso & St. Aubyn, 2006). Not being able to control for quality of education could explain the negative effect of increasing spending at primary level as it could be that more investment in primary education has higher returns from quality at primary level but also at later levels.

Finding statistically significant results with the given data set is difficult due to the small sample size. Some of this is due to missing data for the countries in the data set for specific time periods. If all 25 countries in the data set would have sufficient data for all time periods, the sample size would double. Another way to increase the sample size would be to add countries from other regions to the dataset since currently efficiencies are only measured relative to other countries in the region in other time periods. However, if LAC is relatively less efficient in their education spending compared to other regions it might also be interesting to see, for example, if the high inequality in the region is causing more inefficiencies relative to other regions (Lindert, 2010). Nevertheless, the issue of small sample size is not likely to cause too much bias in the results since the robustness checks have shown the results to be stable.

The results also spark further interest for political economy spheres to investigate the relationship between institutions and human capital development. Since the results suggest that tertiary education budgets are set separately from basic education, it would be interesting to qualitatively investigate how LAC governments and education ministries set their budgets and how allocation decisions are made. Finally, since institutional structures seem to matter for efficiency of public spending, including data on different indicators of institutional quality might capture which kinds of institutions are important for efficiency.

References

Acemoglu, D., Johnson, S. & Robinson, J. A. (2005).Institutions as a Fundamental Cause of Long-Run Growth, Handbook of economic growth, vol. 1, no. 385-472.

Afonso, A., Romero-Barrutieta, A. & Monsalve, E. (2013).Public Sector Efficiency: Evidence for Latin America, vol. no.

Afonso, A. & St. Aubyn, M. (2006).Cross-Country Efficiency of Secondary Education Provision: A Semi-Parametric Analysis with Non-Discretionary Inputs, Economic Modelling, vol. 23, no. 3, pp 476-491 Available online: http://www.sciencedirect.com/science/article/pii/S0264999306000149.

Alfred, M. V., Robinson, P. E. & Alfred, M. C. (Year) Published. Adult Education and Lifelong Learning in the Caribbean and Latin America. Adult Education Research Conference Proceedings, 2011. Citeseer, 9-15.

Arrow, K. J. (1973).Higher Education as a Filter, Journal of Public Economics, vol. 2, no. 3, pp 193-216 Available online: http://www.sciencedirect.com/science/article/pii/0047272773900133.

Azar Dufrechou, P. (2016).The Efficiency of Public Education Spending in Latin America: A Comparison to High-Income Countries, International Journal of Educational Development, vol. 49, no. 188-203 Available online: http://www.sciencedirect.com/science/article/pii/S0738059316300281.

Backman, M. (2014).Human Capital in Firms and Regions: Impact on Firm Productivity, Papers in Regional Science, vol. 93, no. 3, pp 557-575.

Barro, R. J. & Lee, J. W. (2013).A New Data Set of Educational Attainment in the World, 1950–2010, Journal of development economics, vol. 104, no. 184-198.

Baten, J. & Mumme, C. (2010).Globalization and Educational Inequality During the 18th to 20th Centuries: Latin America in Global Comparison, Revista de Historia Económica / Journal of Iberian and Latin American Economic History, vol. 28, no. 2, pp 279-305 Available online: https://www.cambridge.org/core/article/globalization-and-educational-inequality-during-the-18th-to-20th-centuries-latin-america-in-global-comparison/4712E734B46847D88E4BB4487FBE95B2.

Behrman, J. R., Parker, S. W. & Todd, P. E. (2005). Long-Term Impacts of the Oportunidades Conditional Cash Transfer Program on Rural Youth in Mexico,

Benhabib, J. & Spiegel, M. M. (1994).The Role of Human Capital in Economic Development Evidence from Aggregate Cross-Country Data, Journal of Monetary economics, vol. 34, no. 2, pp 143-173.

Benhabib, J. & Spiegel, M. M. (2005). Chapter 13 Human Capital and Technology Diffusion. in: Aghion, P. & Durlauf, S. N. (eds.) Handbook of Economic Growth. Elsevier pp 935-966.

Bennell, P. (1996).Rates of Return to Education: Does the Conventional Pattern Prevail in Sub-Saharan Africa?, World development, vol. 24, no. 1, pp 183-199.

Birdsall, N. (1996).Public Spending on Higher Education in Developing Countries: Too Much or Too Little?, Economics of Education Review, vol. 15, no. 4, pp 407-419 Available online: http://www.sciencedirect.com/science/article/pii/S0272775796000283.

Brown, D. S. & Hunter, W. (2004).Democracy and Human Capital Formation:Education Spending in Latin America, 1980 to 1997, Comparative Political Studies, vol. 37, no. 7, pp 842-864 Available online: https://journals.sagepub.com/doi/abs/10.1177/0010414004266870.

Castillo Caicedo, M., Monroy del Castillo, R. D. & Cardona Ceballos, V. (2015).Efecto Universidad En El Valle Del Cauca 2009: Un Analisis Multinivel. (the University Effect in Valle Del Cauca 2009: A Multilevel Analysis. With English Summary.), Apuntes del CENES, vol. 34, no. 59, pp 15-38 Available online: http://ludwig.lub.lu.se/login?url=https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,uid&db=ecn&AN=1538547&site=ehost-live.

Charnes, A., Cooper, W. W. & Rhodes, E. (1978).Measuring the Efficiency of Decision Making Units, European journal of operational research, vol. 2, no. 6, pp 429-444.

Cruces, G., García Domench, C. & Gasparini, L. (2014). Inequality in Education: Evidence for Latin America, Oxford: Oxford University Press.

Curtin, T. R. C. & Nelson, E. A. S. (1999).Economic and Health Efficiency of Education Funding Policy, Social Science & Medicine, vol. 48, no. 11, pp 1599-1611 Available online: https://www.sciencedirect.com/science/article/pii/S0277953699000842.

Daude, C. & Robano, V. (2015).On Intergenerational (Im)Mobility in Latin America, Latin American Economic Review, vol. 24, no. 1, pp 9 Available online: https://doi.org/10.1007/s40503-015-0030-x.

Drummond, M. F. (1989).Output Measurement for Resource Allocation Decisions in Health Care, Oxford Review of Economic Policy, vol. 5, no. 1, pp 59-74 Available online: http://www.jstor.org/stable/23606198 [Accessed 2021/05/24/].

Engerman, S. L., Mariscal, E. V. & Sokoloff, K. L. (2009). The Evolution of Schooling in the Americas, 1800–1925. in: Eltis, D., Lewis, F. D. & Sokoloff, K. L. (eds.) Human Capital and Institutions: A Long-Run View. Cambridge: Cambridge University Press pp 93-142.

Engerman, S. L. & Sokoloff, K. L. (2005). Colonialism, Inequality, and Long-Run Paths of Development. National Bureau of Economic Research, Inc, NBER Working Papers: 11057.

Farrell, M. J. (1957).The Measurement of Productive Efficiency, Journal of the Royal Statistical Society: Series A (General), vol. 120, no. 3, pp 253-281 Available online: https://rss.onlinelibrary.wiley.com/doi/abs/10.2307/2343100.

Feenstra, R. C., Inklaar, R. & Timmer, M. P. (2015).The Next Generation of the Penn World Table, American economic review, vol. 105, no. 10, pp 3150-82.

Frankema, E. (2009).The Expansion of Mass Education in Twentieth Century Latin America: A Global Comparative Perspective, Revista de Historia Económica / Journal of Iberian and Latin American Economic History, vol. 27, no. 3, pp 359-396 Available online: https://www.cambridge.org/core/article/expansion-of-mass-education-in-twentieth-century-latin-america-a-global-comparative-perspective/BFBA63CA3139E35A91B04F801CFDAFA6.

Franklin, M., Ince, E. & Hosein, R. (2014).Avoiding Vertical Inefficiencies in Funding Tertiary Level Education (Tle) in Resource Abundant States, Social and Economic Studies, vol. 63, no. 1, pp 111-152 Available online: http://ludwig.lub.lu.se/login?url=https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,uid&db=ecn&AN=1597477&site=ehost-live

Gasparini, L., Cruces, G., Tornarolli, L. & Mejía, D. (2011).Recent Trends in Income Inequality in Latin America [with Comments], Economia, vol. 11, no. 2, pp 147-201.

Glewwe, P. & Jacoby, H. G. (2004).Economic Growth and the Demand for Education: Is There a Wealth Effect?, Journal of Development Economics, vol. 74, no. 1, pp 33-51 Available online: https://www.sciencedirect.com/science/article/pii/S0304387803001792.

Goldin, C. & Katz, L. (2007). The Race between Education and Technology: The Evolution of U.S. Educational Wage Differentials, 1890 to 2005,

Gomes-Neto, J. B. & Hanushek, E. A. (1994).Causes and Consequences of Grade Repetition: Evidence from Brazil, Economic Development and Cultural Change, vol. 43, no. 1, pp 117-148.

Gomez Meneses, F. E. & Zarate Camelo, M. A. (2011).Gasto Publico En Educacion Frente Al Comportamiento De Los Principales Agregados Economicos En Latinoamerica. (Economic and Development Performance of Public Spending on Education. With English Summary.), Revista Finanzas y Politica Economica, vol. 3, no. 1, pp 27-38 Available online: http://ludwig.lub.lu.se/login?url=https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,uid&db=ecn&AN=1390804&site=ehost-live.

Grigoli, F. (2015).A Hybrid Approach to Estimating the Efficiency of Public Spending on Education in Emerging and Developing Economies, Applied Economics and Finance, vol. 2, no. 1, pp 19-32.

Gupta, S., Schwartz, G., Tareq, S., Allen, R., Adenauer, I., Fletcher, K. T. & Last, D. (2007).Fiscal Management of Scaled-up Aid, vol. no.

Gupta, S. & Verhoeven, M. (2001).The Efficiency of Government Expenditure: Experiences from Africa, Journal of Policy Modeling, vol. 23, no. 4, pp 433-467 Available online: http://www.sciencedirect.com/science/article/pii/S0161893800000363.

Hanushek, E. A. & Kimko, D. D. (2000).Schooling, Labor-Force Quality, and the Growth of Nations, American Economic Review, vol. 90, no. 5, pp 1184-1208 Available online: <Go to ISI>://WOS:000165912000006.

Herrera, S. & Ouedraogo, A. (2018). Efficiency of Public Spending in Education, Health, and Infrastructure : An International Benchmarking Exercise. The World Bank, Policy Research Working Paper Series: 8586.

Herrera, S. & Pang, G. (2006).How Efficient Is Public Spending in Education?, Ensayos sobre Politica Economica, vol. no. 51, pp 137-201

Jacob, B. A. & Lefgren, L. (2009).The Effect of Grade Retention on High School Completion, American Economic Journal: Applied Economics, vol. 1, no. 3, pp 33-58 Available online: https://www.aeaweb.org/articles?id=10.1257/app.1.3.33.

Jayasuriya, R. & Wodon, Q. (2003). Efficiency in Reaching the Millennium Development Goals: World Bank Publications.

Judson, R. (1998).Economic Growth and Investment in Education: How Allocation Matters, Journal of Economic Growth, vol. 3, no. 4, pp 337-359 Available online: https://doi.org/10.1023/A:1009763906365.

Krueger, A. B. & Lindahl, M. (2001).Education for Growth: Why and for Whom?, Journal of Economic Literature, vol. 39, no. 4, pp 1101-1136 Available online: https://dx.doi.org/10.1257/jel.39.4.1101.

Lavado, R. F. & Cabanda, E. C. (2009).The Efficiency of Health and Education Expenditures in the Philippines, Central European Journal of Operations Research, vol. 17, no. 3, pp 275-291 Available online: <Go to ISI>://WOS:000269187400005.

Lee, C. & Ji, Y.-b. (Year) Published. Data Envelopment Analysis in Stata. Stata Conference DC, 2009. Citeseer.

Lindert, P. H. (2010).The Unequal Lag in Latin American Schooling since 1900: Follow the Money, Revista de Historia Economica, vol. 28, no. 2, pp 375-405 Available online: http://ludwig.lub.lu.se/login?url=https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,uid&db=ecn&AN=1149566&site=ehost-live.

Lochner, L. & Monge-Naranjo, A. (2012).Credit Constraints in Education, Annual Review of Economics, vol. 4, no. 1, pp 225-256 Available online: https://www.annualreviews.org/doi/abs/10.1146/annurev-economics-080511-110920.

Lustig, N. (2014).Income Redistribution and Poverty Reduction in Latin America: The Role of Social Spending and Taxation in Achieving Development Goals, Development, vol. 57, no. 3, pp 388-399 Available online: https://doi.org/10.1057/dev.2015.4.

Manacorda, M. (2012).The Cost of Grade Retention, The Review of Economics and Statistics, vol. 94, no. 2, pp 596-606 Available online: https://www.mitpressjournals.org/doi/abs/10.1162/REST_a_00165 %X

Manacorda, M., Sanchez-Paramo, C. & Schady, N. (2010).Changes in Returns to Education in Latin America: The Role of Demand and Supply of Skills, ILR Review, vol. 63, no. 2, pp 307-326 Available online: https://journals.sagepub.com/doi/abs/10.1177/001979391006300207.

Mandl, U. (2007).Was Beeinflusst Die Effizienz Der Bildungsausgaben? Ein Internationaler Vergleich Der Bildungsausgaben. (What Affects the Efficiency of Public Spending on Education? With English Summary.), Wirtschaftspolitische Blatter, vol. 54, no. 1, pp 131-142 Available online: http://ludwig.lub.lu.se/login?url=https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,uid&db=ecn&AN=0919865&site=ehost-live.

Marozau, R., Guerrero, M. & Urbano, D. (2021).Impacts of Universities in Different Stages of Economic Development, Journal of the Knowledge Economy, vol. 12, no. 1, pp 1-21 Available online: <Go to ISI>://WOS:000633388700001.

Méndez, L. (2020).University Supply Expansion and Inequality of Opportunity of Access: The Case of Uruguay, Education Economics, vol. 28, no. 2, pp 115-135.

Mincer, J. (1974).Schooling, Experience, and Earnings. Human Behavior & Social Institutions No. 2, vol. no.

Naert, F. (2004).Higher Education as an International Public Good and Gats: A Paradox?, UNU-CRIS Occasional Papers, vol. no.

OECD (2020). Making the Most of Technology for Learning and Training in Latin America.

Palmer, S. & Torgerson, D. J. (1999).Economic Notes: Definitions of Efficiency, BMJ (Clinical research ed.), vol. 318, no. 7191, pp 1136 Available online: http://ludwig.lub.lu.se/login?url=https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,uid&db=cmedm&AN=10213735&site=ehost-live.

Psacharopoulos, G. (1996).Public Spending on Higher Education in Developing Countries: Too Much Rather Than Too Little, Economics of Education Review, vol. 15, no. 4, pp 421-422 Available online: http://ludwig.lub.lu.se/login?url=https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,uid&db=eric&AN=EJ537496&site=ehost-live.

Psacharopoulos, G. (2003). Returns to Education: A Further International Update and Implications. in: Scheraga, J. D. (ed.) Discounting and Environmental Policy. International Library of Environmental Economics and Policy. pp 63-84.

Psacharopoulos, G., Tan, J.-P. & Jimenez, E. (1986). Financing Education in Developing Countries: An Exploration of Policy Options: Washington, D.C.: World Bank.

Robles, M., Rubio, M. G. & Stampini, M. (2019).Have Cash Transfers Succeeded in Reaching the Poor in Latin America and the Caribbean?, Development Policy Review, vol. 37, no. S2, pp O85-O139 Available online: https://onlinelibrary.wiley.com/doi/abs/10.1111/dpr.12365.

Salazar Cuellar, A. F. (2014).The Efficiency of Education Expenditure in Latin America and Lessons for Colombia, Desarrollo y Sociedad, vol. no. 74, pp 19-67.

Sanroman, G. (2006).Returns to Schooling in Uruguay, Documento de Trabajo/FCS-DE; 14/06, vol. no.

Solt, F. (2019). The Standardized World Income Inequality Database, Versions 8-9. V6 ed.: Harvard Dataverse.

UN. 2015. Transforming Our World : The 2030 Agenda for Sustainable Development, UN

UNESCO Institute for Statistics. (2021). Available online: www.uis.unesco.org/DataCentre

Villar, A. & Zoido, P. (2016).Challenges to Quality and Equity in Educational Performance for Latin America, a Pisa 2012 Perspective, RELIEVE. Revista Electrónica de Investigación y Evaluación Educativa, vol. 22, no. 1, pp 1-10.

Wagstaff, A. & Wang, L. C. (2011). A Hybrid Approach to Efficiency Measurement with Empirical Illustrations from Education and Health. The World Bank, Policy Research Working Paper Series: 5751.

Winkler, D. R. (1990). Higher Education in Latin America. Issues of Efficiency and Equity. World Bank Discussion Papers 77: ERIC.

Wolff, L., Schiefelbein, E. & Schiefelbein, P. (2002).Primary Education in Latin America, The unfinished agenda. Technical Paper Series Nº EDU-120. Washington, DC: Interamerican Development Bank, vol. no.

World Bank. (2021). World Bank Open Data [Online]. Available online: https://data.worldbank.org/ [Accessed 20 Apr 2021].

Appendix A

Non-missing variables by country and year

Countries	Sum of non missing variables										Total of non missing time periods
	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	
ARG	8	8	8	8	8	8	8	8	8	8	10
BHS							5				1
BLZ						8	8	8	7		4
BRA						8	8	8	8	8	5
BRB		8			8	8	8	8	7		6
CHL	8	8	8	8	8	8	8	8	8	8	10
COL		8	8	8		8	8	8	8	8	8
CRI			8	8		8	8	8	8	8	7
DOM	7		7	8	8	8	6	8			7
ECU	7	7	7	7		8	8	8	8	8	9
GTM	7	7			8	8		8	8		6
GUY	7				6	6	8	8	7		6
HND		7	7		8	8			8	6	6
HTI			7	7	7				5		4
JAM	7	7		8	8	8	8	8	8		8
LCA			7		7				8		3
MEX				8	8	8	8	8	8	8	7
NIC	7	7	7	7	7	5	5		8		8
PAN	8	8	8	8	8	8	8	5	8		9
PER	8					8	8	8	8	8	6
PRY	7			7	8	5	8	8	8	8	8
SLV		7				8	8	8	8	8	6
TTO			8	8	8	5	7				5
URY		7	8	8	8	8	8	8	8	8	9
VCT										6	1
Total Count of non missing observations	11	12	13	14	16	21	20	18	21	13	159

The table above describes the amount of nonmissing variables for each country in each year in the dataset where the maximum amount of variables for a country per year is 8. Blanks indicate that there is data availabe for the given year. The right column on the right shows for how many time periods there is any data available for the country where 10 is maximum. Only countries in LAC that have data for at least average years of schooling and education spending in at least one period are added in the table.

Appendix B

Summary Statistics

Variable		Mean	Std. Dev.	Min	Max	Observations	
Education spending per school aged population	overall	9.13	7.74	0.39	36.54	N=	159
	between		6.15	0.57	21.37	n=	25
	within		5.45	-2.38	31.5	T-bar=	6.4
Average years of schooling	overall	6.63	2.16	1.35	11.59	N=	159
	between		2.12	2.77	11.04	n=	25
	within		1.36	2.55	9.51	T-bar=	6.4
Share of tertiary education spending	overall	0.19	0.08	0.01	0.48	N=	148
	between		0.06	0.05	0.28	n=	23
	within		0.06	0.01	0.42	T-bar=	6.4
Share of secondary education spending	overall	0.29	0.09	0.07	0.44	N=	148
	between		0.07	0.14	0.4	n=	24
	within		0.06	0.12	0.43	T-bar=	6.2
Share of primary education spending	overall	0.4	0.11	0.03	0.67	N=	148
	between		0.09	0.28	0.63	n=	24
	within		0.07	0.15	0.62	T-bar=	6.2
Share of rural population	overall	0.4	0.19	0.05	0.82	N=	159
	between		0.19	0.09	0.75	n=	25
	within		0.06	0.22	0.57	T-bar=	6.4
GDP per capita	overall	10206	5320.06	1592.8	35748	N=	159
	between		6576.84	2074.3	35748	n=	25
	within		2726.93	3600.2	20836.1	T-bar=	6.4
Gini (dummy)	overall	0.22	0.42	0	1	N=	130
	between		0.34	0	1	n=	24
	within		0.29	-0.65	0.97	T-bar=	5.4

N is the number of observations; n is the number countries; T-bar: average amount of periods for each country

Appendix C

Country abbreviations

Abbrevation	Country
ARG	Argentina
BHS	Bahamas
BRB	Barbados
BRA	Brazil
BLZ	Belize
CHL	Chile
COL	Colombia
CRI	Costa Rica
DOM	Dominican Republic
ECU	Ecuador
SLV	El Salvador
GTM	Guatemala
GUY	Guyana
HTI	Haiti
HND	Honduras
JAM	Jamaica
MEX	Mexico
NIC	Nicaragua
PAN	Panama
PRY	Paraguay
PER	Peru
LCA	Saint Lucia
VCT	St. Vincent and the Grenadines
TTO	Trinidad and Tobago
URY	Uruguay

Appendix D

DEA Results

Country	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	Count (and average theta)
ARG	126	110	108	23	8	65	57	34	28	14	10
	(0.55)	(0.59)	(0.60)	(0.84)	(0.98)	(0.72)	(0.74)	(0.80)	(0.82)	(0.95)	(0.76)
BHS							13				1
							(0.95)				(0.95)
BLZ						11	1	9	1		4
						(0.97)	(1.00)	(0.98)	(1.00)		(0.99)
BRA						152	140	114	89	87	5
						(0.42)	(0.50)	(0.58)	(0.66)	(0.67)	(0.57)
BRB		100			74	51	52	37	33		6
		(0.61)			(0.70)	(0.75)	(0.75)	(0.79)	(0.80)		(0.73)
CHL	98	88	111	42	36	63	47	31	24	19	10
	(0.62)	(0.66)	(0.59)	(0.78)	(0.80)	(0.73)	(0.76)	(0.81)	(0.84)	(0.90)	(0.75)
COL		127	129	121		115	113	116	62	70	8
		(0.55)	(0.54)	(0.57)		(0.58)	(0.58)	(0.58)	(0.73)	(0.71)	(0.60)
CRI			146	125		97	93	78	83	55	7
			(0.46)	(0.56)		(0.62)	(0.64)	(0.69)	(0.68)	(0.74)	(0.63)
DOM	144		90	27	1	18	43	68			7
	(0.48)		(0.66)	(0.83)	(1.00)	(0.93)	(0.78)	(0.72)			(0.77)
ECU	119	128	131	139		20	1	103	94	49	9
	(0.57)	(0.54)	(0.53)	(0.51)		(0.86)	(1.00)	(0.61)	(0.64)	(0.75)	(0.67)
GTM	159	158			143	134		150	138		6
	(0.21)	(0.24)			(0.48)	(0.52)		(0.43)	(0.51)		(0.40)
GUY	61				7	22	35	26	32		6
	(0.73)				(0.98)	(0.85)	(0.80)	(0.83)	(0.81)		(0.83)
HND		153	107		82	67			132	104	6
		(0.42)	(0.60)		(0.68)	(0.72)			(0.53)	(0.60)	(0.59)
HTI			145	29	1				15		4
			(0.46)	(0.82)	(1.00)				(0.94)		(0.81)
JAM	149	154		122	99	76	56	41	25		8
	(0.43)	(0.41)		(0.56)	(0.61)	(0.69)	(0.74)	(0.79)	(0.83)		(0.63)
LCA			147		118				64		3
			(0.46)		(0.57)				(0.72)		(0.58)
MEX				133	135	124	101	80	66	50	7
				(0.53)	(0.52)	(0.56)	(0.61)	(0.68)	(0.72)	(0.75)	(0.63)
NIC	157	137	155	148	1	69	48		79		8
	(0.31)	(0.51)	(0.40)	(0.44)	(1.00)	(0.71)	(0.75)		(0.68)		(0.60)
PAN	142	136	123	102	96	75	59	44	39		9
	(0.48)	(0.51)	(0.56)	(0.61)	(0.63)	(0.69)	(0.74)	(0.77)	(0.79)		(0.64)
PER	151					21	12	10	40	30	6
	(0.43)					(0.85)	(0.97)	(0.97)	(0.79)	(0.81)	(0.80)
PRY	120			45	17	117	105	53	84	60	8
	(0.57)			(0.77)	(0.93)	(0.58)	(0.60)	(0.74)	(0.67)	(0.73)	(0.70)
SLV		156				112	86	85	54	95	6
		(0.39)				(0.58)	(0.67)	(0.67)	(0.74)	(0.63)	(0.62)
TTO			106	92	71	58	38				5
			(0.60)	(0.65)	(0.71)	(0.74)	(0.79)				(0.70)

URY		141	130	109	77	91	72	81	73	46	9
		(0.48)	(0.54)	(0.59)	(0.69)	(0.66)	(0.71)	(0.68)	(0.70)	(0.76)	(0.64)
VCT										16	1
										(0.94)	(0.94)
Count	11	12	13	14	16	21	20	18	21	13	159
Average theta	0.49	0.49	0.54	0.65	0.77	0.70	0.75	0.73	0.74	0.77	0.68

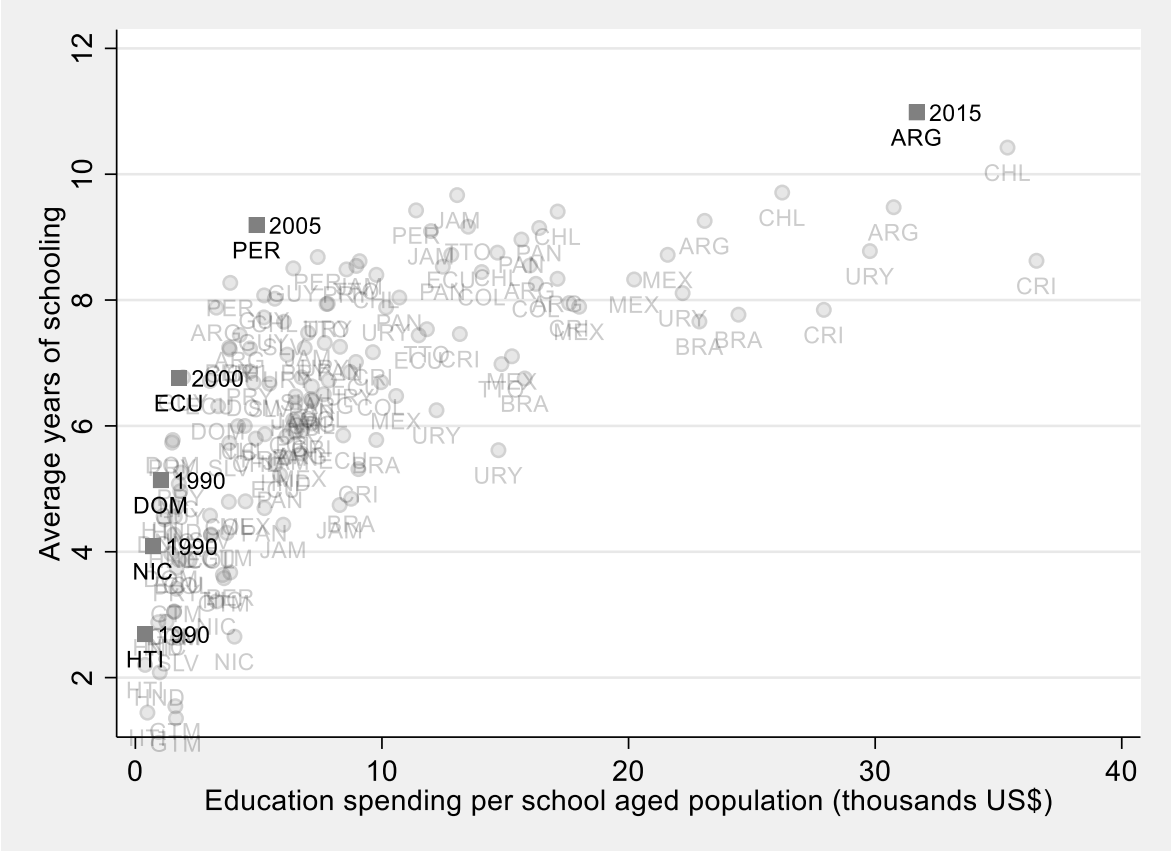
Appendix E

Robustness Check for Efficiency Scores (without countries with population < 0.5 million)

Country	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	Count (and average theta)
ARG	105	91	83	40	7	46	39	28	36	1	10
	(0.64)	(0.69)	(0.72)	(0.86)	(0.99)	(0.83)	(0.86)	(0.89)	(0.87)	(1.00)	(0.83)
BRA						128	110	95	74	73	5
						(0.51)	(0.61)	(0.68)	(0.74)	(0.74)	(0.66)
CHL	107	96	94	54	35	30	29	15	22	12	10
	(0.63)	(0.68)	(0.69)	(0.80)	(0.87)	(0.88)	(0.89)	(0.94)	(0.91)	(0.95)	(0.82)
COL		123	124	116		101	90	87	38	47	8
		(0.55)	(0.55)	(0.58)		(0.66)	(0.69)	(0.70)	(0.86)	(0.83)	(0.68)
CRI			121	102		70	68	56	76	58	7
			(0.56)	(0.65)		(0.75)	(0.77)	(0.79)	(0.73)	(0.79)	(0.72)
DOM	133		100	48	1	18	57	75			7
	(0.48)		(0.66)	(0.83)	(1.00)	(0.93)	(0.79)	(0.73)			(0.77)
ECU	117	122	115	109		34	1	72	64	27	9
	(0.57)	(0.55)	(0.58)	(0.62)		(0.87)	(1.00)	(0.74)	(0.77)	(0.90)	(0.73)
GTM	144	143			132	126		138	127		6
	(0.21)	(0.24)			(0.48)	(0.52)		(0.44)	(0.52)		(0.40)
GUY	77				10	37	45	32	21		6
	(0.73)				(0.98)	(0.86)	(0.84)	(0.88)	(0.92)		(0.87)
HND		139	111		97	82			113	93	6
		(0.42)	(0.60)		(0.68)	(0.72)			(0.59)	(0.69)	(0.62)
HTI			135	51	1				13		4
			(0.46)	(0.82)	(1.00)				(0.94)		(0.81)
JAM	134	131		108	89	55	23	14	8		8
	(0.48)	(0.50)		(0.63)	(0.70)	(0.80)	(0.91)	(0.94)	(0.99)		(0.74)
MEX				125	112	98	81	59	52	43	7
				(0.54)	(0.60)	(0.68)	(0.72)	(0.78)	(0.82)	(0.85)	(0.71)
NIC	142	129	140	136	1	84	71		88		8
	(0.31)	(0.51)	(0.40)	(0.45)	(1.00)	(0.71)	(0.75)		(0.70)		(0.60)
PAN	130	120	106	85	66	44	31	24	20		9
	(0.51)	(0.56)	(0.63)	(0.71)	(0.77)	(0.84)	(0.88)	(0.90)	(0.92)		(0.75)
PER	137					33	9	1	19	11	6
	(0.44)					(0.87)	(0.99)	(1.00)	(0.93)	(0.98)	(0.87)
PRY	118			65	17	99	104	69	63	26	8
	(0.57)			(0.77)	(0.93)	(0.66)	(0.64)	(0.76)	(0.78)	(0.90)	(0.75)
SLV		141				114	92	80	49	78	6
		(0.39)				(0.59)	(0.69)	(0.72)	(0.83)	(0.73)	(0.66)
TTO			86	61	42	25	16				5
			(0.71)	(0.78)	(0.85)	(0.90)	(0.94)				(0.84)
URY		119	103	79	67	62	41	50	60	53	9
		(0.57)	(0.65)	(0.73)	(0.77)	(0.78)	(0.85)	(0.83)	(0.78)	(0.81)	(0.75)
Count	11	11	12	14	14	19	17	16	18	12	144
Average theta	(0.51)	(0.52)	(0.60)	(0.70)	(0.83)	(0.76)	(0.81)	(0.80)	(0.81)	(0.85)	(0.73)

Appendix F

Efficiency Frontier with limited sample (without countries with population < 0.5 million)



Appendix G

Robustness check without small countries and the Caribbean

Country Fixed Effects

VARIABLES	(1) FEbase Theta	(2) FEbaseC Theta	(3) FEbaseS Theta*	(4) FEfull Theta	(5) FEfullC Theta	(6) FEfullS Theta*
% 3ry Spending	0.278	0.283*	0.233	0.180	0.226	0.118
	(0.179)	(0.167)	(0.175)	(0.146)	(0.155)	(0.123)
% 2ry Spending	0.392**	0.464**	0.298	0.701***	0.741***	0.412**
	(0.192)	(0.191)	(0.199)	(0.189)	(0.206)	(0.162)
% rural pop	-0.815***	-0.900***	-1.202***	0.421	0.087	0.466*
	(0.202)	(0.200)	(0.208)	(0.260)	(0.300)	(0.235)
lagged lnGDPpc	0.044	0.005	0.029	-0.115	-0.088	-0.041
	(0.054)	(0.054)	(0.057)	(0.075)	(0.081)	(0.063)
Edu Spending				0.002	0.002	-0.002
				(0.002)	(0.002)	(0.002)
lagged Yrs of Sch				0.051***	0.036**	0.082***
				(0.014)	(0.016)	(0.012)
H Gini				0.012	0.011	0.020
				(0.028)	(0.028)	(0.023)
Constant	0.429	0.745	0.776	1.007	0.957	0.340
	(0.519)	(0.524)	(0.553)	(0.650)	(0.695)	(0.552)
Observations	133	106	120	111	92	102
R-squared	0.286	0.382	0.439	0.416	0.416	0.633
Number of _ISO3N_	23	17	20	21	17	19

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

* The efficiency scores have been recalculated with the restricted sample without countries with a population of less than 0.5 million

Appendix H

Robustness check for inequality variable

	Country Fixed Effects					
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	FEint75 Theta	FEint50 Theta	FEintC Theta	FEfull75 Theta	FEfull50 Theta	FEfullC Theta
Tertiary spending	0.222	0.354*	1.755	0.180	0.235	0.238
	(0.244)	(0.187)	(1.960)	(0.270)	(0.255)	(0.250)
Secondary spending	0.735**	0.691**	0.686**	0.701**	0.689**	0.630*
	(0.312)	(0.274)	(0.283)	(0.304)	(0.305)	(0.303)
Gini (.50=high)	0.038			0.012		
	(0.181)			(0.029)		
Tertiary spending X Gini (.50=high)	-0.135					
	(0.817)					
Gini (0.45=high)		0.077			0.035	
		(0.048)			(0.027)	
Tertiary spending X Gini (0.45=high)		-0.352				
		(0.242)				
Gini coefficient			0.928			0.712*
			(0.984)			(0.404)
Tertiary spending X Gini coefficient			-3.422			
			(4.514)			
Rural pop	-0.163	-0.257	-0.216	0.421	0.482	0.558
	(0.305)	(0.342)	(0.361)	(0.428)	(0.403)	(0.381)
$lnGDPpc_{t-1}$	0.076	0.063	0.080	-0.115*	-0.115	-0.083
	(0.058)	(0.068)	(0.077)	(0.062)	(0.070)	(0.064)
Edu spending				0.002	0.002	0.002
				(0.002)	(0.002)	(0.002)
Yrs of Sch_{t-1}				0.051***	0.054***	0.055***
				(0.014)	(0.013)	(0.012)
Constant	-0.198	-0.067	-0.623	1.007	0.938	0.320
	(0.540)	(0.674)	(0.760)	(0.598)	(0.683)	(0.617)
Observations	112	112	112	111	111	111
R-squared	0.292	0.302	0.299	0.416	0.421	0.430
Number of countries	22	22	22	21	21	21

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix I

Robustness Check with Truncated Regression Model

VARIABLES	(1) FEbase Theta	(2) Truncated Base Theta	(3) Truncated FE Theta	(4) FEfull Theta	(5) Truncated Full Theta	(6) TruncatedFull FE Theta
Tertiary spending	0.278	0.072	0.539**	0.180	0.049	0.384***
	(0.179)	(0.219)	(0.222)	(0.146)	(0.120)	(0.126)
Secondary spending	0.392**	0.459***	0.402	0.701***	0.091	0.620***
	(0.192)	(0.155)	(0.266)	(0.189)	(0.127)	(0.156)
Rural pop	-0.815***	-0.083	-0.746***	0.421	-0.058	0.329
	(0.202)	(0.087)	(0.261)	(0.260)	(0.060)	(0.214)
$lnGDPp_{ct-1}$	0.044	0.021	0.073	-0.115	-0.097***	-0.109*
	(0.054)	(0.040)	(0.068)	(0.075)	(0.037)	(0.061)
Gini (.50=high)				0.012	-0.003	0.016
				(0.028)	(0.022)	(0.022)
Edu spending				0.002	-0.003**	0.003*
				(0.002)	(0.002)	(0.002)
Yrs of Sch_{t-1}				0.051***	0.072***	0.050***
				(0.014)	(0.007)	(0.011)
Constant	0.429	0.371	-0.130	1.007	1.128***	1.042*
	(0.519)	(0.359)	(0.663)	(0.650)	(0.327)	(0.543)
Country Fixed Effects	YES	NO	YES	YES	NO	YES
Observations	133	128	128	111	108	108

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1