The Effect of Educational Expenditure on Academic Performance and its Mechanisms

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Considering a Colombian reform to the educational system as a quasi-natural experiment, this article attempts to find the effect and some mechanisms that Central Government's spending in education has on academic performance. The reform generated an exogenous change in the amount of public school spending that each municipality received from the Central Government. I used the variation of public school expenditure and the results of the standardized test Saber11, between 2004 and 2013, to find the causal effect of national expenditure on education in academic results. Using an instrumental variable model, the results show that an increase in transfers per student during his/her academic life, of around 5%, generates an improvement of 0.1 standard deviations in the test score at national level. Furthermore, I found that the students per teacher ratio and local resources per student are relevant mechanisms to explain this effect.

INTRODUCTION

An important proportion of the GDP of many countries is invested in education. According to data from the World Bank, the amount of money invested in education has increased by two billion dollars between 2000 and 2010. This growing pattern of public spending on education raises the following questions: Does the effort on increasing public spending in education have an effect on academic results? What are the mechanisms that generate this effect?

Researchers have tried to answer the first question since the 1960's, reaching different and even opposite conclusions. The second question is a recent subject that, apparently, has not been solved yet.

Since the Coleman Report (1966), researchers have tried to understand how public spending affects academic results. After making a descriptive analysis with US data from 1965 to 1966, Coleman argues that there is no evidence that an increase in public spending per student has a positive effect on academic performance. Other authors, with more recent researches, reached the same conclusion, as is the case of Hanushek (1996).

These results surprise many, a positive effect is expected on academic performance due to an increase in public spending per student. In both developed and developing countries, having an answer to this question became a very interesting matter at the end of the 1990's. As a result, some researchers used econometric tools to find this relation; however, the answer is ambiguous. Downes et al. (1998), Card et al. (2002), Guryan et al. (2001), Hoxby et al. (2001), Roy (2011) and Jackson et al. (2017) analyzed the effects of a financial reform in education during the 1970's and 1980's in the United States.

Regarding developing countries, Boateng (2014) performed an analysis for South Africa, Cuesta (2014) made a research in Thailand, and Gupta et al. (1999) considered 50 developing countries to carry out its analysis, including Algeria, Brazil, Colombia, Ghana, Madagascar, among others.

Downes et al. (1997), Card et al. (2002), Boateng (2014), Gupta et al. (1999) and Cuesta (2014) looked for evidence of the correlation between public spending and academic performance. Downes et al. (1997) and Boateng (2014) did not find evidence of a relationship between public spending and academic performance. In contrast, Card et al. (2002) concluded that where equity on the spending per student is achieved among low and high income families, the existing gap in academic results is reduced; therefore, low income families were favored. Otherwise, Cuesta (2014) showed that in Thailand, financial reforms did not have any effect in reducing the knowledge gap. Finally, Gupta et al. (1999) found a positive and significant effect of public spending on academic results.

Their identification strategy does not deal with endogeneity problems; therefore, they do not find a causal effect of public expenditure on academic results. They correlate the total expenditure in education with academic performance, and this kind of analysis generates bias because it does not take into account the characteristics of the population. Furthermore, these authors correlated the expenditure in a certain period using the academic results of this same period. This correlation should be a sensitive topic because the effects on academic results are

not immediate, the effect should be assessed considering the amount of resources that each student receives during his/her academic life, prior to the year in which the measure of academic performance is taken.

Downes et al. (1998), Card et al. (2002), Guryan et al. (2001), Hoxby et al. (2001) and Roy (2011) propose an instrumental variable method to find the causal effect: first, they find the effect of the financial reform on public expenditure for education; then, they analyze the impact of the variation in public resources, due to the reform, on academic performance. In the same way as these authors, I use the instrumental variable methodology; however, unlike them, I use a different measure of spending per student: while, they correlate the expenditure and the academic results of the same period, I add the expenditure per student during their entire school life, from the moment he/she enters school until graduation.

Jackson et al. (2017) propose that spending should be added during the entire academic life of individuals. Using an instrumental variable model, they find long term results regarding poverty, future wages, and years of study for the United States. They find positive and significant effects, especially in the localities with fewer resources. Unlike them, in this article, I intend to find the effect of expenditure on short term results for a developing country, in this case, Colombia.

To answer the second question, different mechanisms can be considered, such as the number of students per teacher, didactic material, investment in infrastructure, teachers' salaries, etc. Some researchers relate the effect of such mechanisms with academic results. Hence, they analyze the effect of variables other than public expenses on academic performance: Hanushek et al. (2006), Aaronson et al. (2007), Straiger et al. (2010) show that teachers´ performance has an effect on student achievements. Duflo et al. (2012), Muralidharan (2011), Kremer et al. (2010) show how teachers´ income is an incentive that can affect academic results. Other authors show how teaching material, like textbooks (Glewwe et al. 2009), remedial education (Banerjee et al. 2007), computers (Banerjee et al. 2007; Sánchez et al. 2011), etc., improve academic outcomes. Unlike them, this article attempts to find a mediation effect of national expenditure in academic performance, mediated by the students per teacher ratio and local resources per student. As far as I know, this could be the first article analyzing the mediation between expenditure, a mechanisms and academic results.

This article also gives an insight of the effects of decentralization in academic results, contributing to the literature in this field. Since the 1990's many developing countries have been decentralized, and the effect of the decentralization in economic development outcomes, as education, became a very important research topic. Faguet (2002, 2008, 2009) found that decentralization had a positive effect on public educational outcomes in Colombia and on the redistribution of investments in local areas in Bolivia, where the most vulnerable areas received higher investments. Barrera (2003) and Rodriguez (2010) also analyzed the Colombian case; Barrera concluded that decentralization increases the test scores for individuals at the left tail of the income distribution. Rodriguez showed that when controlling for households´ schooling decisions, decentralization has a positive effect on academic performace. Habibi et al. (2001) and Galiani et al. (2001) examined the effects in Argentina. They found positive effects on academic performances and on the reduction of intraregional

disparities. King et al (2000) reached to the same positive conditions in the case of Nicaragua. Unlike them, this article analyzes an asymmetric decentralized context. This occurs because the explanation of the effect of public resources on academic results is based in a quasi-natural experiment in Colombia , which led to an exogenous change in transfers per student and to the division of municipalities in two groups: centralized and decentralized.

My research contributes to the literature into two aspects: first, I find evidence of the causal relationship between national transfers for education and academic outcomes in a developing country (Colombia); second, I find evidence of the existence of the students per teacher ratio and local resources as mediators, which lead to relevant conclusions regarding asymmetric decentralization.

I find the causal effect of national transfers on academic results by taking advantage of an exogenous shock that a Colombian regulation generates in public spending, and I relate it to academic results. I used an instrumental variable model and I find that increasing transfers per student by 5% lead to an improvement in academic results of around 0.1 standard deviations.

For my second contribution, I used the mediation model with instrumental variable proposed by Dippel et al. (2016) and I find a causal mediation of the students per teacher ratio in Colombian municipalities. This relationship may change depending on the effect that national transfers have on local resources.

The remaining of this article is organized as follows: Section II describes the empirical strategy, Section III presents the data, Section IV reveals the results, Section V explains the mechanisms and section VI contains the conclusions.

EMPIRICAL STRATEGY

By using an econometric approach, a Colombian reform allows me to determine the effect that transfers have on academic results with the following goals: first, isolating the exogenous effect on per student transfers due to the new regulation; second, finding the causal relation between transfers and academic results; and third, finding the mechanisms through which transfers can have an effect on academic results.

Dealing with endogeneity problems

There is a correlation between national transfers in education and academic performance; for instance, municipalities that receive high amounts of resources per student usually have the most vulnerable population. The relation between the nation's expenditure and academic performance would be negative bias, due to the negative relation between resources per student and students characteristics, and this leads to an endogeneity problem.

To find the causal effect of public spending in academic results, I used an exogenous variation of public expenditure to explain causality: the variation of public expenditure per student generated by the introduction of Law 715 of 2001.

The key assumption is that the change in the distribution of public expenditure, due to the new reform, only has an effect on academic performance because of the variation in the amount of national public resources. To support this assumption, I must guarantee that an endogeneity problem between the change in resources per student due to the reform and academic performance does not exist.

This type of problems may arise for two reasons: first, inverse causality, i.e. those municipalities that have worse (or better) academic results received a higher (or lower) participation on public resources due to the reform. This is not an endogeneity problem because I used projections based on the distribution from 2003, when the characteristics of the population did not affect the distribution of resources. The second reason is simultaneity, i.e. there are no other factors, different from Law 715 of 2001, that can explain the change in public resources and academic performance. In this case, I only used the 2004-2013 period, when there were no additional changes in the distribution of public expenditure for education.

Context and sources of variation

The number of resources allocated to education from 1994 to 2003 was ruled by Law 60 of 1993. This law established that educational resources were a percentage of the National Income (NI), which consists of tax and non-tax revenues, and were divided into two groups: "Situado Fiscal (SF)" and "Participación de los Ingresos Corrientes de la Nación (PICN)".

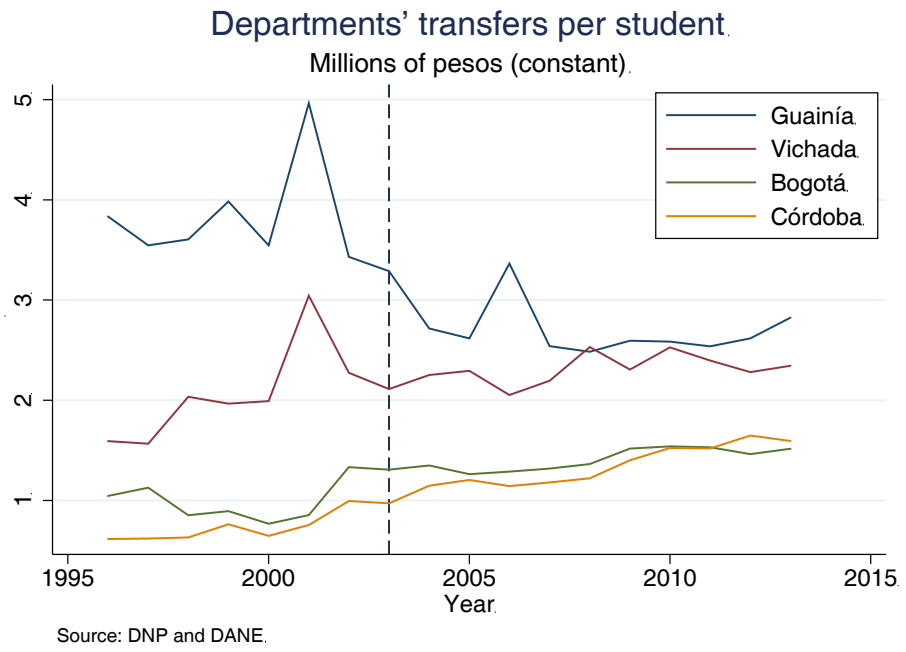
The resources of the SF were allocated to pay teachers in accordance to the distribution of teachers in 1993; also, these funds were administrated by the Department. The resources of the PICN were distributed among municipalities according to the characteristics of the population, and these funds were invested mainly in infrastructure for education.

One of the problems with these resources was their dependence on National Income: when Colombian economy was growing, educational resources increased accordingly. However, when the economy was contracting, these resources could not be reduced; they should grow at least according to the inflation rate. This generated a deficit in the educational system, which resulted in the creation of the "Fondo Educativo de Compensación (FEC)", used by the Government to finance the deficit.

Another problem is that the distribution was unequal, especially because most of the resources were used for paying teachers according to their physical location, not to their actual number of students. The Department of National Planning (DNP) states:

Regarding equity in the distribution of resources, in the case of the SF, a high variability in the per capita allocation between departments was evidenced; because the allocation was made according to the historical trend and not to the increases in coverage. In education, the initial distribution was based on the existing number of teachers in 1993, thus perpetuating an allocation of resources that does not match the characteristics of each region. The resources aimed at paying teachers where they were located and not where children were. This is how some departments and districts receive today 5 times more resources per capita than others (CONPES 57 of 2002, page 4). (Figure 1)

Figure 1:



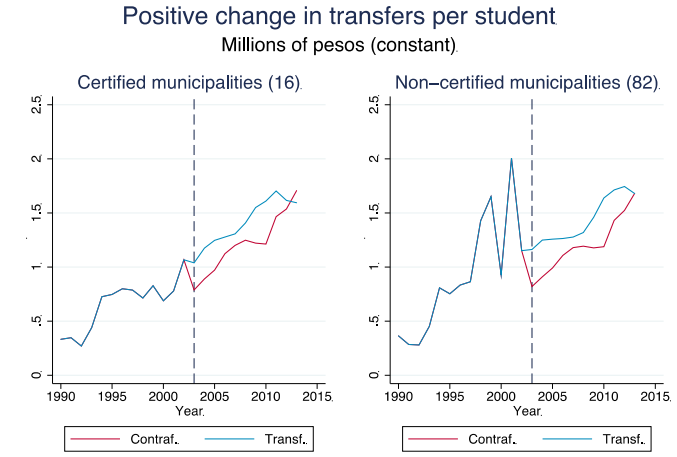
As a result of these inconveniences, Law 715 of 2001 came into force in 2003 and affected all municipalities at the same time. The "Sistema General de Participación (SGP)" was created, and it was a single package that contained all the transfers from the national Government; besides, it had the same amount of money as the addition of the SF, PICN, and FEC. Once the initial value of the SGP was obtained, its growth would no longer depend on the NI but would have an annual growth of 2% and 2.5% plus the inflation caused.

Furthermore, autonomy in the administration of transfers was given to municipalities with more than 100,000 inhabitants, known as certified municipalities. This generated the second group of municipalities: the non-certified municipalities with less than 100,000 inhabitants. They were administratively dependent on the departments to which they belonged; therefore, these departments were responsible for the administration of the nation's transfers.

Finally, the formula for the distribution of resources changed: from 2003, the resources were delivered per student; hence, municipalities began to receive similar amounts of transfers per student at national level. When the distribution formula was changed, the amount of money per student for each municipality changed as well. Municipalities with few students and many teachers, before 2003, received higher resources per student compared to municipalities with many students and few teachers. As a consequence, after 2003, municipalities with few students and many teachers would have a decrease in their total amount of transfers, while municipalities with many students and few teachers would have an increase on their resources (Figure 2, Figure 3 and Figure 4).

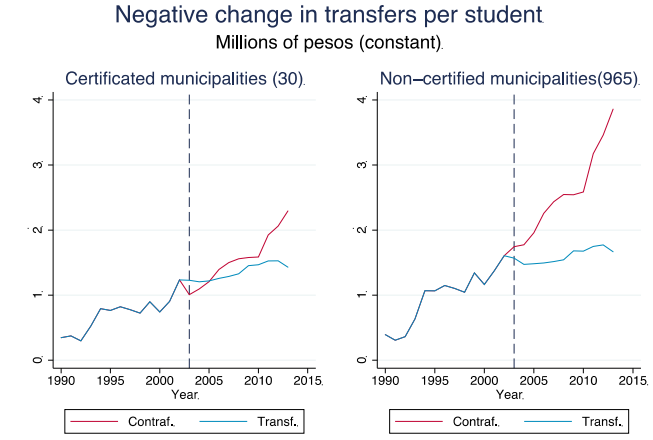
The changes generated by the introduction of the new law produced two variations: the total resources given to each municipality as well as the resources invested in each student changed. After the implementation of the new law, each municipality received a different amount of money depending on its number of students.

Figure 2:



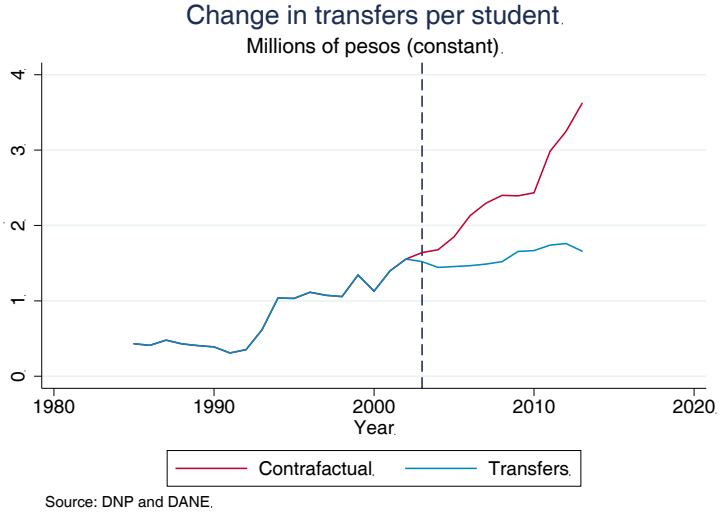
Source: DNP and DANE.

Figure 3:



Source: DNP and DANE.

Figure 4:



Source: DNP and DANE.

Figures 2, 3 and 4 consider 1,093 municipalities, 46 of which are certified. When analyzing the real expenses executed, compared to a scenario where the law was not deployed, the majority of certified and non-certified municipalities received a lower amount of transfers per student (Figure 3). At national level, the average resources per student were lower with the new regulation than with the previous one (Figure 4).

Instrumental variable

The difference between the resources that municipalities actually receive and those they would have received without the application of this law is the effect of the educational reform on public transfers on education, i.e is the instrumental variable. This is the key variable denoted as D i,m,c which explains the variation in national transfers due to the constitutional reform.

Thus, I predicted the annual change in the public expenditure per student due to the reform, which I calculated as follows: I projected the amount of the resources per student, received by each municipality from 2004 to 2013, according to the distribution of 2003 (Equation 1). Then, I projected the amount of money that each municipality would receive if the new constitutional reform did not take place. I considered the proportion of the NI (2000 and 2001 average) that each municipality was assigned for education (Equation 2). Then, for each year, I subtracted equation 2 from equation 1 (Equation 3). Finally, in equation 4, I added the resulting variables over time (12-year academic period).

$$t.per.stu_{m,t}^{Proj.715} = \left(\frac{1}{population_{5-17,t,m}}\right)\left(\frac{transfers_{m,2003}}{tot.transfers_{2003}}\right)(nac.transfers_t) \quad (1)$$

$$t.per.stu_{t,m}^{Proj.60} = \left(\frac{1}{population_{5-17,t,m}}\right)\left(\frac{transfers_{m,2000-2001}}{NI_{2000-2001}}\right)(NI_t) \quad (2)$$

$$d.t.per.stu_{t,m} = (t.per.stu_{t,m}^{Proj.715}) - (t.per.stu_{t,m}^{Proj.60}) \quad (3)$$

$$D_{m,c} = \sum_{t=c-12}^{c} d.t.per.stu_{(t,m)} \quad (4)$$

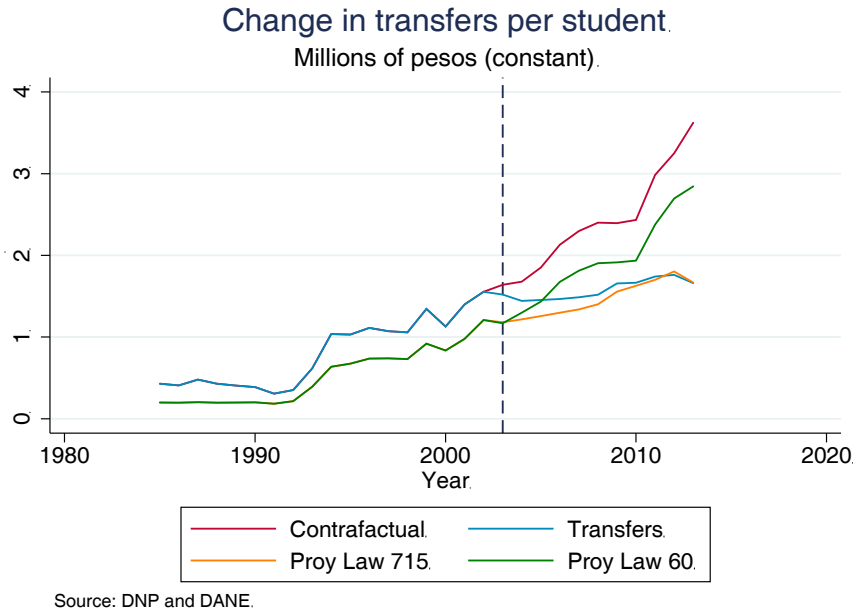
The variables are described below:

Table 1

Variable	Description
$t.per.stu_{m,t}^{Proj.715}$	Transfers per student projected under Law 715 for the municipality m in year t
$t.per.stu_{t,m}^{Proj.60}$	Transfers by students projected under Law 60 for the municipality m in year t
$population_{5-17,t,m}$	Number of people between the ages of 5 and 17 in the municipality m during year t
$transfers_{m,2003}$	Transfers received by municipality m in 2003
$tot.transfers_{2003}$	Total transfers at national level in the year 2003

Variable	Description
$nac.transfers_t$	Transfers at national level in year t
$transfers_{m,2000-2001}$	Average transfers for the years 2000 and 2001 received by municipality m
$NI_{2000-2001}$	Average NI between the years 2000 and 2001
NI_t	NI in the year t
$D_{m,c}$	The difference in transfers between the projection of Law 715 and Law 60.

Figure 5:



Source: DNP and DANE.

Unlike figure 4, figure 5 includes the calculation of the projections. They differ in the value per student. In the first figure, transfers and contrafactual are divided by the number of students of municipality m in year t , while the projections are divided by the number of individuals between 5 and 17 years old. As expected, the projections are lower because the coverage rates do not reach 100% (Appendix 1).

As shown in Figure 5, the projection of the transfers generated by Law 60 is greater than the projection from Law 715. Therefore, the difference per student in most municipalities is negative (995 municipalities, Figure 3). This is mainly due to the negative change in non-certified municipalities. In the case of certified municipalities, some have a positive change; this is expected since certified municipalities represent more than 50% of the population considered. As a result, these municipalities obtained the greatest benefits from the implementation of this law.

Econometric strategy

The methodology used is Ordinary Least Squares in Two Stages. The variable of interest is national public spending per student, accumulated during his/her academic life (Equation 5). This means that all students of the same cohort c received the same amount of money within the same municipality. This variable is endogenous and I instrumented it.

$$T_{m,c} = \sum_{t=c-12}^{c} \frac{transfers_{m,t}}{student\ s\ m,t} \qquad (5)$$

The model is as follows:

$$Y_{i,m,c} = \beta_0 + \beta_1 \hat{T}_{i,m,c} + \gamma X_i + \eta_m + \eta_c + \varepsilon_{i,m,c} \qquad (6)$$

The first stage is:

$$T_{i,m,c} = \alpha_0 + \alpha_1 D_{i.m.c} + \gamma X_i + \eta_m + \eta_c + e_{i,m,c} \qquad (7)$$

The first stage should be at cohort and municipality level. Nevertheless, I included data at individual (student) level, which is the unit of measure of the available information about academic performance.

The variable T i,m,c is the amount of money (million pesos) that student i received during her/his academic life, in the municipality m , that belongs to the cohort c . This variable is endogenous and the instrument is D i,m,c , which is a measure of the change in public transfers due to the regulation. In addition, I included a vector of individual characteristics X i , like the educational level of parents, stratum, school hours (i.e. morning, evening, etc.) and gender. Furthermore, I introduced fixed effects of municipality η m and fixed effects of cohort η c , as well as the error terms (ε i,m,c and e i,m,c).

In this analysis I correlated the academic performance with the predicted change in public expenditure, eliminating the influence of unobserved variables, which could have an effect on public expenses in education and affect the academic results.

DATA

I created a database with information from ICFES for the 2004-2013 period. This information contains the results of the SABER11 academic test as well as the characteristics of students. To be able to compare between years, I standardized the test scores by subtracting the mean and dividing it by the standard deviation. Furthermore, I added information about per student public transfers for each municipality, obtained from DNP, which values are in real prices of 2008.

The following assumptions were taken: students do not migrate during their academic life, and they studied only for 12 years before taking the test.

The final database has nearly three million observations at national level. I included information of students from public schools, who took the SABER11 test during 2004 and 2013. In addition, I selected students whose ages were between 15 and 21 years old at the time they took the test.

Table 2 shows descriptive statistics and difference in means. The means of the outcome variable, public expenditures and the characteristics of the population give some insight regarding the results of the article.

The analysis was divided into certified and non-certified municipalities because they have different characteristics (Resource management, size of the population, provision of public services, rurality index, etc.). In addition, each group of municipalities was divided into two groups: those that received additional resources (g1), and those that received fewer resources (g2) due to the new regulation. As shown in Table 2, for both, certified and non-certified municipalities, receiving a greater amount of national transfers during academic life generates better school results. The null hypothesis that the difference in means is zero is rejected in both cases.

Table 2. Descriptive statistics - Difference in means

	Certified municipalities (N=1,658,688)				Non-certified municipalities (N=1,303,475)			
	Mean g1	**Mean g2**	**Diff.**	**p-value**	**Mean g1**	**Mean g2**	**Diff.**	**p-value**
Outcome								
Test score	0.023	0.150	-0.127	0	-0.130	-0.036	-0.08	0
Expenditure per student								
Transfers (M COP)	14.06	13.56	.50	0	15.29	14.55	0.74	0
Local resources (M COP)	1.57	2.66	-1.09	0	0.38	0.45	-0.07	2.12e-53
Teachers' salaries (M COP)	6.73	7.84	-1.11	0	13.16	12.37	0.79	0
Infrastructure (M COP)	0.81	0.83	-0.02	2.3e-115	1.28	0.67	0.61	0
Didactic material (M COP)	0.22	0.23	-0.09	2.0e-121	0.56	0.26	0.30	0
Students per teacher	28.27	27.24	1.03	0	24.75	25.51	-0.76	0
Characteristics of students								
Age	17.26	17.03	.23	0	17.32	17.17	0.15	0
Men (%)	43.8	45.1	-1.2	7.97e-52	45.3	44.9	0.4	1.90e-06
Students: Mother with primary education (%)	32.2	34.1	-1.8	1.7e-115	52.1	51.2	0.9	1.72e-23
Students: Mother with secondary education (%)	51.4	50.6	0.7	1.09e-17	36.7	38.2	-1.4	3.45e-60
Students: Mother with technical education (%)	10.5	10.2	0.3	2.83e-07	6.8	6.3	0.5	1.12e-30
Students: Mother with tertiary education (%)	5.7	4.8	0.9	1.1e-111	4.2	4.3	0.1	0.8
Low stratum (%)	74.9	75.7	-0.7	1.12e-26	92.2	90.8	1.4	5.7e-181
Middle stratum (%)	24.6	24	0.6	3.22e-16	7.6	9.1	-1.4	4.0e-176
High stratum (%)	0.3	0.2	0.1	9.3e-105	0.06	0.09	-0.03	3.44e-07
School day hours: Complete (%)	12.4	12.5	-0.1	0.03	34 .4	28	6.4	0
School day hours: Morning (%)	50.8	48.7	2	1.6e-120	46.9	53.1	-.6.2	0
School day hours: Nocturnal (%)	5.1	5.3	-0.1	1.02e-06	4.5	4.4	0.1	.00003
School day hours: Afternoon (%)	30.1	32.8	-2	1.4e-254	12.2	12.8	-0.6	3.54e-23
School day hours: Weekends (%)	1.5	0.5	1	0	1.9	1.6	0.03	4.25e-21

Notes: The results of the SABER11 test are normalized per year; the information comes from the ICFES databases. The characteristics of the students, with the exception of age, are in %; this information comes from the ICFES database. The values corresponding to the expenditure per student are in real prices of 2008; the information comes from the National Department of Planeation (DNP) databases and own calculations

Moreover, Table 2 shows that a Colombian student received, on average, 14 million pesos from national transfers during her/his academic life, and 1 million pesos from local resources. The main investments are teachers' salaries (9.8 million pesos), infrastructure (1 million pesos) and teaching materials (0.3 million pesos). On average, there are 26 students per teacher. The average age of students is 17 years old. Half of the students are men. The majority of students

has mothers with primary and secondary education. More than 80% of the students belong to the lowest strata of society . Finally, the majority of students receive a part-time education (morning or afternoon).

Between certified and non-certified municipalities, the following differences are found: non-certified municipalities receive a higher amount of transfers, local Governments invest fewer resources per student, mothers have a lower level of education, and there is a higher proportion of students that belong to the lowest stratum. Therefore, non-certified municipalities have worse living conditions; thus, it is necessary to do a separate analysis by type of municipality.

In Table 2 individual characteristics appear to be different, this is due to a large number of observations included in the analysis. Hence, I included a normalized difference in means (Table 3). The results show that individual characteristics are not different between groups.

Table 3: Descriptive statistics - normalized difference in means

	Certified municipalities (N=1,658,586)			Non-certified municipalities		
	Mean g1	**Mean g2**	**Diff.**	**Mean g1**	**Mean g2**	**Diff.**
Expenditure per student						
Transfers (M COP)	14.06	13.56	-0.21	15.29	14.55	-0.21
Local resources (M COP)	1.57	2.66	0.48	0.381	0.454	0.03
Teachers' salaries (M COP)	6.73	7.84	0.41	13.16	12.37	-0.24
Infrastructure (M COP)	0.81	0.83	0.04	1.28	0.672	-0.13
Didactic material (M COP)	0.22	0.23	0.04	0.559	0.260	-0.12
Students per teacher	28.27	27.24	-0.39	24.75	25.51	0.19
Characteristics of students						
Age	17.26	17.03	-0.2	17.32	17.17	-0.12
Men (%)	43.8	45.1	0.03	45.4	44.9	-0.01
Students: Mother with primary education (%)	32.3	34.2	0.04	52.2	51.3	-0.02
Students: Mother with secondary education (%)	51.4	50.7	-0.01	36.7	38.2	0.03
Students: Mother with technical education (%)	10.5	10.3	-0.01	6.8	6.3	-0.02
Students: Mother with tertiary education (%)	5.7	4.9	-0.04	4.3	4.3	-0.001
Low stratum (%)	75	75.8	0.02	92.2	90.8	-0.05
Middle stratum (%)	24.6	24	-0.01	7.7	9.1	0.05
High stratum (%)	0.3	0.2	-0.03	0.7	0.9	0.01
School day hours: Complete (%)	12.4	12.5	0.004	34.4	28	-0.14
School day hours: Morning (%)	50.8	48.8	-0.04	46.9	53.1	0.12
School day hours: Nocturnal (%)	5.1	5.3	0.01	4.6	4.4	-0.008
School day hours: Afternoon (%)	30.1	32.9	0.06	12.2	12.8	0.02
School day hours: Weekends (%)	1.5	0.4	-0.11	1.9	1.6	-0.02

Notes: The results of the SABER11 test are normalized per year; the information comes from the ICFES databases. The characteristics of the students with the exception of age are in %; this information comes from the ICFES database. The values corresponding to the expenditure per student are in real prices of 2008; the information comes from the National Department of Planeation (DNP) databases and own calculations.

RESULTS

This section presents the results of the Two Stage Least Squares regression described in equations (6) and (7). The explanatory variable is national public spending per student, accumulated during his/her academic life. The estimated effects on academic performance are presented in Table 4.

Table 4: Effect of transfers per student on academic results

	(1) OLS	(2) IV	(3) IV
Transfers	0.002*** (0.001)	0.078*** (0.005)	0.086*** (0.004)
F-statistic (F. stage)	-	120,359***	119,918***
Fixed effects of cohort	Yes	Yes	Yes
Fixed effects of municipality	Yes	Yes	Yes
Controls	Yes	No	Yes
Number of obs.	2,962,167	2,962,167	2,962,167

Notes: Standard errors in parenthesis. Scores are in units of standard deviation.All regressions include fixed effects of municipality. Columns (1) and (3) includeindividual controls: gender, educational level of mothers, school day hours nd stratum. *** p <0.01, ** p <0.05, * p <0.1

The OLS model (Column 1) shows that an increase of one million pesos in transfers per student has a near zero effect on academic results; however, these results are biased. To eliminate the bias, I estimated the effects with an IV model. The results of this model are presented in columns (2) and (3) of Table 4. Columns (2) and (3) include fixed effects of cohort and municipality, and column (3) also includes control variables such as education level of mothers, stratum, school day hours and gender. The results show that an increase of one million pesos in transfers per student has an improvement of near 0.1 sd in academic performance. To put this effect in perspective, the test scores are measured on a scale of 0 to 100 points, and one standard deviation is near 5 points. This means that an increase of about 5% on public spending invested in a student's academic life is reflected in an improvement of 0.5 points of the test. This can be compared with the effect found in Rodriguez (2010), which states that after the Colombian decentralization (1991), an increase of 1sd of local income per capita improves the academic results by 0.004sd.

As a matter of fact, changes in education policy have an effect on academic performance, but above all, they have an effect on the enrollment rate. Since municipalities are receiving transfers per student, this encourages them to keep more students in the educational system, and thus the coverage increases. Therefore, I present an analysis that controls the impact of the expansion in coverage. I used the methodology proposed by García et al. (2017) in which they remove the lower tail with a non-parametric strategy . This methodology maintains, after a certain year, the composition of students who take the exam according to the educational level of their mothers. This exercise has two stages.

First, the cut will be made based on a reference year, in this case, the year 2001. This year determines the distribution of the individuals who took the SABER11 exam based on the education level of their mothers . For each municipality and educational level of mothers, I calculated the proportion of students over the total population between 15 and 21 years old. This information provides the threshold for which the exercise is performed.

During the second stage, the tail is cut. The number of students that remains in the sample is calculated so that the thresholds are maintained. Students who entered and remained in the education system due to the expansions of coverage have lower performance in standardized tests; therefore, I organized the students in descending order by their test score and those in

the lower part of the distribution, according to the previously defined thresholds, were eliminated.

Table 4 shows how this adjustment generates significant changes in academic performance: an increase of one million pesos in added transfers per student has an improvement close to 0.2 sd. This change represents twice the impact shown in Table 4. Hence, the effect of an increase of 5% in public spending per student, during his/her academic life, has an effect of one point in the results of the test.

Table 5: Effect of transfers per student on academic results controlled by coverage

	(1) OLS	(2) IV	(3) IV
Transfers	0.025*** (0.001)	0.177*** (0.005)	0.196*** (0.004)
F-statistic (F. stage)	-	97,107***	96,915***
Fixed effects of cohort	Yes	Yes	Yes
Fixed effects of municipality	Yes	Yes	Yes
Controls	Yes	No	Yes
Number of obs.	1,972,170	1,972,170	1,972,170

Notes: Standard errors in parenthesis. Scores are in units of standard deviation. All regressions include fixed effects of municipality. Columns (1) and (3) include individual controls: gender, educational level of mothers, school day hours and stratum. *** p <0.01, ** p <0.05, * p <0.1

Heterogeneous effects

As mentioned above, the new regulation changed the formula of the distribution of public expenditure and divided municipalities in certified and non-certified. Each group of municipalities invests the resources in different ways. Certified municipalities are not centralized and have the autonomy to use their educational resources. For non-certified municipalities, departments decide how investments are made. Therefore, the estimated effect could be different depending on the group to which the municipality belongs.

Table 6 shows the estimated effect of national transfers per student on academic performance. Columns (1) and (2) contain the estimated effects with the total sample, and columns (3) and (4) show the results controlled by coverage.

Columns (1) and (3) show the effect in certified municipalities. When we have the total sample, the effect is negative: an increase of one million pesos results in a decrease of 0.1 sd in academic performance. When the model is controlled by the expansion of coverage, the effect is the opposite: an increase of one million pesos in transfers per student has a positive effect of 0.1 sd on academic results.

Columns (2) and (4) show the estimated effect in non-certified municipalities. Similarly to certified municipalities, when the model is controlled by coverage, the effect is greater. However, both cases have a positive effect.

In the sample controlled by coverage, the effect is greater in certified municipalities (0.095) compared to non-certified municipalities (0.062). Therefore, the effect of decentralization on academic performance is positive and greater than in the case of municipalities managed by Departments once the effect of coverage is controlled.

Table 6: Effect of transfers per student on academic results

	Not controlling by coverage		Controlling by coverage	
	(1) Certified	(2) Non-certified	(3) Certified	(4) Non-certified
Transfers	-0.109*** (0.014)	0.037*** (0.003)	0.095*** (0.015)	0.062*** (0.003)
F-statistic (F. stage)	27,050***	114,832***	18,210***	97,369***
Fixed effects of cohort	Yes	Yes	Yes	Yes
Fixed effects of municipality	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Number of obs.	1,658,690	1,303,477	1.158.196	813,974

Notes: Standard errors in parenthesis. Scores are in units of standard deviation. All regressions include fixed effects of municipality. All columns include individual controls: gender, educational level of mothers, school day hours and stratum. *** p <0.01, ** p <0.05, * p <0.1

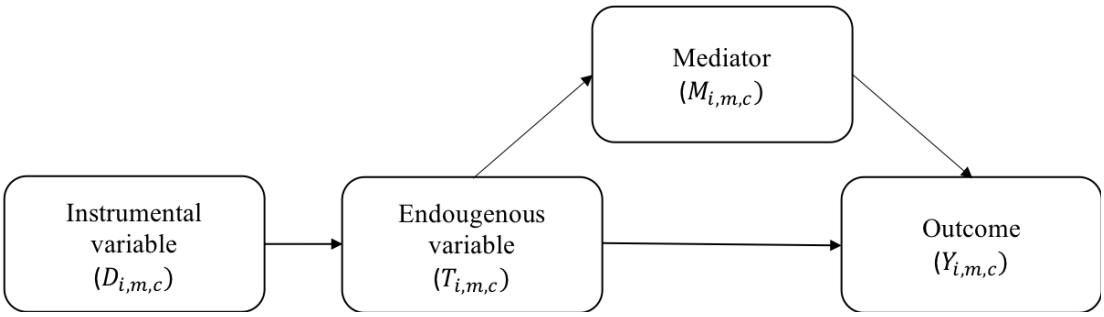
MEDIATION ANALYSIS

I used a standard instrumental variable model to evaluate the causal effect of transfers per students (T i,m,c) on academic results (Y i,m,c). The instrument is the variation in the number of transfers due to a new regulation (D i,m,c) . With the purpose of finding the mediators through which transfers can affect academic performance, I used the mediation model with instrumental variables proposed by Dippel et al. (2017).

The Dippel's model shows that the instrument (D i,m,c) causes the endogenous variable (T i,m,c), and allows the identification of the causal effect of public transfers (T i,m,c) on the outcome (Y i,m,c), this effect is known as the total effect (Equations 6 and 7).

Assuming the existence of a mechanism, this model can be seen as:

Figure 6:



The identification of the causal mediation is divided into two parts. On one hand, the effect of transfers per student on the mediator must be identified through the standard 2SLS (Equations 8 and 9). According to Dippel's article, the effect of public transfers (T i,m,c) on the mediator (M i,m,c) can be identified with the same instrument (D i,m,c). The model is as follows :

First stage:

$$T_{i,m,c} = \alpha_0 + \alpha_1 D_{i.m.c} + \gamma X_i + \eta_m + \eta_c + e_{i,m,c} \qquad (8)$$

Second stage:

$$M_{i,m,c} = \Gamma_0 + \Gamma_1 \hat{T}_{i,m,c} + \gamma X_i + \eta_m + \eta_c + \varepsilon_{i,m,c} \quad (9)$$

On the other hand, the effect of the mediator (M i,m,c) on academic results (Y i,m,c) must be identified conditioned on public transfers (T i,m,c), considering the change in transfers due to the new regulation (D i,m,c) as an instrument (Equations 10 and 11). The 2SLS model is defined as follows:

First stage:

$$M_{i,m,c} = \theta_0 + \theta_1 D_{i,m,c} + \theta_2 T_{i,m,c} + \gamma X_i + \eta_m + \eta_c + e_{i,m,c} \quad (10)$$

Second stage:

$$Y_{i,m,c} = \lambda_0 + \lambda_1 \widehat{M}_{i,m,c} + \lambda_2 T_{i,m,c} + \gamma X_i + \eta_m + \eta_c + \varepsilon_{i,m,c} \quad (11)$$

In equation (6), β 1 identifies the total effect of transfers per student on academic results. In equation (8), Γ 1 identifies the total effect of transfers on the mediator. Finally, Γ 1 * λ 1 identifies the indirect effect of transfers on academic results mediated by the mechanism, and λ 2 identifies the residual direct effect of transfers on academic results.

The direct effect provides an answer to the following question: keeping the mediator constant, how can academic results vary when transfers change? Conversely, the indirect effect answers this second question: keeping the transfers constant, how do the academic results change by changing the mediator in the direction derived from the effect between the transfers and the mediator? Finally, the total effect is the sum of the direct and indirect effect.

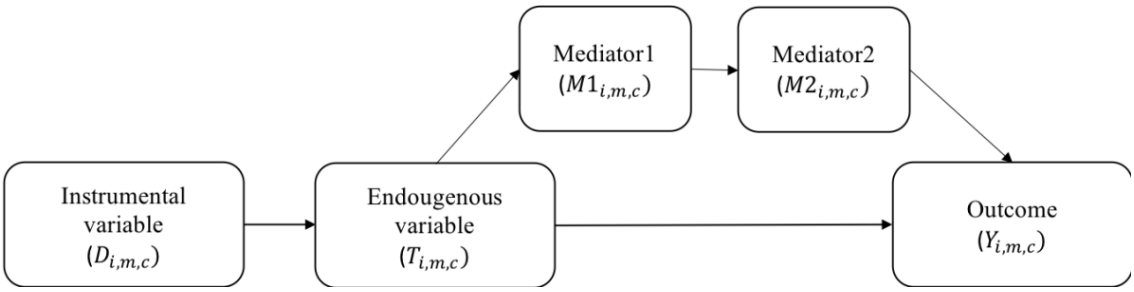
Results of the mediation model

In this part of the article, I want to explain some of the reasons behind the effect of transfers per student on academic results, using the mediation analysis.

My hypothesis is as follows: an increase in national resources per student will have an effect on local resources per student. This effect will have an impact on the students per teacher ratio. Finally, this chain of effects has an impact on academic results (Figure 7).

This research shows a mediation analysis into another mediation analysis. There is no empirical technique that proofs this structure; therefore, I divided the analysis into two parts. In the first part, I find the effect that transfers per student have on the students per teacher ratio, mediated by local resources. In the second part, I find the effect of transfers per student on academic performance, mediated by the students per teacher ratio. Each analysis will show the total, direct and indirect effects.

Figure 7:



Certified Municipalities

Effect of transfers per student on the students per teacher ratio, mediated by local resources

Table 6 shows that the total effect of transfers on the students per teacher ratio is positive and significant. This result is controversial because it is expected that an increase in transfers generates an increase in the number of teachers; as a result, the ratio will decrease. To have an idea of why the total effect has an unexpected result, I carry out the mediation analysis by dividing the effect into direct and indirect effects, which are mediated by local resources. As expected, the direct effect (Column 2) of transfers in the student per teacher ratio is negative, while the effect mediated by local resources (Column 3) is positive and greater than the direct effect. It seems that an increase in local resources, generated by a change in transfers, increases the ratio. This may occur for two reasons: either the number of students increases or the number of teachers decreases. According to the regulations, the number of teachers cannot be reduced; therefore, the effect of transfers on students per teacher ratio is due to an increase in coverage. This effect is expected because the local resources are used on investments that expand the coverage, such as school transportation, creation, and expansion, among others.aragraph style.

Table 7: Certified municipalities Effect of transfers on the students per teacher ratio mediated by local resources

	(1) Total effect	(2) Direct effect	(3) Indirect effect
Transfers	0.70*** (0.015)	-0.04*** (0.004)	0.76*** (0.00)
F-statistic (F. stage)	29,468***	191,325***	-
Fixed effects of cohort	Yes	Yes	Yes
Fixed effects of municipality	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Number of obs.	1,653,702	1,653,702	1,653,702

Notes: Standard errors in parenthesis. Generalized Method of Moments was used to find the p-value of the indirect effect. The monetary variables are at constant prices of 2008, and are in millions of pesos. All regressions include fixed effects of municipality and cohort. All columns include individual controls: gender, educational level of the mother, school day hours and stratum. *** p <0.01, ** p <0.05, * p <0.1

It is important to know the effect that transfers per student have on local resources. Table 8 shows the total effect: an increase in national transfers per student will reduce the investment of local resources in education. This can be justified because municipalities manage both national and local resources. Therefore, when national resources increase, it is possible for local Governments to allocate their local resources to investments other than education, such as health.

Table 8: Certified municipalities Effect of transfers on local resources

	(1) Total effect
Transfers	-1.71*** (0.010)
F-statistic (F. stage)	27,050***
Fixed effects of cohort	Yes
Fixed effects of municipality	Yes
Controls	Yes
Number of obs.	1,658,690

Notes: Standard errors in parenthesis. The monetary variables are at constant prices of 2008, and are in millions of pesos. All regressions include fixed effects of municipality and cohort. All columns include individual controls: gender, educational level of the mother, school day hours and stratum. *** p <0.01, ** p <0.05, * p <0.1

Effect of transfers on academic results, mediated by the students per teacher ratio

The total effect of the transfers in the academic results (Table 9) is negative, e.i. an increase in transfers reduces the academic outcomes of the student. This effect is divided into two: the direct effect which is positive, and the indirect effect which is negative and greater than the direct effect. This means that an increase in transfers has a positive effect on academic performance; although, the increase in students per teacher ratio, generated by a change in transfers, reduces the scores on the test.

Table 9: Certified municipalities Effect of transfers on academic results mediated by the students per teacher ratio

	(1) Total effect	(2) Direct effect	(3) Indirect effect
Transfers	-0.11*** (0.014)	0.01*** (0.003)	-0.11*** (0.00)
F-statistic (F. stage)	27,050***	3,116***	-
Fixed effects of cohort	Yes	Yes	Yes
Fixed effects of municipality	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Number of obs.	1,653,702	1,653,702	1,653,702

Notes: Standard errors in parenthesis. The Generalized Method of Moments was used to find the p-value of the indirect effect. The monetary variables are at constant prices of 2008, and are in millions of pesos. All regressions include fixed effects of municipality and cohort. All columns include individual controls: gender, educational level of the mother, school day hours and stratum. *** p <0.01, ** p <0.05, * p <0.1

In summary, for certified municipalities, an increase in national spending per student is detrimental to academic results due to an increase in coverage driven by the change in local resources.

Non-certified municipalities

Effect of transfers per student on the students per teacher ratio, mediated by local resources

The direct and indirect effects are negative and positive, respectively, and have a very similar absolute value. Hence, the effect of an increase in transfers per student on the students per teacher ratio (Table 10) is close to zero. As in the certified municipalities, increasing the transfers has a negative direct effect on the students per teacher ratio. I assume that this happens because the number of teachers in these municipalities increases. This increase in

transfers has a positive indirect effect generated by the increase in coverage, which is a reflection of the increase in local resources, as is the case of certified municipalities.

Table 10: Non-certified municipalities Effect of transfers on the students per teacher ratio mediated by local resources

	(1) Total effect	(2) Direct effect	(3) Indirect effect
Transfers	-0.00 (0.007)	-0.16*** (0.003)	0.17*** (0.00)
F-statistic (F. stage)	114,298	302	-
Fixed effects of cohort	Yes	Yes	Yes
Fixed effects of municipality	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Number of obs.	1,289,201	1,289,201	1,289,201

Notes: Standard errors in parenthesis. The Generalized Method of Moments was used to find the p-value of the indirect effect. The monetary variables are at constant prices of 2008, and are in millions of pesos. All regressions include fixed effects of municipality and cohort. All columns include individual controls: gender, educational level of the mother, school day hours and stratum. *** p <0.01, ** p <0.05, * p <0.1

For this case, and opposite to certified municipalities, increasing transfers encourages the investment of local resources in education (Table 11). My hypothesis is that this occurs because non-certified municipalities do not manage the resources given by the national Government, and not knowing the exact amount of these resources encourages them to keep using their local budget and even increasing their investments in education.

Table 11: Non-certified municipalities Effect of transfers on local resources

	(1) Total effect
Transfers	0.083*** (0.004)
F-statistic (F. stage)	114,832
Fixed effects of cohort	Yes
Fixed effects of municipality	Yes
Controls	Yes
Number of obs.	1,303,477

Notes: Standard errors in parenthesis. The monetary variables are at constant prices of 2008, and are in millions of pesos. All regressions include fixed effects of municipality and cohort. All columns include individual controls: gender, educational level of the mother, school day hours and stratum. *** p <0.01, ** p <0.05, * p <0.1

Effect of transfers on academic results, mediated by the students per teacher ratio

Table 12 shows that for the total effect, an increase in transfers per student improves the academic results. This effect consists of the direct effect which is positive, and the indirect effect which is near zero. Therefore, the total effect is explained by the direct effect. Mediators other than the students per teacher ratio could explain the total effect.

Table 12: Non-certified municipalities Effect of transfers on academic results mediated by the students per teacher ratio

	(1) Total effect	(2) Direct effect	(3) Indirect effect
Transfers	0.04*** (0.003)	0.04*** (0.004)	0.00*** (0.00)
F-statistic (F. stage)	114,832***	4,408***	-
Fixed effects of cohort	Yes	Yes	Yes
Fixed effects of municipality	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Number of obs.	1,289,201	1,289,201	1,289,201

Notes: Standard errors in parenthesis. The Generalized Method of Moments was used to find the p-value of the indirect effect. The monetary variables are at constant prices of 2008, and are in millions of pesos. All regressions include fixed effects of municipality and cohort. All columns include individual controls: gender, educational level of the mother, school day hours and stratum. *** p <0.01, ** p <0.05, * p <0.1

CONCLUSIONS

There are previous works in developing countries that correlate public spending on education with academic results. However, as far as I know, this is the first article that finds the causal effect of public spending on academic results and the causal mediators. This result is achieved by using a quasi-natural experiment in Colombia.

I created a repeated cross-section database of individuals from 2004 to 2013, which included academic results, individual characteristics, and information of transfers per student that each municipality received from the national Government. With this information, I conclude that an increase in national transfers per student close to 5% improves academic results by 0.1 standard deviations. These results differ depending on the group of municipalities analyzed: certified municipalities have a negative effect (-0.1 sd) and non-certified municipalities have a positive effect (0.037 sd). These effects increase when controlling by the expansion in coverage: for the total sample, an increase of 5% of accumulated transfers per student generates an improvement of 0.2sd on academic results. The increase is 0.1sd for certified municipalities and 0.06sd for non-certified municipalities.

I propose a chain of mediation in which transfers affect the local resources, transfers and local resourses affect the student per teacher ratio, and finally, all these facts are reflected in academic results.

When reviewing the mediation analysis, I conclude that there is a direct positive effect of the transfers in academic results when the mediator is the students per teacher ratio. On the other hand, the indirect effect is negative for both groups of municipalities; i.e when the students per teacher ratio increases, due to a change in transfers per student, the academic performance decreases.

I also find that the total effect of transfers on the students per teacher ratio is positive in certified municipalities and it is close to zero in non-certified municipalities. This occurs because there is an effect of the transfers in students per teacher ratio mediated by local resources. That is, when local resources increase due to a change in transfers, the students per teacher ratio increases, as a result of an increase in coverage.

The difference in the total effect, of trasfers in academic perfomance, between certified and non-certified municipalities is due to the values of the direct and indirect effects: certified municipalities have a higher indirect effect wich is negative, while non-certified municipalities have a higher direct effect which is positive.

This analysis gives two major political lessons for the Colombian context. On one hand, both national and local Governments have to pay attention to the incentives that national expending on education generate in the local investment, especially in the case of decentralized municipalities. On the other hand, the regulation has been a good initiative to increase the attendance rates, but this change has been detrimental to academic results. Therefore, it is time to generate changes regarding the educational quality.

These findings contribute to the human capital literature, since they show that increases in public efforts can have a positive effect on academic variables in short term. And, according to Heckman (2007), an effect in the short term also has long term impacts on the individual and on society. For this reason, there is plenty of work to be done. Particularly, this research should be complemented with the long term effects, such as academic results of tertiary education and future salaries. Thus, it can be proved that the Government's effort regarding public spending has both short and long term effects.

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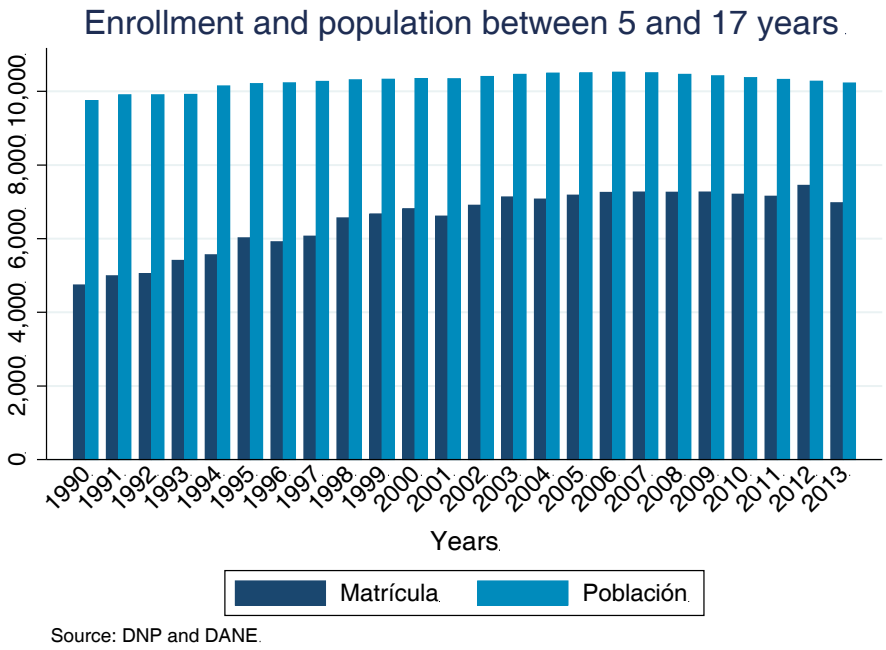
APPENDIX

In this appendix you will find the evolution of the students enrolled and the population between 5 and 17 years. As you can see, the coverage increases over time while the population remains relatively constant. It should be pointed out that a 100% coverage is not achieved in any of the years.

Figure 8:



Source: DNP and DANE.