Estimating the scope for governmental interventions to improve education performance

The objective of this study is to analyse what policies the government can adopt in order to improve educational performance. The Educational Production Function approach is used to identify the scope for possible interventions. To do this, it is first necessary to control for individual-specific and family-specific factors on performance. After having controlled for these factors, the econometric analysis can be focused on determining the effect on performance of different manipulative inputs such as teacher training, classroom infrastructure and number of school days.

The data analysed comes from the National Evaluation System (SINEC) that contains information on performance but also on students, their family, teachers and school. This data structure allows implementing the Multilevel Modelling technique that has the advantage of identifying the different levels of the data and consequently obtaining more efficient estimates of the coefficients. Additionally, the availability of information about the student's classmates allows the construction of a social interaction model to analyse the peer effect. In education, two different interaction effects can be identified. The first one is between teacher and students and the second is among students only. This study, using the multilevel modelling and the social interaction approach mentioned above, used to model the peer effect, attempts to identify them and provide efficient estimators.

After controlling for the different variables that affect performance, the scope for governmental intervention was identified. Some of the policies that this study highlights are related to the teacher's characteristics and others to the school and some to individuals themselves. With respect to the teachers, a policy that increases the possibility of granting them tenure, as well as the availability of special training programmes and the incentives to join these would improve performance. Additionally, it was found that an improvement in a teacher's job satisfaction would benefit the students. Additionally, policies that increase the number of school days and improve classroom characteristics would have a positive effect on performance. Finally, policies successful at persuading a student to give up work would improve not only the pupil's own performance but also her classmates' through the spillover effect present in educational process.

Estimating the scope for governmental interventions to improve education performance

Emmanuel Abuelafia[1]
University of Cambridge

e.abuelafia.02@cantab.net

[1] I want to thank the Interamerican Development Bank and the Japanese Government for the financial support, Dr. Melvyn Weeks for his guidance and my classmates for their help with my really bad English.

Index

Index 3
Section I: Introduction 4
Section II: Educational Production Functions 6
II.1: Educational Production Functions: Motivation and Problems. 6
II.2: A Simple Model of Educational Production Function. 8
II.3: Empirical Studies 9
Section III: Econometric Technique for EPF 12
III.1: Multilevel Modelling: 12
III.2: Estimation Procedure 16
Section IV: The Variables of the Model. 18
IV.1: The Database and the Dependent Variable 18
IV.2: Explanatory Variables 20
IV.3: Expected results 20
IV.3.a: Family and individual characteristics 20
IV.3.b: Teacher's characteristics 21
IV.3.c: Classroom and school characteristics 22
IV.3.d: Peer Effect 23
Section V: Estimation Results. 26
V.1: Estimated econometric models 26
V.2: Interpretation of the obtained results 29
Section VI: Identifying Scope for Interventions. 32
Section VII: Conclusion and Further Extensions. 35
Bibliography 37
Appendix 40

Section I: Introduction

Education is one of the main instruments used to foster human capabilities and offer people the opportunity to have the freedom to lead the kind of lives they value. It is also essential in building democratic values, improving human development and contributing to economic growth[2].

The educational system in Argentina is not operating efficiently within the confounds of its resources. Low-income people fail to complete secondary education, a consequence of poor access to any form of high quality education. Several studies have pointed out that education acts to reinforce inequities rather than reduce them[3]. Furthermore, the performance of the system is poor compared to other countries that invest similar amounts in education. These are some of the factors that have led to a general consensus for the of educational reform.

The objective of this study is to analyse what policies the government can adopt in order to improve educational performance. The Educational Production Function approach is used to identify the scope for such interventions. To do this, it is first necessary to control the effect of individual-specific and family-specific factors on performance. After having controlled for these factors, the econometric analysis can be used to determine the effect of different manipulative inputs such as teacher's training, classroom infrastructure and number of school days on the performance of students.

[2] Sen, A (1996)
[3] Fiszbein, A (1999)

If all students in a class have the same teacher for all subjects, such as in a traditional primary school, there is a combined effect of the teacher and the specific composition of the classroom[4]. Two different interactions effects can be identified. The first is the relation between teacher and students and the second is the relation of the students among themselves. This study, by means of the multilevel modelling and the social interaction approach used to model the peer effect, attempts to identify them and provide efficient estimators.

The data analysed come from the National Evaluation System (SINEC) and includes not only information on performance but also on students, family, teachers and school. There are different levels of data available. Individual students form the first level while the classroom and the school form a second level of observations as there is only one classroom observation per school[5]. The structure can be expressed as:

Level	Observational Unit
2	School
1	Individuals

This structure allows the implementation of the Multilevel Modelling technique, which has the advantage of being able to identify the different levels of the data and consequently obtaining more efficient estimates of the effects of the different variables. Additionally, the availability of information about the student's classmates allows the construction of a social interaction model to analyse the peer effect, given that it is commonly believed that better classmates leads to better performance.

In the second section, the motivations and problems behind the Educational Production Function approach are exposed, as well as a simple theoretical model and a literature review. The third explains the econometric technique and the estimation procedure while the fourth analyses the dependent and the explanatory variables. Section five provides an interpretation of the results and the sixth identifies the scope for governmental intervention. Finally, section seven concludes.

[4] Hanushek (1986).
[5] To avoid confusion, the second level unit is called school, but it is worth to notice that contains not only school level variables but also classroom level ones.

Section II: Educational Production Functions

In this section the motivation of the Educational Production Functions (EPF) are explained, a theoretical model is developed and a review of EPF empirical results from different studies are shown. Special attention is given to the results obtained for Latin America and, particularly, Argentina.

II.1: Educational Production Functions: Motivation and Problems.

Most economic studies on school effectiveness follow the EPF approach, asking the question of which manipulative inputs can increase output: personal characteristics, socio-economic background, classroom and school structure and environment are treated as inputs, while student performance is the output:

$$A_{ijt} = G(A_{ijt-1}, F_{ijt}, T_{jt}, S_{jt}, P_{ijt})$$

$$\begin{aligned} &where \quad i = 1,...,Nj \text{ represents students} \\ &\qquad\quad j = 1,...,J \text{ represents classrooms} \end{aligned}$$

Where A_{ijt} denotes the student's attainment at date t, F_{ijt} refers to family inputs and personal characteristics, T_{jt} denotes teacher inputs, S_{jt} school inputs, and P_{ijt} peer group effects.

The aim of this analysis is to measure the effect of the change in one of the manipulative inputs on the students' achievement. Given that, the functional form of the EPF is an important factor but it is not clarified by the literature[6]. Generally, G(.) is assumed to be homothetic and in particular, additive. Some studies[7] use translog production functions instead of linear ones.

The main features of this approach are that the production function is unknown and must be estimated using imperfect data. In addition, the decision-maker cannot change some important inputs and any estimates of the production function will be subject to considerable uncertainty[8].

The inputs of the Educational Production Functions can be classified as:

$$\begin{cases} F_{ijt} = (\text{Gender, KindergartenAttendance, Repetition, } S\text{chool}C\text{hange, Density in} \\ \qquad \text{the Household, Wealth Index, Parental Education)} \\ T_{jt} = (E\text{ducation, } E\text{xperience, Dedication, Tenure, Training, Turnover, Absenteeism)} \\ S_{jt} = (C\text{lass } S\text{ize, } S\text{chool } S\text{ize, } S\text{tructure, } S\text{chool } D\text{ays, Social Assistance)} \\ P_{jt} = (\text{Peer Group variables)} \end{cases}$$

To analyse school production it is essential to employ an adequate measure of outcomes. This is not an easy task, since education has multiple objectives, many of which are difficult to measure. A majority of studies in the EPF traditionally measure output by standardized achievement test scores, although other studies have employed different measures such as student attitudes, school attendance rates and high school continuation or dropout rates. In this study, test scores are used as the measure of attainment.

The problem in statistical terms is to describe the relationships between test scores, school and teacher processes, and characteristics of the pupil intake. Two problems arise when an achievement measure is simply regressed on available inputs. First of all, adequate measures of innate abilities have never been available. Second, while education is cumulative, frequently only contemporaneous measures of inputs are available, leading to measurement and specification errors. Each of these problems

[6] Figlio (1998)
[7] Figlio (1998) and other references there
[8] Hanushek (1986)

leads to biases in the estimated effects of educational inputs. In a regression analysis framework, the effect of omitting an important variable is to generate a bias in the estimated regression coefficients where the size of bias is related to the significance of the variable in the model and the correlation of the omitted variable with the others included. Because it is reasonable to assume that innate abilities are positively correlated with family background, their omission will probably lead to an upward bias of the estimated impact of family background on achievement[9].

II.2: A Simple Model of Educational Production Function.

Pritchett et al (1999) sketch some positive theories of expenditure allocation that might underlie production function estimates. If A_{ijt} is the educational output and is related to educational inputs that are under policymaker control, denoted as s_{jt} , with price p_s according to a technically determined EPF G(.), then the maximisation problem subject to a budget constraint is:

$$Maximise \quad A_{ijt} = G(S_{jt},...) \quad subjecttop'S = B$$

The first order condition of this maximisation problem is:

$$\frac{G_s}{p_s} = \frac{G_w}{p_w} \quad \forall s, w$$

which implies that the increment in the educational output per dollar should be exactly the same for each input.

An interesting extension to this simple maximization problem developed by Pritchett et al is where the policymaker is maximizing the weighted average of the A_{ijt} function and the teacher's utility function T(x). In this case the maximization problem becomes:

$$Maximise \quad C_{jt} = (1-a)A_{ijt} + aT(S) \quad subjectto\ p'S = B$$

$$where \quad a \in (0,1) \text{ and assumed as known}$$

In this case, the outcome depends not only on the underlying production function but also on the structure of the teacher's utility function.

[9] Hanushek (1986)

If the latter is assumed to be the weighted average of the direct utility function derived from inputs and student's achievement[10], the maximization problem can be rewritten as:

$$Maximise \quad ((1-a)+ad)A_{ijt} + a(1-d)U(g'S) \quad subject to \ p'S = B$$

$$where \quad d \equiv \text{weight of educational inputs in the teacher's utility function (T(S))}$$

$$g \equiv \text{weight of educational inputs in the teacher's direct utility function}$$

In this case the FOC is:

$$\frac{G_s}{p_s} = \frac{G_w}{p_w} + \frac{a(1-d)}{(1-a)+ad} U_s \left[\frac{g_w}{p_w} - \frac{g_s}{ps} \right]$$

As long as the weight given to teacher's utility is not zero and the degree of professionalism is not selfish ($d < 1$) then marginal products per dollar will not be equalised.

II.3: Empirical Studies

The history of the educational production function is typically traced back to *Equality of Educational Opportunity*, referred to as the "Coleman Report" that was conceived as a study of the distribution of educational resources within the United States by race or ethnic background. The study appeared to demonstrate that differences in schools had little to do with differences in students' performances[11]. Instead, family background and the characteristics of other students in the school seemed to be much more important.

There are a large number of studies about educational achievement that use EPF approach, with different specifications of the function as well as different ways to measure students' performance. Hanushek (1986) undertook a detailed analysis of the results obtained and problems found in more than one hundred studies. The author points out that besides the problems already mentioned, there are problems due to the imprecise measurement of the specific school resources relevant to students at a given point of time. This problem occurs because schools are quite heterogeneous

[10] $T(S) = (1-d)U(g\,S) + d\,A(S)$ where U(.) is the direct utility derived from inputs, g is a vector which gives a weight to each of the inputs. d is the professionalism parameter and lies between 0 and 1

[11] Hanushek (1986)

institutions offering a diversity of inputs to specific students, and the exact provision for each individual is often not recorded or available [12].

To summarize the findings of the different EPF studies, tables from Hanushek (1986), Pritchett et al (1999) and Vele z et al (1993) are reproduced below. The "confirmation percentage" suggested by Pritchett et al is used to analyse the coincidence of the results with the theoretical predictions. This measure shows the frequency where the coefficients estimated are consistent with the theoretical predictions and are statistically significant.

The Hanushek's results are constructed from studies dated from 1967 to 1986, which do not contradict the findings of Coleman et al where the teacher's characteristics have little influence over students' performance.

Table 1: Confirmation ratios of the significance of various inputs (Hanushek)

	Number of Studies	Statistically significant		Confirmation Percentage
		(+)	(-)	
Teacher/pupils ratio	112	9	14	12.5
Teacher Education	106	6	5	5.7
Teacher Experience	109	33	7	30.1

Source: Hanushek 1986 and Pritchet et al modification

A more recent survey was made by Fuller et al (1994), reproduced in Pritchett et al (1999), where the studies analysed found a greater occurrence of a statistically significant relationship between teachers' characteristics and students' performance.

[12] Another problem mentioned is the reliability of using level observations or valued added (in the sense of how much the student's performance change during a given period of time). The issue that determines what technique should be used is the availability of data, which in this study, is only cross-sectional and possesses a structure that doesn't allow the identification of the year that students are in.

Table 2: Confirmation ratios of significance of various inputs. (Pritchett et al)

	Number of Studies	Positive and statistically significant	Confirmation Percentage
Teacher's salary level	11	4	36.4
School teacher pupil ratio	26	9	34.6
Teacher's years of schooling	18	9	50
Teacher's experience	23	13	56.5
Class instructional time	17	9	88.2
School Library	18	16	88.9
School textbooks	26	19	73.1

Source: Pritchett et al (1999)

It can be observed that when recent studies are included in the comparison[13], the teacher's characteristics and educational inputs are more often found to be statistically significant than the studies included in Hanushek's survey. This result coincides with the characterization made by Kreft (1993) where the EPF studies were classified in first and second generations. The former were centred on individuals' factors and the latter on teachers and the educational process taking place in schools.

It can be expected that the results are going to be different for Latin America because of the conclusion reached by Pritchett et al that in developing countries, teachers influence the allocation of expenditure to inputs that increase teachers' welfare, unlike in developed countries. Therefore, in addition to those two surveys, it is worth including the summary elaborated by Velez at al (Table 3 in the appendix) that analyses the findings of studies focused on this region.

There are several studies for Argentina. The main one is Llach et al (2000) that describes the overall educational system and uses the EPF approach for test scores in 1993 and 1997[14]. Another, made by Eskeland et al (2000), has a different objective because they were attempting to analyse the effect of participation and autarky on student's performance. Another, made by Murrillo et al (2000) also undertook EPF estimation but this study differs from the present in the econometric technique used and the period under consideration. All those studies are going to be used as benchmarks for the results obtained in the present study.

[13] Fuller et al (1994) includes studies from 1988 - 1993.
[14] The difference between the present analysis is the econometric technique, the variables of interest and the periods analysed.

Section III: Econometric Technique for EPF

The technique used to estimate the EPF differs from the OLS estimation technique. The problem is that the disturbance term is correlated within each school. In that case, this technique can be seen as a random components model. In this section the theoretical motivation is discussed, but also its estimation strategy.

III.1: Multilevel Modelling:

The techniques used for the study of EPF have evolved in the last decades to become a procedure based on hierarchical nesting, namely Multilevel Analysis. Students are nested in classrooms, classrooms belong to schools, and schools to school systems, regions and counties. Consequently, data are collected as a clustered sample, and observations within the same cluster are dependent, which contradicts the independence assumption of the traditional linear model. A simple way to understand this approach is to see it, in a two level case, as a random effect model in panel data, with the same variance-covariance matrix structure than an unbalanced panel[15].

Another issue is to decide which unit of study to use for analysis: the students or the school. In the first alternative, the already mentioned clustering characteristic of the data is present. In the second, there is a problem of aggregation bias that occurs when a variable takes on different meanings and consequently, has different effects at different levels of aggregation. Lee et al (1989) give the example of the average social class of a school that has an effect on a student's performance above and beyond the effect of the individual child's social class.

[15] It will be clarified in the development of this section.

In a multilevel data analysis model, a single estimation procedure is used that can deal with variables from both levels. These procedures compare the aggregate coefficients while accounting for standard errors of the coefficients. Also this kind of model considers the difference in the number of students in each class in the sample. The presence of unbalanced number of observations in each group such that the assumption of equal error variances for all groups is not credible[16].

As Goldstein (1995) states *" An analysis that explicitly models the manner in which students are grouped within schools has several advantages. First, it enables data analysts to obtain statistically efficient estimates of regression coefficients. Secondly, by using the clustering information it provides correct standard errors…"*

The other possibility, in a 2-level case, is to ignore the hierarchical structure and treat each school completely separately by fitting a different regression model within each one. This approach works efficiently where there are a small number of schools and a reasonably large number of students in each school, or when it is desired to make inferences only about those schools.

In a multilevel analysis, all levels are recognised[17] and analysed in relation to one another. Therefore, it is possible to analyse students within schools without losing the distinction between the levels, and then inferences can be made to school and student level[18].

For purpose of exposition, consider a simple example of how to build up the multilevel model structure, reproduced from Goldstein (1995):

[16] Kreft (1993).
[17] In our example, there are two levels: students and schools, there is no classroom level because there is only one observation per school.
[18] Kreft (1993)

In a simple model of one school, the EPF[19] can be written as

(1) $y_i = b_0 + b_1 x_i + e_i$

where i=1,...,n represent students

y_i is student's performance and x_i is an explanatory variable

Where the standard interpretations can be given to the parameters. If a set of J school are considered simultaneously, the model can be written, for school j, as:

(2) $y_{ij} = b_{0j} + b_{1j} x_{ij} + e_{ij}$

$i = 1,2,...,n_j \qquad j = 1,2,...,J$

Where j refers to schools (level 2 unit in this case) and i refers to students (level 1 unit). In this case, it is necessary to estimate 2n+1 parameters assuming a common "within-school" residual variance and separate EPF for each school.

A simple extension of this model is to consider the parameters as variables:

(3) $b_{0j} = b_0 + u_{0j} \qquad b_{1j} = b_1 + u_{1j}$

where u_{0j} and u_{1j} are random variables with parameters

$E(u_{0j}) = E(u_{1j}) = 0$

(4)

$Var(u_{0j}) = s_{u0}^2 \quad Var(u_{1j}) = s_{u1}^2 \quad Cov(u_{0j}, u_{1j}) = s_{u01}$

Then (2) can be written in the form:

(5) $y_{ij} = b_0 + b_1 x_{ij} + u_{0j} + u_{1j} x_{ij} + e_{0ij}$

$i = 1,2,...,n_j \qquad j = 1,2,...,J$

Consequently, y_{ij} is expressed as a sum of a fixed part and a random part. The estimation of this model involves two fixed coefficients b_0 and b_1, and four random parameters, $s_{u0}^2, s_{u1}^2, s_{u01}^2$ and s_{e0}^2. This feature makes it different from standard linear regression models because of the requirement of special procedures to obtain satisfactory parameter estimates.

[19] Assuming that it is linear

Considering the simplest model[20] where only the coefficient b_{0j} is regarded as random, the conditional variance of y_{ij} is

(6) $\mathrm{var}(y_{ij} \mid b_0, b_1, x_{ij}) = \mathrm{var}(u_0 + e_{0ij}) = s_{u0}^2 + s_{e0}^2$
assuming $\mathrm{cov}(u_0, e_0) = 0$

and the conditional covariance between two students in the same school j is

(7) $\mathrm{cov}(y_{ij}, y_{sj} \mid b_0, b_1, x_{ij}) = \mathrm{cov}(u_{0j} + e_{0ij}, u_{0j} + e_{0sj}) = \mathrm{cov}(u_{0j}, u_{0j}) = s_{u0}^2$

The correlation between those two observations is:

(8) $$r = \frac{s_{u0}^2}{s_{u0}^2 + s_{e0}^2}$$

which is referred to as the intra level 2 unit correlation. It measures the proportion of the total variance that is between schools.

As it can be seen from the disturbance structure, the OLS regression is not adequate for the estimation of this kind of multilevel models because it leads to incorrect inferences. It can be seen as the same disturbances structure that random effect panel data estimation features.

The variance-covariance matrix of all the students in the school j is:

$$\Sigma_j = \begin{bmatrix} s_{u0}^2 + s_{e0}^2 & s_{u0}^2 & s_{u0}^2 & s_{u0}^2 & s_{u0}^2 \\ s_{u0}^2 & s_{u0}^2 + s_{e0}^2 & s_{u0}^2 & \vdots & s_{u0}^2 \\ \vdots & s_{u0}^2 & \ddots & s_{u0}^2 & s_{u0}^2 \\ \vdots & \vdots & \ddots & \ddots & s_{u0}^2 \\ s_{u0}^2 & s_{u0}^2 & s_{u0}^2 & s_{u0}^2 & s_{u0}^2 + s_{e0}^2 \end{bmatrix}$$

The dimension of Σ_j is Nj that varies accordingly with the number of students in each school, adding another source of complexity to the problem, as was pointed earlier in this section.

[20] For didactical purposes

III.2: Estimation Procedure

Now that the main idea behind multilevel modelling has been described, we turn to the estimation procedure[21]. Considering a general two level hierarchical model:

(9) $$y_{ij} = b_{0j} + \sum_{q=1}^{Q} b_{qj} x_{qij} + e_{ij}$$

where b_{qj} are level-1 coefficients

x_{qij} are level-1 predictors q for case i in unit j

$e_{ij} \sim N(0, s^2_{eO})$

And for each coefficient b_{qj} :

(10) $$b_{qj} = g_{qo} + g_{q1} W_{1_q j} + \ldots + g_{qs} W_{s_q j} + u_{qj}$$

where W_{qj} are level-2 predictors

u_{qj} are level-2 random coefficients

$u_{qj} \sim MN(0, \Omega)$

$\mathrm{var}(u_{qj}) = t_{qq}$ *and* $\mathrm{cov}(u_{qj}, u_{q'j}) = t_{qq}$

Three kinds of parameter estimates are available in a hierarchical linear model: empirical Bayes estimates of randomly varying level-1 coefficients; generalized least squares estimates of the level-2 coefficients; and maximum-likelihood estimates of the variance and covariance components.[22]

Empirical Bayes estimates of randomly varying level-1 coefficients: these estimates of the level-1 coefficients for each unit j are optimal composites of an estimate based on the data from that unit and an estimate based on data from other similar units.

Generalized least squares (GLS) estimates of the level-2 coefficients: substitution of the level-2 equations into their corresponding level-1 terms yields a single-equation linear model with a complex error structure[23]. Proper estimation of the regression coefficients of this model requires taking into account the differential precision of the information provided by each of the J units. This is accomplished through generalized least squares.

---

[21] The econometric study was realised using HLM 5.02 software developed by Randeubush et al (2003)
[22] Based on Randeubush et al (2003)
[23] for a simple example, see previous section

Maximum likelihood estimates of variance and covariance components, at Level 1, and t at Level 2: because of the unbalanced nature of the data traditional methods for variance-covariance component estimation fail to yield efficient estimates. Through iterative computing techniques, such as the EM algorithm and Fisher scoring, maximum-likelihood estimates for s_{e0}^2 and t can be obtained.

Section IV: The Variables of the Model.

This section contains all the relevant information about the database, the dependent variable and the explanatory variables. This is followed by a discussion of the expected effect of the different explanatory variables.

IV.1: The Database and the Dependent Variable

Since 1993, the Ministry of Education of Argentina implements a National Evaluation System, to quantify the students' knowledge in a variety of subjects and to collect complementary information in order to analyse students' performance determinants[24]. The observational units are: the student, the family, teachers and school.

The data used comes from the National Evaluation Survey of 1997 and 1999, where only data of the mathematics exams of 7th grade public schools students is used. The sample size is independent for each year in each jurisdiction to obtain some relative reliability in the estimated average math test result for each jurisdiction.

The total dataset is composed of 17,549 observations on students and their families and 916 classrooms and schools. There is only one classroom per school each year and the schools are not repeated in different surveys. To be able to compare the data obtained from the two years, the test scores have been adjusted by the degree of difficulty of each test[25].

As the data comes from two different waves of a survey, one possible course of action considered is to construct a pseudo panel data model. In this case, the procedure is to

[24] Since 1997
[25] The adjustment is based on estimates realised by the Ministry of Education. See Perusia (2002)

define a cohort, that is, *"a group with fixed membership, individuals of which can be identified as they show up in the surveys"*[26]. This technique is widely used in consumer demand analysis whenever a true panel data structure is not available. In the present study, the cohorts can be defined, for example, using the student's wealth distribution. This technique implies averaging the variables among cohorts. As was pointed out in the section III, this averaging may cause aggregation bias in the estimation. This problem together with the characteristic that schools are not repeated each year and that the data is clustered within schools[27] makes it undesirable to construct a pseudo panel. It seems to be incompatible with the hierarchical structure of the available data.

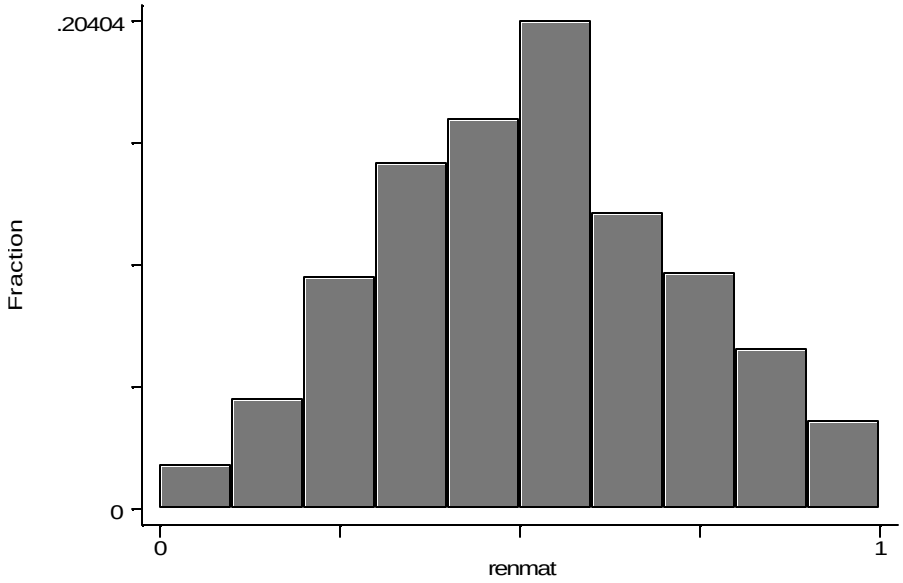
There is a consensus in the literature about the variations in the effect of different inputs in the math and language learning processes. In the case of mathematics, it is more hierarchically organized and limited to the formal schooling than language learning[28]. Consequently, considering math results may be more accurate to identify both teacher and peer effects on achievement.

As Vignoles et al (2000) point out, parents who send their children to private schools can choose the quality of their children's schooling. This situation may cause endogeneity problems of school quality. In an attempt to avoid this problem, only students that attend public schools were considered. It is assumed that the Tiebout voting is not very important in the case of public education.

To summarise, the dependent variable in the present study is the mathematics test result for 7th grade primary public-urban school students. The two databases are pooled into a single one after the adjustment mentioned above. The mean value of the dependent variable is 49.52, its standard deviation is 20.6 and it ranges between 0 and 100.

[26] Deaton (1985)
[27] See previous section.
[28] Kastakis (1987)

Graph 1: Math Test Results. 1997 and 1999 (adjusted)



Source: database

IV.2: Explanatory Variables

The explanatory variables included can be classified in the different levels that they entered in the multilevel modelling analysis. In level 1, the student and her family characteristics and in level 2, the variables that capture the teachers and school characteristics, are included. Tables 4 and 5 in the appendix show the definition and statistics of the variables used in the analysis.

IV.3: Expected results

IV.3.a: Family and individual characteristics

It can be expected that the student who attended kindergarten will perform better in the test due to the influence of early stimulation on posterior school performance. On the other hand, if a student repeated a grade or if she changed school, one can expect worse results in the tests that a student that did not. Also, it can be expected that if the student had a job[29] she will perform worse than if she did not.

[29] Paid or not

Under the assumption that the parents' education can be considered as a proxy of parents' skills and the initial human capital of their sons and daughters, there may exist a positive relationship between parents' education and student's performance. Parents with higher levels of education provide inputs of higher quality in the sense that they are more effective in stimulating children's intellectual interest[30].

Family wealth is also expected to be positively related to children's achievement. The rationale is that additional income permits parents to provide better inputs to their children. There is no direct measure of family wealth available in the raw dataset but it is constructed based on the belongings of a student in their house and assigning them their market prices[31].

A higher density of people at home is considered to deteriorate students' performance. In an overcrowded house it may be difficult for children to find a quiet space to read and do their homework. In addition, interruptions may diminish the effectiveness of parental time inputs. This formulation of the variable excludes parent's characteristics not revealed by the other explanatory variables such IQ and principally their perception of optimal family size [32].

IV.3.b: Teacher's characteristics

In order to capture the teachers' effect on their students, the optimal procedure is to regress student's achievement on their passed performance, family background and a separated intercept for all students that share the same teacher[33]. This kind of analysis allows us to obtain an implicit measure of teacher effectiveness and is called the teacher's total effect. A number of studies provide direct analysis of this question of differential effectiveness of teachers through the estimation of total teacher effects. The findings of these studies are unequivocal: "*teachers and schools differ*

[30] See Llach *et al* (2000)
[31] The assigned market values are: $ 400 to fridge, water heater and stove, $ 800 to fridge with freezer and air conditioner, $ 50 to portable fan, $ 200 to microwave, clothes dryer and telephone, $ 300 to color TV and video reproducer, $ 360 to Cable TV, $ 500 to washing machine and music equipment, $600 to personal video camera and $ 1000 to personal computer.
[32] See Llach et at (2000)
[33] Hanushek (1986)

dramatically in their effectiveness"[34]. Existing measures of teachers' and schools' characteristics are seriously flawed and thus are poor indications of their pure effects on performance. When these measurement errors are corrected, schools are seen to have an important effect on students' performance[35].

While it is important to confirm that teachers differ in effectiveness, it would be more desirable to identify the specific aspects and characteristics of teachers and schools that are important. There is a core set of factors that was almost universally investigated. According to conventional wisdom, more educated, more experienced and more dedicated teachers both cost more and are presumed to be beneficial for the student. It is also expected that greater job satisfaction and work environment for teachers leads towards better student performance. The other classroom characteristic that is analysed is its infrastructure measured by the teacher's opinion about how appropriate the classroom is.

IV.3.c: Classroom and school characteristics

The total school enrolment and class size are expected to have negative effects over student's performance. They may be considered as a proxy of the degree of personal involvement on the part of principals and teachers in the education of individual students, as well as teacher turnover and absenteeism. . As Hanushek[36] says *"…reduced class size rests on common sense, with fewer students, teachers can devote more attention to each child and can tailor the material to the individual child's needs…"*

There is no disagreement in the literature that more school days benefit students[37]. Additionally, a higher percentage of students receiving school assistance (milk cup, lunch, didactic supplies and teacher special tutoring) will indicate worse social and economic students' background and consequently, it may be expected to have a negative effect on student results. Another variable included in the regression, in the second level, reflects whether the school has received resources from the government

[34] Hanushek (1986)
[35] Hanushek (1986)
[36] Hanushek (1999)
[37] This variable is included because there is a high variability of the number of school days that students have in different educational districts.

to improve its infrastructure. In this case, the same coefficient sign is expected. The rationale for both coefficient signs is the compensatory focus of the social assistance programmes in Argentina[38]. An additional variable included is the percentage of the students in the school that have under-nourishment problems, given by the principal's opinion. It is logical to expect, that after controlling for the other individual and school characteristics, this problem had a negative effect on performance.

IV.3.d: Peer Effect

Peer effect is an important issue to consider since it's reasonable to expect that better classmates will induce better student performance. It can be studied in the social interaction framework, where social interaction can be defined as "…observations that individuals belonging to the same group to behave similarly."[39]. Manski (1995) classifies the social interaction effects in: endogenous wherein the propensity of an individual to behave in some way varies with the prevalence of that behaviour in groups, contextual wherein the propensity of an individual to behave in some way varies with the distribution of background characteristics of the group and correlated effects, wherein individuals in the same group tend to behave similarly because they face similar institutional environments or have similar individual characteristics.

On one hand, it is simple to identify the structure and the different effects elaborated by Manski (1995). Firstly, the social group is unambiguously identified, because each student belongs to a single classroom and a single school. Secondly, the different effects can be identified: the endogenous effect is that student's performance varies with the average performance of her classmates, the contextual effects are the socio-economic characteristics of the classmates and the correlated ones are the classroom and school characteristics. On the other hand, it is difficult to model them in the present study. Manski (1995) provides an example of endogenous effects that show the complexity of this topic. He analysed the effect of a tutoring programme because if individual achievement depends on average classmates performance, there is feedback from the increase in the individual achievement of the recipient of the tutoring to the classmates of the student. It is denoted as a social multiplier of the

[38] See Murillo et al for Argentina and Vignoles et al (2000)
[39] Maskin (1995)

endogenous effect that it is present neither on a contextual nor on a correlated effect. As Weeks[40] states, this effect is not identified in the linear case but it can be circumvented in non-linear models.

Now the problem is how to measure it. There is no methodological consensus in the literature about how to treat this issue in the EPF approach. The average socio-economic characteristics of the student's classmates can be considered as a good proxy of the peer effect. The problem is that all the potential indicators are highly multicollinear, as can be seen in table 6 in the appendix.

In the present case, the average wealth, the proportion of classmates that have a job (paid or not) and the proportion of classmates that repeated a grade, are considered as the measure of peer effect.

One possibility to avoid the multicollinearity problem is to include the variables by means of principal component methodology defining ex ante what variables have positive and negative effect and then grouping it in different principal components.

In a general case there exist a set of variables $x_1, x_2, \ldots, x_n$ with variance-covariance matrix V and the objective is to find a linear function $a'X$ with maximum variance subject to $a'a = 1$. Then, the idea is to find the eigenvalues of $|V - l I| = 0$ and the corresponding eigenvectors, arranging them in order of magnitude. The vectors obtained by the linear combination of the eigenvalues of V and the matrix X is called principal components $z_1 = a_1'X, z_2 = a_2'X, \ldots z_n = a_n'X$. These vectors have the properties that $\mathrm{var}(z_1) + \mathrm{var}(z_2) + \ldots + \mathrm{var}(z_n) = l_1 + l_2 + \ldots + l_n = \mathrm{var}(x_1) + \mathrm{var}(x_2) + \ldots + \mathrm{var}(x_n)$ where l_i are the eigenvalues of the system. Also, given that the vectors $(a_1, a_2, \ldots, a_n)$ are orthogonal, $z_1, z_2, \ldots, z_n$ are also orthogonal.

In the present case, there are two sets of principal components defined. In the first one (the ex ante positive one) the variables included were the average value of: the classmates' parent educational level, number of books at her classmates homes, the wealth level and the proportion of classmates that had attended kindergarten. In the

[40] Weeks (2003). Advanced Econometrics lecture notes.

second, the proportion of student's classmates that have a job, that had repeated a grade and had changed her school in previous years, were included. The weights for the former are 1:1:0.89:0.96:0.93 and for the latter 1:0.73:0.86:1.16.

This methodology has been used in other EPF studies[41]. The main critique of this approach is that as the weights are constructed in such way that the vectors are orthogonal, the principal components don't have any economic interpretation[42]. Both measures are trying to capture the same effect. Hence, two alternative models are estimated stating clearly which measure of peer effect is used.

[41] Feinstein et al (1999) and Lee et al (1989)
[42] Maddala (1996)

Section V: Estimation Results.

In this section, the econometric models estimated are shown, beginning with an unconditional regression, where all the coefficients are considered as random. After testing the randomness of the coefficients, the model that includes the school level variables is regressed. Then, the results obtained are interpreted.

V.1: Estimated econometric models

The general form of the model estimated is:

$$
\begin{aligned}
A_{ij} &= b_0 + b_{1j} SGENDER_{ij} + b_{2j} KINDERGA + b_{3j} WORK + b_{4j} DENSITY + \\
&+ b_{5j} REPEAT + b_{6j} WEALTH + b_{7j} SCHANGE + b_{8j} PAEDUC + e_{ij} \\
b_{0j} &= g_{00} + g_{01} W_{1_0 j} + g_{02} W_{2_0 j} + \ldots + g_{0s} W_{s_0 j} + u_{oj} \\
b_{1j} &= g_{10} + u_{1j} \\
&\vdots \\
b_{8j} &= g_{80} + u_{8j}
\end{aligned}
\tag{11}
$$

where g_{00} is the average of the school means on math achievement

g_{0v} is the main effect of the variable v

g_{zj} is the mean marginal effect of the variable z, z=1,..,8

The first model estimated is one where all the coefficients of the explanatory variables are considered as random, which is referred to as unconditional regression[43]. It means that in equation 11 all the W_{ij} are set equal to zero. From this model, using a chi-squared test, the coefficients were set as fixed or random.

[43] Lee et al (1989)

As can be observed in the table 7 on the appendix, the coefficients of DENSITY, WEALTH, SCHANGE and PAEDUC can be considered as fixed, given that it is not possible to reject the null hypothesis that the variance is the same for all the schools[44].

After deciding whether the coefficient were random, level two (school) variables that were assumed to influence students' performance were included in the equation for b_0. The regression results obtained are shown in table 8.

[44] As Lee et al notice, the chi-squared statistics reported provide only approximate probability values because that they are estimated only on the basis of those schools that have sufficient data to compute a separate OLS and they are simple univariate tests.

Table 8: Estimation Results

Fixed Effect	Coefficient	Standard Error
Level 2 variables – School Level Variables		
Intercept	-0.38	4.34
CLASSMATES AVERAGE WEALTH	0.01***	0.00
CLASSMATES AVERAGE REPEAT	-42.81***	3.04
CLASSMATES AVERAGE WORK	-14.07***	3.43
TEACHER'S EDUCATION	-0.36	0.33
TEACHER'S EXPERIENCE	-0.14	0.09
TEACHER TENURE (1 if tenured)	3.46***	1.04
TEACHER DEDICATION (1if more than one job)	-2.32**	1.05
TEACHER SPECIFIC TRAINING (1 if yes)	3.76***	1.13
TEACHER'S SATISFACTION	2.18***	0.49
VIOLENCE SITUATION IN THE SCHOOL (1 if yes)	1.42	1.08
CLASSROOM INFRASTRUCTURE	0.50***	0.18
WORK ENVIRONMENT	0.18	0.30
TEACHER TURNOVER	-1.33	3.12
TEACHER ABSENTEEISM	2.65	4.25
SCHOOL SIZE	-0.21	0.19
SCHOOL DAYS	0.20***	0.02
CLASS SIZE	0.03	0.08
% students receiving LUNCH	-0.15	0.32
% students receiving MILK CUP	-0.29	0.23
% students receiving TUTORING	-0.69*	0.38
% students receiving DIDACTIC SUPPLIES	-0.35	0.27
School received SOCIAL PROGRAMMES	0.50	1.15
% students that are UNDERNOURISHED	-1.73***	0.35
Level 1 Variables – Student Level Variables		
GENDER (1=female)	-0.67***	0.24
KINDERGARTEN ATTENDANCE (1 if yes)	0.90***	0.34
AVERAGE PARENTS EDUCATION	0.36***	0.04
WORK (1 if student has a job)	-2.14***	0.25
DENSITY OF PEOPLE IN THE HOUSEHOLD	-0.43***	0.09
WEALTH INDEX	0.00027***	0.0001
REPEAT (1 if repeated a year)	-6.62***	0.44
SCHOOL CHANGE (1 if changed school)	-2.19***	0.31

(***) Statistically signifi cant at 1% confidence level
(**) Statistically significant at 5% confidence level
(*) Statistically significant at 10% confidence level

Source: database

An additional model is estimated. The unique difference with respect to the previous one is that the principal components associated with the peer effect are included as

explanatory variables of the level-2 coefficients rather than the average of the classmates' socio-economic characteristics.

As can be observed from table 9, the coefficients selected as random are still random when the additional explanatory variables are incorporated in the regression analysis.

V.2: Interpretation of the obtained results

In order to simplify the exposition of the findings, we first consider the case where the variables are related to the individual student and her family. Secondly, we consider those related to the teacher's characteristics, then to the classroom and school characteristics and finally the ones related with peer effects.

It was found that female students performed worse in the math exams than the male ones. This finding coincides with others in the EPF literature[45]. A student that had attended kindergarten performed better than one that didn't attend. This reflects, as was mentioned in the previous section, the effect of early stimulation that a child receives while she is in kindergarten.

With respect to family characteristics, it was found that better educated parents (measured as the average education of the mother and the father) had a positive effect on their sons and daughters. Additionally, the more crowed the household of the student, the worse was her performance, while the wealthier the student's family, the better was her performance.

A student that had repeated a grade performed worse than a student that hadn't [46]. This variable can be considered in two different ways. First, it can be considered as an indicator of the student's capacity. Secondly, it can be an indicator of the educational inputs that the student received in previous years. In any case, this variable indicates that a student who repeated a grade is disadvantaged in performing.

[45] Murillo et al and the studies summarized by Velez et al (1993).
[46] This variable is also used as a dependent variable in other studies, but in this case there are not data available to realize this analysis.

It was found that a student that had a job had lower achievement, net of the effect of other family and personal characteristics, than other students, as they had less time to study because of the time consumed by working. Another variable that had a negative effect over performance is a change of school in previous years, due to the time taken for adapting to a new environment, such as new classmates, teachers and teaching techniques.

Now, considering the results related to the second level in the multilevel modelling, the school, the results were not as unequivocal as they were in first level variables[47]. On one hand, it was found that neither the teacher's education nor the teacher's experience had statistically significant effect on students. On the other hand, the teacher's tenure situation, her hourly dedication, her specific training and her job satisfaction had statistically significant effects on performance.

It was obtained that a student that was taught by a teacher without tenure or by a substitute teacher, caeteris paribus, had lower performance than a student that was taught by a teacher with tenure[48]. The intuition behind that result is that a teacher that had tenure was more involved with the class. Also, considering the case where a teacher worked in different educational institutions, it was found that this characteristic worsened her students' performance. This variable potentially measures the involvement of the teacher with the grade that she was teaching and the time that she had available to prepare the lectures and mark the exams. It was found that the specific training of the teacher had a positive effect on performance. This finding coincides whit the one obtained by Monk(1994) where he concluded that teachers' preparation does make a difference. Another result obtained was that the students of teacher who was satisfied with her job performed better.

The results showed a positive effect of classroom infrastructure on student performance, measured as the teacher's general opinion about the classroom[49]. The variables related with work environment and if there were violent situations in the

[47] It is a characteristic of almost all EPF studies, please refer to section II.c
[48] This result coincides with the findings of Murillo et al. There is a caveat, because as tenure is related with absenteeism, there may be a under representation of this kind of teachers in the sample.
[49] It is constructed from the question about how appropriate is the classroom in terms of lighting, heating and ventilation.

school were found to be no statistically significant as well the variables related with teacher's turnover and absenteeism.

With regard to the school characteristics, there were found that neither school size nor class size were statistically significant. The second result it is not surprising, given that even one may expect that smaller class will improve achievement this finding does not differ from the results of other studies[50]. As was expected, more school days improved learning.

The findings related to the social assistance that the school has received do not have a clear interpretation, because it is worth noticing that these particular variables are measured at school level[51] and that the social assistance programmes are mainly compensatory in the sense that they focused on schools that had low performance in previous years. Therefore, a higher proportion of students receiving social assistance leads to lower performance. The same result was obtained for the variable that indicates the proportion of students that are undernourished.

The last topic to be analysed is the peer effect. In the present model, the average values of the wealth of the classmates, the proportion of students that repeated a grade and the proportion of classmates that had a job were included in the model only as explanatory variables of the intercept coefficient. It was found that the coefficients of these variables had the expected sign, indicating that better classmates generated better performance[52].

[50] See Vignoles et al and the literature review section.
[51] Unfortunately, there are not individual data available.
[52] The same regression is realized including the principal component obtaining the same result. It is available upon request.

Section VI: Identifying Scope for Interventions.

In order to analyse the variables that are important for the policymaking process, we must first identify which of these are under the policymaker's control[53]. In relation to the teacher, these are teacher's tenure situation, the number of jobs that she has, her special training and job satisfaction. With respect to the schools, the variables are the classroom structure, the number of schools days and the social assistance that the student receives. With regard to the student, the main variable that the policymaker has influence over is whether the children work or not. Additionally, the situation where the student repeats a year can be influenced by policy-makers through an improvement in the already mentioned variables, because of the relationship of this variable with the previous inputs that were available for the student.

Firstly, it was found that students that were taught by a tenured teacher performed better, implying an increase of 3.46 percent in their marks. Additionally, a teacher who had more than one job saw deterioration in her students' achievement by 2.32 percentage points. Consequently, a policy that encourages the teacher to work in a single educational institution and gives the teacher a higher degree of involvement with her class, (by having tenure), will substantially improve the students' performance.

Increasing the availability of special training programmes and the incentives for the teachers to join them can also increase the performance of the students. It was found that a teacher that has taken these courses had a positive effect on the students of 3.76 percent[54]. It was found that a student that was taught by a more satisfied teacher

[53] That were statistically significant in the present analysis.
[54] It is worth to notice that this coefficient is potentially biased because of the prior decision of the teacher to join or not a trainingprogramme. Then the coefficient may reflect the incentives and quality

performed better. In this case the policy related to this characteristic is not straightforward. Kallenbeg (1977) states "job satisfaction depends on the personality of the worker and on the nature of the job he performs (including wages, fringe benefits, hours of work, degree of control, promotional opportunities, etc)"[55]. Based on that, there is some scope for policy intervention orientated to improve the teacher's job satisfaction and consequently students' performance.

Now, analysing the school level variables, the first variable under policy maker control is determining how many school days students will have. The rationale of this variable is that the teachers go on strike due to delays in payment or the low level of salaries[56]. Then, avoiding these delays or increasing the salaries will allow the student to perform better. For example, if the number school days is raised from the mean to the maximum, the performance is expected to rise by 6.4 percentage points. In the same way, if the classroom infrastructure is improved from the mean to its maximum value, the performance of the student is expected to rise by 3.75 percentage points.

Regarding the effect of social assistance in the school, the estimated coefficient of this variable is negative. At first, it may seem that more assistance worsened the performance but in this case the assistance is compensatory and the coefficient is implying the allocation rule.

The last set of variables that is under a policymaker's influence is those related to the students. It was found that a student that has to work had worse performance than her classmates. A scholarship scheme that allows the student to not work will therefore be beneficial not only for the student's achievement but also to her classmates' achievement as well. This policy has a social multiplier effect, as Maskin defined it[57]. The direct effect on a student that is spared from having to work and can spend the time studying and typical childlike activities[58] is an increase of 2.29 percentage points

---

of the teacher as well as the effect of the specialization. A simple probit model was run to analyse the decision determinants and the only variables that were found statistically significant were the teacher's job satisfaction, her opinion about the work environment and the her opinion about the classroom infrastructure. All were find to be influence positively in the decision.

[55] For further details about this topic, please refer to Murillo et al and other references there.

[56] See Murillo (2001) for further details about teacher's strikes in Argentina.

[57] But at was already mentioned, it is not identified.

[58] Please remember that in this study, students that attend to 7th grade of elementary school are analysed.

on their mark. In addition to this effect, the proportion of classmates that work decreased by 1/Ni, and this effect can be estimated around the mean of the class size. Consequently, it was found to have an additional influence of 0.59 percentage points.

With the adoption of one or a set of these policies, the student's probability of repeating a grade will decrease. For example, avoiding rigorousness, a decrease of one standard deviation in this probability will improve student performance by 2.03 percentage points. In addition to this direct effect, this decrease reduces the proportion of classmates that repeated a year and consequently reduces the negative effect of this variable on the performance, improving the mark by 5.43 percentage points.

Section VII: Conclusion and Further Extensions.

The aim of the study was to estimate the scope for governmental interventions. To do this, the educational production function approach was used, analysing the effect of different factors on the student's performance. The structure and availability of data allowed the use of a multilevel modelling framework, where efficient estimates of the coefficients were obtained.

First of all, it was found that family and individual factors were important for performance. Parental education and the wealth level were found to have a positive effect. On the contrary, the density of people in the child's household, whether the child worked or not and whether a year was repeated or school changed, led to deterioration in performance.

Secondly, some teachers' characteristics were found to be positive correlated with performance. Specifically, whether a teacher had tenure, the dedication, training, and the job satisfaction present, were found to positively influence achievement. On the one hand, neither the school nor classroom size were statistically significant. On the other hand, non-surprisingly, more school days and better classroom infrastructure improved performance. Finally, the peer group effect was modelled by social interaction modelling. This study reasserts the belief that better classmates lead to better performance.

After controlling for the different variables that affect performance, the scope for governmental intervention was identified. It is obvious to notice that this is a theoretical exercise in the sense that when one of these policies is adopted the complete model may change and so consequently all of the estimates too. Some of the

policies that this study highlights were related to the teacher's characteristics and others to the school and even to the individuals. With respect to teachers, a policy that increases the availability of special training programmes and the incentives to join them and the possibility of granting tenure to the teachers, would improve performance. Additionally, it was found that an improvement in job satisfaction of the teacher would be beneficial to the students. Regarding school characteristics, it was found that policies that increase the number of school days and also improve the quality of classrooms had a positive effect on performance.

In the case of individual factors, a policy that allows a working student to stop working would have a multiplier effect. The direct effect is her own improvement, but there is also a spill over effect on the other students in his/her class, whose performance is improved as well.

Possible extensions to this study are to explore different functional forms, consider different year-grades and to more accurately measure the peer effect. Additionally, the adoption of allocating students according to their performance (streaming) and its effects can be studied.

Bibliography

Aitkin, M. and Longford, N. (1986): "Statistical Modelling Issues in School Effectiveness Studies" Journal of the Royal Statistical Society. Series A, Volume 149, Issue 1.

Angrist, J. and Lavy, V. (1998): "Does Teacher Training Affect Pupil Learning? Evidence from matched comparisons in Jerusalem public schools" NBER Working Paper Series Nº 6781.

Browne, W., Draper, D., Goldstein, H. and Rasbash, J. (2002): "Bayesian and Likelihood Methods for Fitting Multilevel Models with Complex Level-1 Variation" Computational Statistics & Data Analysis 39, 203-225.

Burstein, L., Fischer, K. and Miller David (1980): "The Multilevel Effect of Background on Science Achievement: A Cross-National Comparison" Sociology of Education, Volume 53, Issue 4, 215-225.

Butler, M. and Mc Nertney, E. (1991): "Estimating educational production functions: The problem of multicollinearity", Social Science Journal Volume 28, Issue 4.

Chizmar, J. and Zak, T. (1983): "Modelling Multiple Outputs in Educational Production Functions" The American Economic Review, Volume 73, Issue 2, 18-22.

Deaton, A. (1985): "Panel Data From Time Series Of Cross-Section" reproduced in "New Approaches to Modelling, Selection and Econometric Inference" W. Barnett and R. Gallant (Edits).

Eskeland, G. and Filmer, D. (2000): "Does decentralization improve learning? Autonomy and parental participation in Argentine School, World Bank.

Feinstein, L. and Symons, J. (1999): "Attainment in Secondary School" Oxford Economic Papers 51 (1999). 300-321.

Figlio, D. (1999): "Functional Form and the Estimated Effects of School Resources" Economics of Education Review 18 (1999), 241-252.

Fiszbein, A (1999): "Institutions, service delivery and social exclusion: a case study of the educational sector in Buenos Aires" Documento de Trabajo Nº 35, C.E.D.I. – F.G.&S.

Goldstein, H. (1995): Multilevel Statistical Models. London: Edward Arnold: New York, Wiley.

Hanushek, E. (1971): "Teacher Characteristics and Gains in Student Achievement: Estimation Using Micro Data" The American Economic Review, Volume 61, Issue 2, 250-290.

Hanushek, E. (1986): "The Economics of Schooling: Production and Efficiency in Public Schools" Journal of Economic Literature Volume XXIV, 1141-1177.

Hanushek, E. (2002): "The Importance of School Quality" Mimeo, Hoover Institution, Stanford University.

Hanushek, E., Kain, J., Markman, J. and Rivkin, S. (2001): "Does Peer Ability Affect Student Achievement?" Mimeo. Stanford University.

Haveman, R. and Wolfe, B. (1995): "The Determinants of Children's Attainments: A review of Methods and Findings" Journal of Economic Literature, Volume 33, Issue 4.

Hsiao, C. and Sun, B. (2000): "To Pool Or Not To Pool Panel Data" in Panel Data Econometrics Future Directions, J. Krishnajumar and E Renchetti (edits). Elsevier Science B V.

Kostakis, A. (1987): "Differences Among School Outputs and Educational Production Functions" Sociology of Education, Volume 60, Issue 4, 232-241.

*Kalleber, A. (1977):"*Work Values and Job Rewards: a Theory of Job Satisfaction" American Sociological Review 42, 123-143

Kreft, I. (1993): "Using Multilevel Analysis to Assess School Effectiveness: A study of Dutch Secondary Schools" Sociology of Education, Volume 66, Issue 2, 104-129.

Lee, V. and Bryk, A. (1989): "A Multilevel Model of the Social Distribution of High School Achievement" Sociology of Education, Volume 62, Issue 3, 172-192.

Leiter, J.(1983) "Classroom Composition and Achievement Gains" Sociology of Education Volume 56, Issue 3.

Llach, J; Montoya S. y Roldan F.(2000): Educación para todos. IERAL

Maddala, G.S. (1996): Introducción a la Econometria. Prentice Hall.

Maskin, C. (1995): Identification problems in the Social Sciences. Harvard University Press.

Montmarquette, C. and Mahseredjian, S. (1989): "Does School Matter for Educational Achievement? A Two-Way Nested-Error Component Analysis". Journal of Applied Econometrics, Volume 4, Issue 2, 181-193,

Murnane, R, Maynard, J and Ohls, J (1981): "Home Resources and Children's Achievement" The Review of Economics and Statistics, Volume 63, Issue 3.

Perusia, J (2002): "Puntuaciones Equiparadas de las Pruebas de Matematica y Lengua" Evolucion de los resultados de los operativos de calidad educativa. Ministry of Education. Working Paper No 13.

Pritchett, L. and Filmer, D. (1999): "What Education Production Functions Really Show: a Positive Theory of Educational Expenditures" Economics of Education Review 18, 223-239.

Raudenbush, S., Bryk, A and Congdon, R. (2003): HLM for Windows.

Robertson, D. and Symons, J. (1996): "Do Peer Group Matter? Peer Group versos Schooling Effects on Academic Attainment" Centre of Economic Performance. London School of Economics.

Sen, Amartya (1990): "Development as freedom" KNOPF, New York.

Velez E., Schiefelbein E., Valenzuela J. (1993): "Factors Affecting Achievement in Primary Education: A review of the Literature for Latin America and Caribbean" HRO Working Paper No 2. Washington, DC: The World Bank.

Vignoles, A., Levacic, R., Walker, J., Machin, S. and Reynolds, D. (2000): "The Relationship Between Resource Allocation and Pupil Attainment: A Review" Centre for the Economics of Education. London School of Economics.

Weeks, M. (2003): "Social Interaction: A Modelling Framework" Advanced Econometrics lecture notes. Faculty of Economics, University of Cambridge.

Appendix

Table 3: Confirmation ratios of significance of various inputs. Velez et al (1993)

	Number of studies	Positive Relation	No relation	Negative Relation	Confirmation percentage
Class size	8	1	6	1	12.5
Pupils – teacher ratio	21	2	10	9	42.8
Classrooms structure	17	13	4	0	76.5
Years of teacher's formation	68	31	33	4	45.6
Teacher's experience	62	25	35	2	40.3
Teacher's dedication	1	0	0	1	0
Job satisfaction	43	4	37	2	0.9
Teacher's absenteeism	60	8	34	18	30

Source: Velez et al 1993

Table 4: Level 1 (Student) Variables

Variable		Mean	Std. Dev.	Min	Max
GENDER	1 if female	0.5	0.5	0.0	1.0
KINDERGARTEN	1 if she attend to the kindergarten	0.8	0.4	0.0	1.0
BOOKS	Number of books at home	41.1	39.7	0.0	125.0
WORK	1 if the student has a job	0.4	0.5	0.0	1.0
FAEDUC	Father education	3.0	1.6	1.0	6.0
MOEDUC	Mother education	3.1	1.6	1.0	6.0
PAEDUC	Average parent's education	3.2	1.3	1.0	6.0
DENSITY	Number of people that lives at the household over quantity of rooms	1.9	1.3	0.3	12.0
REPEAT	1 if the student had repeated a grade	0.5	0.5	0.0	1.0
WEALTH	Family's wealth index	3680.5	1452.3	50.0	7170.0
SCHANGE	1 if the student had change her school before this year	0.3	0.4	0.0	1.0
AVG_WEALTH	Average wealth of student's classmates	2981.0	10813.4	166	7170
AVG_WORK	Proportion of student's classmates that has a job	0.34	0.26	0	0.96
AVG_REPEAT	Proportion of Student's classmates that repeated a grade	0.28	0.18	0	0.92
PEP	Positive Peer effect	0.0	2.0	-5.3	14.5
PEN	Negative Peer effect	0.0	1.5	-3.2	14.1

Source: database

Table 5: Level 2 (School) Variables

Name	Description	Mean	St. Deviation	Min	Max
TEDUC	Teacher's years of schooling after high school	2.4	1.5	1.0	7.0
TEXP	Teacher's experience in years	6.4	4.9	0.5	23.0
TPERFECT	1 if teacher had taken specific training courses	0.5	0.5	0.0	1.0
TPOST	1 if teacher has more than one job in this school	0.4	0.5	0.0	1.0
TWORK	1 if teacher works in more than one place	0.2	0.4	0.0	1.0
TSATIS	Teacher satisfaction.	2.6	1.3	0.0	4.0
TINFRA	Classroom structure	7.1	2.8	3.0	15.0
TVIOLEN	1 if there were some violent situations in the school	0.3	0.4	0.0	1.0
TENURE1	1 if the teacher has tenure	0.6	0.5	0.0	1.0
TENURE2	1 if the teacher has no tenure	0.2	0.4	0.0	1.0
TENURE3	1 if the teacher is substitute	0.2	0.4	0.0	1.0
TWENV	Teacher's appreciation about work environment (the higher the better)	3.9	2.2	0.0	10.0
PSOC	1 if the school had received social assistance	0.8	0.4	0.0	1.0
UNDERN	Proportion of students that are undernourished (higher worse)	2.8	1.4	0.0	5.0
LUNCH	Proportion of students that receive lunch in the school	1.1	1.6	0.0	5.0
MILK	Proportion of students that receive milk cup in the school	2.0	1.9	0.0	5.0
TAHELP	Proportion of students that receive tutoring in the school	0.9	1.2	0.0	5.0
DIDSUP	Proportion of students that receive didactic supplies	2.8	1.8	0.0	5.0
ABSENT	1 if there are teacher's absenteeism problems	0.0	0.1	0.0	1.0
TURNOVER	1 if there are teacher's turnover problems	0.0	0.1	0.0	1.0
SCDAYS	How many school days the student had each year	133.7	37.2	115	165.0
CSIZE	Class size	25.4	6.6	2.0	56.0
SCSIZE	School size	6.3	2.6	1.0	10.0

Source: database

Table 6: Correlation among peer effect variables

	AVG PAED	AVG KINDER	AVG BOOK	AVG WEALTH	AVG DENS	AVG REPEAT	AVG SCHAN	AVG WORK
AVG_PAED	1.00							
AVG_KIND	0.83	1.00						
AVG_BOOK	0.89	0.83	1.00					
AVG_WEALTH	0.87	0.90	0.92	1.00				
AVG_DENS	-0.49	0.76	0.41	-0.54	1.00			
AVG_REPEAT	-0.31	-0.48	0.26	-0.34	0.53	1.00		
AVG_SCHAN	-0.39	0.43	0.28	0.35	0.46	0.36	1.00	
AVG_WORK	-0.28	-0.54	0.22	-0.32	0.73	0.56	0.35	1.00

Source: Database

Table 7: Chi squared test for variability of coefficients:

Random Effect		Standard Deviation	Variance Component	Degree of freedom	Chi-square	P-Value
Intercept	U_0	26.3	693.5	624	2092.8	0.00
GENDER, slope	U_1	3.2	10.3	624	694.2	0.03
KINDERGARTEN, slope	U_2	3.7	13.7	624	686.2	0.04
WORK, slope	U_3	3.2	10.1	624	714.1	0.01
DENSITY, slope	U_4	0.8	0.7	624	599.0	>0.500
REPEAT, slope	U_5	9.6	92.5	624	2633.0	0.00
WEALTH, slope	U_6	2.5	8.2	624	613.2	0.21
SCHOOL CHANGE, slope	U_7	3.4	11.9	624	662.6	0.14
PARENTAL EDUC, slope	U_8	0.4	0.2	624	530.2	>0.500
level-1,	R	12.6	160.0			

Source: database