The Quality of Public Education in Unequal Societies: The Role of Tax Institutions

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Abstract

This research establishes that in the presence of weak tax institutions, the quality of public education is adversely affected by an increase in inequality. Moreover, the adverse effect of inequality is diminishing on the quality of institutions. This effect operates via two channels, namely via an effect on the resources allocated to public education and via an effect on the number of individuals participating in the public schooling scheme. Exploiting variations in the levels of inequality and corruption across countries, the empirical analysis confirms the theoretical predictions.

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1 Introduction

The interaction between inequality and public education is the cornerstone of recent policy debate focusing on the role of education on the observed trend of increasing income inequality in developed countries during the last thirty years (see e.g. Atkinson, 2007; Card, 1999; Goldin and Katz, 2008). In most of the relevant studies, the issue under examination is the effect of public education on the distribution of earnings and consequently on income inequality (see e.g. Glomm and Ravikumar 1992; 2003) whereas the opposite effect (i.e. the effect of inequality on the size and the quality of public education) has not been examined in fairly detailed way.

Similarly, the detrimental effect of weak institutions on a wide range of economic and social aspects of economies has been extensively analyzed, by primarily focusing on the direct adverse effects of corruption on government spending (Gupta et al., 2001; Mauro, 1998; Tanzi and Davoodi, 1997).[1] Interestingly though, corruption may operate via various alternative channels, that have been left relatively unexplored by the relevant literature. For example corruption coexist and interact with income inequality (see e.g. Chong and Gradstein (2007); Dessy and Palage (2003); Roine (2006)). However, the potential interaction between corruption and inequality has not been extensively analyzed in the context of public education. Therefore, although it is widely recognized that corruption hurts the quality of public education (Mauro, 1995) the only channel that has been explored by the relevant literature is that of the reduced government spending on education due to corrupt government activities.[2]

The present paper contributes to three different strands of the literature. First it contributes to the literature that explores the relationship between inequality and education.[3] More precisely, this paper explores the link from inequality towards the quality

[1] For a survey of the empirical literature examining the relation between corruption and public finances, see Hillman (2004).

[2] In particular, Mauro (1995) suggests that since social spending is more transparent compared to other types of spending, public funds are directed towards less transparent activities.

[3] Previous studies examining the relationship between inequality and education include Glomm and Ravikumar (1992) who argue that in societies where the majority of agents have incomes below average, individuals will choose public schooling and Besley and Coate (1991) who find that, in the presence of inequality, public provision favors those with low income but involves greater deadweight loss. Finally, Epple and Romano (1996) have formulated the "ends against the middle" hypothesis, according to which the coalition of the "ends" in the income distribution (low and high incomes), reduces public school spending. Most of these results have been empirically tested (Poterba, 1997; Harris, Evans and Schwab, 2001) and evidence suggests that support for public education is correlated to the income distribution of the voters.

of education and suggests that in the presence of weak institutions, inequality exerts a detrimental impact on the quality of public education. This effect operates via two channels. On the one hand, an increase in inequality affects the revenue allocated to public education, while on the other hand it affects the number of people choosing to participate in the public schooling scheme. Specifically, in the presence of weak institutions, an increase in inequality will increase number of children in public schooling (since a larger fraction of households will not being able to afford private education) but this increase will not be accompanied by the corresponding increase in public funds. Consequently, the public spending per student will be reduced which in turn hurts the quality of education provided. These finding complements previous theoretical studies that do not take into account the impact of institutions and therefore find a clear cut positive relation between income inequality and the quality of public education (see e.g. De la Croix and Doepke, 2009; Fernandez and Rogerson, 1995). Moreover, whereas the literature suggests that corruption has a negative effect on education spending (Mauro, 1995, 1998; Gupta, Davoodi and Rosa ,1998), interestingly, this paper suggests that the effect of corruption on the quality of education, despite being negative as suggested by the literature, nevertheless its severity depends on the level of inequality.

Second, it contributes to the literature that explores the choice between public and private schooling. As Stiglitz (1974) claimed, the public provision of education was originally desirable for its redistributive effects. Glomm and Ravikumar, in a series of papers (1992; 1998; 2001; 2003), have illustrated that coexistence of public and private education is an equilibrium outcome and that, in the long run, public education works towards closing the income gap between the rich and the poor.[4] Moreover, they argue that public spending on education (as a share of GNP) is increasing over time and that the quality of education is increasing over time as well. This paper suggests that private alternatives to the public education can indeed emerge and coexist but in the presence of weak institutions, the quality of public education deteriorates whereas private education remains significantly superior.

In Section 2, we build an overlapping generations model with the preferences of indi-

[4]Evidence around the world indicates that public schooling is one of the most prevailing social policies and that especially at early stages (elementary, secondary schooling) the fraction of students participating in public schools is very high, i.e. in the US it is above 85% and in Canada it is above 95%.Additionally according to the World Bank, most countries spend approximately 9%-15% of total government expenditure on education (Greece- 9.2%, France-10.6, Germany-9.7%, US-14.1%). Still though, private schooling spending comprises a significant part of GDP, ranging from 0.1-3% in OECD countries (Busermeyer, 2007).

viduals being defined over consumption and their preference for children. When it comes to children, individuals are faced with the standard quality-quantity trade-off, namely the number of children they wish to have and the quality of education they choose to provide for them (Galor and Moav, 2004; Galor, 2005; 2011). Individuals have the option to tax evade where the probability of being caught depends on the overall quality of institutions. Agents are heterogeneous only with respect to their income, allowing us to capture the element of inequality. Our theoretical results are as follows: a) in the presence of strong institutions and reduced tax evasion, inequality has a positive effect on the quality of public education, and b) in the presence of weak institutions and high levels of tax evasion, increases in inequality reduce the quality of public education. The intuition behind these results is due to a two-fold effect; first a direct effect of tax evasion on the level of public spending, and second an indirect effect of tax evasion on the number of children participating in public schooling.

In Section 3, we examine the empirical validity of our theoretical model. More precisely, we proceed to the estimation of an empirical model where the independent variables are: (i) the international student assessment scores for Mathematics and Science developed by PISA, OECD (2012) and (ii) the cognitive skills variable developed Hanushek and Woessmann (2012) whereas the key explanatory variables are alternative measures of income inequality.[5] After extensive sensitivity analysis across a number of different specifications, our empirical findings suggest that the relationship between quality of education and income inequality is indeed negative and statistically significant, thus confirming our theoretical priors. In turn, our empirical analysis places the spotlight on the effect of institutions on the nexus between income inequality and educational quality by examining whether such a nexus is affected by the quality of institutions. Our findings provide once again empirical evidence in favor of our theoretical model. Namely, in countries characterized by poor governance, higher income inequality results in deterioration of the quality of education, whereas in countries with solid institutions, increases in inequality

[5] Approximating the quality of education has been an issue of considerable disagreement in empirical studies. Previous empirical studies basically rely on indirect measures such as the spending per student or the pupil-teacher ratio (see e.g. De la Croix and Doepke, 2009) in order to capture the quality of educational system. The major shortcoming of all these indirect measures is that they consist inputs rather than outputs of the educational procedure and therefore fail to reflect the quality of the educational system in clear cut way (see e.g. Hanushek, 2003; 2008). In contrast, PISA OECD (2012) and Hanushek and Woessmann (2012) measures are based on international student assessments tests (ISAT) and they definitely consists outcomes of the educational procedure rather than inputs. Therefore these measures are able to capture the quality of education in a more direct way.

lead to improvement of educational quality.

The remainder of the paper is organized as follows. Section 2 introduces the model and derives the effects of inequality on public education. Section 3 tests empirically our theoretical predictions. Section 4 draws summarizes the main points.

2 The Model

We build upon the De la Croix and Doepke, henceforth C-D, (2009) model by introducing the option to tax evasion and the presence of weak institutions. Interestingly, this modification yields interesting theoretical and empirical predictions that highlight the role of institutions. For ease of comparison and for brevity, we use the same notation and omit some of the details. Consider an overlapping generations economy consisting of a continuum of agents whose total mass is equal to 1. Economic activity extends over infinite time.

2.1 Demographics, Preferences and Budget Sets

All agents, endowed with one unit of time, care about their own consumption, c, and the quantity and quality of their children, n and h, respectively:

$$\ln(c) + \gamma(\ln(n) + \eta \ln(h)), \quad \gamma > 0, \quad \eta \in (0, 1). \tag{1}$$

Each individual has a level of human capital, x, which is also equal to the wage that this individual can obtain in the labor market, i.e., the wage rate per unit of human capital is normalized to unity. We assume that x is uniformly distributed over the interval $[1 - \sigma, 1 + \sigma]$.

Human capital is being obtained via formal education provided by teachers, whose wage is assumed equal to unity and equal to the average wage in the population. Parents can enroll their children either to a public education system or to a private one. The public education system provides the same level of education s to all students. It is financed through an income tax at the rate v, imposed on all adult agents in the economy independently of their preferred mode of education for their children. For those parents that choose the public education scheme no additional cost is applicable. The educational quality, s, and the tax rate, v, are determined endogenously, via a voting procedure that will be described below.

The private education system provides children with an education quality equal to e. Parents pay for it out of their income at the expense of their own consumption. Education is measured in units of time of the average teacher and hence the cost of educating each child in the private system is also e. This cost is assumed to be tax deductible. Besides the education expenditure, raising a child requires a fraction ϕ of a parent's time. Hence, a parent's taxable income is $x(1-\phi n)-ne$.

Crucially, individuals have the option to evade taxes. They decide what fraction μ to *declare* knowing that the detection probability is $\theta(1-\mu)$; $\theta > 0$ is an institutional parameter that captures the effectiveness of the auditing mechanism. Delinquent tax payers are charged a penalty rate $\zeta > 1$ on evaded tax payments, which are $v(1-\mu)(x(1-\phi n)-ne)$.[6] In sum, the budget constraint of an agent with human capital x is

$$c = (1 - v\mu - \pi v(1-\mu)^2)(x(1-\phi n) - ne), \tag{2}$$

where $\pi = \zeta\theta$. The term $v\mu + \pi v(1-\mu)^2$ is the effective tax rate; recall that taxes at a rate v are paid on a fraction μ of taxable income and the *expected* penalty rate $\zeta\theta(1-\mu) = \pi(1-\mu)$ applies on evaded taxes. Given μ, an improvement in tax institutions, i.e., an increase in θ, or an increase in the penalty rate ζ lead to an increase in the expected penalty rate.

Agents can offer to their children either public, s, or private, e, education, but not both. Therefore parents choosing public education choose $e = 0$. Effective education is expressed as the maximum of the two, i.e., $h = \max\{e, s\}$. Substituting the budget constraint (2) into an agent's utility function (1) yields

$$u[x, v, \mu, n, e, s] = \ln\{(1 - v\mu - \pi v(1-\mu)^2)(x(1-\phi n) - ne)\} + \gamma \ln n + \gamma\eta \ln \max\{e, s\}.$$

The sequence of events is the following. First, individuals make their decision over the optimal number of children, n, educational quality e,[7] and the fraction of their taxable income that they will declare to the tax authorities, μ. Second, all adults vote regarding the tax rate v, and hence, given the government budget constraint (specified below), the public education level, s.

[6] This assumption, besides the fact that it allows for analytical tractability, is a plausible one, since most countries follow this practice.

[7] Parents who prefer public education will choose $e = 0$.

2.2 Individual Choices and the Distribution of Income

For parents that provide public education to their offsprings, the optimization problem is $\max u[x, v, \mu, n, 0, s]$ with respect to μ and n. For these individuals the optimal fraction of their income that will be reported to the tax authorities is

$$\mu^s = 1 - \frac{1}{2\pi}. \tag{3}$$

Equation (3) implies that the rate of tax evasion, $1-\mu^s$, is constant and unaffected by the tax rate, v,[8] or the income of the individual, x. Thus, all individuals, irrespectively of their income, evade at the same rate. Instead, evasion rate is adversely affected by π, implying that improvement in the institutional quality, θ, or increases in the penalty rate imposed on evaded tax, ζ, lead to a decrease in the tax evasion rate. The condition $\pi = \zeta\theta \geq 1/2$ must be imposed, to ensure that $\mu^s \geq 0$.

Also, as in C-D (2009), the number of children chosen by individuals who provide public education to their offsprings is

$$n^s = \frac{\gamma}{\phi(1+\gamma)}. \tag{4}$$

Individuals have the option to choose a private education scheme for their offsprings if they are not satisfied with the quality of public education s. For parents planning to provide private education to their offsprings, the optimization problem reduces to $\max u[x, v, \mu, n, e, s]$ with respect to μ, n and e. The optimal fraction of income that will be reported to the tax authorities by these individuals is also

$$\mu^e = 1 - \frac{1}{2\pi}. \tag{5}$$

Similarly to the public education regime, the rate of tax evasion, $1-\mu^e$, is independent of the tax rate, v, and the income of the individuals, x. As it will become clear later, this result, along with the other assumptions in C-D (2009) maintains the analysis tractable by keeping the tax base constant (see C-D 2009 for details). In fact, from now on we write $\mu^s = \mu^e = \mu$.

The number of children and the level of education chosen by an individual who prefers private education is

[8] It is clear that this simplified formula is, among others, the outcome of the assumption that the fine is imposed on evaded tax and not, for example, on evaded income. As already argued, this assumption is not only plausible, but it also renders the model tractable.

$$n^e = \frac{\gamma(1-\eta)}{\phi(1+\gamma)} \tag{6}$$

and

$$e = \frac{\eta\phi x}{1-\eta}. \tag{7}$$

Interestingly, spending on private education is not directly affected by π, i.e., the quality of tax institutions θ and the penalty rate ζ.[9]

The parental cost of an individual that provides public education is $\phi n^s x$, which after substituting from equation (4) is equal to $\gamma x/1+\gamma$. Similarly, the parental spending of an individual that chooses the private education scheme is given by $\phi n^e x + ne$, which after using equations (7) and (6) reduces also to $\gamma x/1+\gamma$, i.e., as in C-D (2009), overall parental spending remains unaffected by the choice of the educational regime. This in turn implies the constancy of the tax base, an outcome that allows us to explore the underlying mechanism behind the effect of inequality on the quality of education. A direct implication of this outcome, is that the taxable income of each individual remains unaffected by the choice between private or public schooling, since richer parents will have fewer children to offset the increased spending on their education. In other words, the taxable income of those who send their children to a public school is equal to $x(1-\phi n^s) = x/1+\gamma$, and is equal to that of individuals who select a private school $x(1-\phi n^e) - n^e e) = x/1+\gamma$.

By setting $u[x, v, \mu, n, 0, s] = u[x, v, \mu, n, e, s]$, we can find the income level $\tilde{x}$ of the marginal household that is indifferent between choosing private or public education. This is

$$\tilde{x} = \frac{1-\eta}{\delta\phi\eta} E[s], \tag{8}$$

where $\delta \equiv (1-\eta)^{1/\eta}$ and $E[s]$ denotes the expected quality of public schooling. For given $E[s]$, all agents with income above $\tilde{x}$ choose private education whereas those with income below $\tilde{x}$ choose public education.

Recall our assumption that human capital follows a uniform distribution over the interval $[1-\sigma, 1+\sigma]$. Thus, the density function is $g(x) = 0$ for $x < 1-\sigma$ and $x > 1+\sigma$, whereas $g(x) = 1/2\sigma$ for $1-\sigma \leq x \leq 1+\sigma$. Therefore the fraction of children enrolled in public schools (Ψ) is

[9] However, as will become clear below, these parameters affect the quality of public education, s and, hence, indirectly the decision regarding the education system, i.e., whether $e = 0$ or $e > 0$.

$$\Psi = \int_0^{\tilde{x}} g(x)dx = \begin{cases} 0 & if \quad \tilde{x} < 1-\sigma, \\ \frac{\tilde{x}-(1-\sigma)}{2\sigma} & if \quad 1-\sigma \leq \tilde{x} \leq 1+\sigma, \\ 1 & if \quad \tilde{x} > 1+\sigma. \end{cases} \tag{9}$$

2.3 Voting

The government provides public education under a balanced-budget rule:

$$\int_0^{\tilde{x}} n^s s g[x]dx = \int_0^{\tilde{x}} v\mu(x(1-\phi n^s))g[x]dx + \int_{\tilde{x}}^{\infty} v\mu(x(1-\phi n^e) - n^e e[x])g[x]dx, \tag{10}$$

where the LHS of (10) is the total spending on public education and the RHS equals tax revenues collected by all agents, regardless of the education system that they choose.

Employing equations (3), (4), (5), (7) and (6), i.e., the individually optimal choices of the rate of declared income, the amount of private education and the fertility rates, the government budget constraint reduces to the following equation

$$v = \frac{\Psi\gamma}{\phi\mu}s. \tag{11}$$

Given v, the level of education s follows from (11) and vice versa. Naturally, the higher the fraction of children participating in the public schooling system, Ψ, and the higher the quality of public education, s, the higher the tax rate. Moreover, the higher the fraction of income that individuals declare to the tax authorities, μ, the lower the tax rate.

As in C-D (2009), the level of public spending and thus implicitly of taxes is determined via a probabilistic voting model, which allows for the smooth aggregation of all voters' preferences. The voting outcome follows from the maximization of the following objective function

$$\Omega(s) = \int_0^{\tilde{x}} u[x, v, \mu^s, 0, s]g[x]dx + \int_{\tilde{x}}^{\infty} u[x, v, \mu^p, e[x], 0]g[x]dy \tag{12}$$

subject to the government budget constraint (11).

Solving the above optimization problem and using equations (3) and (5) yields the quality of public education

$$s = \frac{2\eta\phi(2\pi - 1)}{(1+\eta\gamma\Psi)(4\pi - 1)}. \tag{13}$$

Next, using equations (13) and (11), we have that the corresponding tax rate is

$$v = \frac{4\pi\eta\gamma\Psi}{(1+\eta\gamma\Psi)(4\pi-1)}. \tag{14}$$

2.4 Education Regimes

Three alternative education regimes can emerge: i) a fully private education regime ($\Psi = 0$), where all children attend private schools; ii) a fully public education regime ($\Psi = 1$), in which case all individuals send their offsprings to public schools and iii) segregation ($\Psi \in (0,1)$), where there are private and public schools and the richer individuals provide private education to their children while the rest use public schools.[10]

Assumption 1. The parameters of the model satisfy:

$$\gamma < \tilde{\gamma} \equiv \frac{2(1-\delta-\eta)}{\delta\eta}.$$

Assumption 1 puts a restriction on the preference parameter towards children γ. If it is not satisfied then Ψ takes values in the interval $[0, 1/2)$, i.e., for the percentage of student population that attends public school is lower than fifty. We note that C-D (2009) argue that their Assumption 1, $\gamma < (1-\delta-\eta)/\delta\eta$, "is the empirically relevant case" (p. 606). Their assumption is clearly a sufficient condition for our assumption to hold (see also footnote 11 in C-D 2009 and C-D 2003).

The following proposition gives the conditions under which each education regime arises.

Proposition 1.

i) If $\pi < \pi_1 \equiv \frac{2(1-\eta)-\delta(1-\sigma)}{4((1-\eta)-\delta(1-\sigma))}$, then the fully private regime arises.

ii) If $\pi > \pi_2 \equiv \frac{2(1-\eta)-\delta(1+\eta\gamma)(1+\sigma)}{4[(1-\eta)-\delta(1+\eta\gamma)(1+\sigma)]}$, then the fully public regime arises.

iii) If $\pi \in (\pi_1, \pi_2)$, then there is segregation; the richest individuals send their children to private schools, while the rest attend public schools. In particular, if $\pi \gtrless \tilde{\pi} \in (\pi_1, \pi_2)$, then $\Psi \gtrless 1/2$, where $\tilde{\pi} \equiv \frac{4(1-\eta)-\delta(2+\eta\gamma)}{4[2(1-\eta)-\delta(2+\eta\gamma)]}$.

Proof. All proofs are presented in Appendix A.

Proposition 1 suggests that tax institutions play a critical role in the emergence of the equilibrium outcome. If the quality of tax institutions is very low, implying a very high

[10] The existence of an equilibrium with $\Psi \in [0,1]$ is essentially the same as that in C-D (2009) and thus omitted.

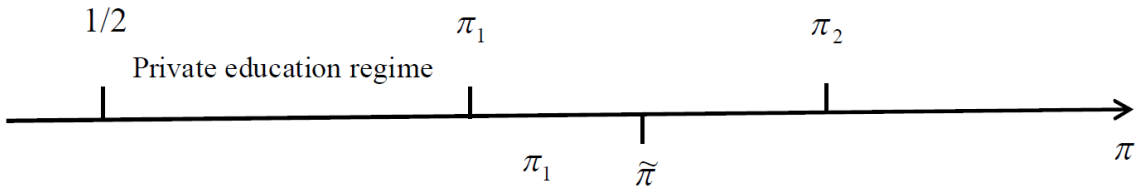

Figure 1. Education Regimes.

tax evasion rate, the public revenue and hence the quality of public education is so low that all individuals send their children to private schools, i.e., a fully private education regime emerges. We note that in the C-D (2009) setting, where tax institutional quality is not considered, the fully private is not an equilibrium. There, if the number of students is low, then the quality public education (measured as spending per student) is sufficiently high, which induces the poorest parents to send their children to public schools.

For high-enough quality of tax institutions, the tax evasion rate is low and hence public revenue and spending per student are high. This makes even the richest individual to prefer public to private schools.[11] Finally, for an intermediate level of institutional quality, which is perhaps the case for most countries, the two regime co-exist. The richer individuals send their children to private schools and the poorer to public schools. Assumption 1 guarantees that a positive level of institutional quality $\tilde{\pi}$, which divides the student population equally between private and public schools, exists. Figure 1 depicts the relation between π_1, π_2, and $\tilde{\pi}$ and indicates the education regime that emerges depending on the level of institutional quality.

The following proposition establishes the effect of inequality on segregation, the quality of the public schools and the tax rate.

Proposition 2. Whenever there is segregation, i.e., $\Psi \in (0,1)$,

$$\text{If } \pi \lesseqgtr \tilde{\pi}, \text{ then } \frac{\partial \Psi}{\partial \sigma} \gtreqless 0, \ \frac{\partial s}{\partial \sigma} \lesseqgtr 0, \text{ and } \frac{\partial v}{\partial \sigma} \gtreqless 0.$$

According to Proposition 2, in the presence of weak tax institutions, i.e., $\pi < \tilde{\pi}$, an increase in inequality (an increase in σ) leads to a higher share of public schooling (Ψ),

[11] Note that for π_2 to be positive and greater than 1/2, it is required that the income inequality be sufficiently compressed. More specifically, $\sigma < [(1-\eta)/(1+\gamma\eta)\delta] - 1$. If this condition does not hold we have either segmentation or the private education regime.

lower quality of public schooling (s) and a higher tax rate. When institutions are weak and there is a lot of tax evasion, the fraction of the population that prefers public schooling is small because the quality of public schooling is low. As inequality increases and total income is redistributed, the income of the marginal person, who was indifferent between private and public schooling before the change in σ, decreases and this person prefers now public schooling. This raises the number of students in the public school system. Despite the fact that the tax rate increases, the change in the participation rate is higher and hence the spending per student (quality of public education) decreases.

We note that C-D (2009), who do not consider differences in institutional quality, find the opposite results from those in the previous paragraph; such results emerge in our case when the quality of tax institutions is sufficiently high, $\pi > \tilde{\pi}$. More specifically, in the presence of weak tax institutions, an increase in inequality leads to a lower share of public schooling, higher quality of public schooling and a lower tax rate.

3 Cross-Country Evidence

This section empirically explores the hypothesis suggested by the theory, that (i) in the presence of weak tax institutions, an increase in inequality adversely affects the quality of public education and, (ii) in the presence of strong institutions, an increase in inequality positively affects the quality of public schooling. Overall, the purpose of the empirical part is to explore if indeed this reversal on the effect of inequality on the quality of public education can take place under different levels of institutional quality.

3.1 Empirical Strategy

First, the analysis establishes, the adverse effect of inequality on the quality of public education. The following empirical model is employed to study this relation,

$$\text{Quality}_i = a_0 + \beta_1 \text{Gini}_i + \beta_k \text{Controls}_i + \text{Continental Fixed Effects}_i + u_i, \qquad (15)$$

Accordingly, the quality of the educational system in country i is expressed as a function of income inequality, a set of control variables, geographical dummies and a stochastic term u_i. To estimate equation (15) we build a cross-section data set of 63 -developed and developing- countries. The dependent and explanatory variables are discussed below. Explicit definitions, descriptive statistics and sources for the variables employed are

provided in Table A.

3.2 Data

Quality of Education measures Approximating the quality of education has been an issue of considerable disagreement in empirical studies.[12] In this paper, we employ as dependent variables direct, international student assessments scores. More precisely we use: (i) The Programme for International Student Assessments (PISA) scores for Mathematics and Science and (ii) the "cognitive skills" variable developed by Hanushek and Woessmann (2012) based on 12 different international student achievements tests (ISATs).

PISA surveys are international students' evaluations that take place every three years in a large number of countries starting from year 2000. PISA surveys test reading, mathematics, and scientific literacy in terms of general competencies, that is, how well students can apply the knowledge and skills that they have learned at school to real-life challenges. Schools in each country are randomly selected by the international contractor for participation in PISA and participating students are nearing the end of compulsory education (their average age is 15 years old). In this study, we employ data from the second (year 2003), the third (year 2006) and the fourth (year 2009) PISA surveys. Specifically, we focus on: (i) the average PISA score in Mathematics for the period 2003-2009 (denoted as "PISA Mathematics"), (ii) the average PISA score in Science (denoted as "PISA Science") and (iii) the average PISA score in Reading for the same time period (denoted "PISA Reading"). Taking data from these sub-components, we construct a composite index (denoted as "PISA (mean)") that is the average PISA score in Mathematics, Science and Reading. "PISA (mean)" is the basic dependent variable in our analysis.

Moreover, we employ the average test score in math and science, in primary through the end of secondary school (denoted as "Hanushek and Woessmann Cognitive") and the average test score in math and science, only in lower secondary school (denoted as "Hanushek and Woessmann LowSec") developed by Hanushek and Woessmann (2012). Hanushek and Woessmann (2012) cognitive skills' measures are based on a total of twelve

[12] Previous empirical studies in order to capture the quality of educational system rely on several indirect measures such as the spending per student or the pupil-teacher ratio (see, for example, C-D 2009). The major shortcoming of all these indirect measures is that they constitute inputs rather than outputs of the educational procedure and therefore fail to reflect the quality of the educational system in a clear-cut way. For an extensive critique of the input-based measure of education see Hanushek (2003 2008).

international student achievements tests that were conducted from 1964 to 2003.[13]

The basic advantage of both PISA and Hanushek and Woessmann (2012) cognitive skills' measures is that they are comparable across different countries. Moreover, they definitely constitute outcomes of the educational procedure rather than inputs in it.

Income Inequality Measures In order to control for income inequality, we rely on three alternative Inequality Databases and we employ six alternative proxies of income inequality. Our benchmark inequality variable -which is employed in most of our specifications- is the Gini coefficient developed by the Texas University Inequality Project (2003) (denoted as "texgini"). Note that "texgini" is the average over the period 1980-2002.

In order to test the robustness of our baseline results we also employ two alternative inequality proxies: (i) the income share held by the richest 20% of the population (denoted as "Ineq_20"), which is taken from World Bank (World Development Indicators (WDI), 2011) and (ii) the Gini coefficient before taxes and transfers, which was developed by Solt (2009) (denoted as "gini_Solt"). Both alternative inequality variables are also averages over the period 1980-2002.

Control Variables To ensure robust econometric identification, we use a number of control variables in the estimated equations. First, to control for the overall level of productivity and wealth in the economy, we employ the logarithm of real GDP per capita (denoted as "gdppercap"). Data for this variable is from the World Bank (WDI, 2011). Countries with higher real income are expected to have better educational systems.

In addition, we account for the effect of democracy (denoted as "democracy"), since it is expected democratic regimes to exert a positive effect on the quality of education and human capital accumulation. Tavares and Wacziarg (2001) uncovered a positive effect of democracy on human capital accumulation, whereas Lindert (2004) documented how the extension of the franchise in European rising democracies gradually led to the introduction of public funding for education over the 19th and 20th centuries. Our data regarding the level of democracy within a country are taken from Polity IV (2004) Database. In order to control for the effect of elderly people on the per capita spending on education and

[13] The first international students' achievement test that was included as primary source in Hanushek and Woessmann (2012) is the First International Mathematics Study (FIMS), which was conducted in 1964, whereas the last one is the second PISA survey, which took place in 2003. Fore more details regarding the primary sources employed as well as the methodology followed, see Hanushek and Woessmann (2012).

consequently on the quality of education (see, for example, Poterba (1995); Harris et al. (2001)), we employ as explanatory variable the share of the population aged 64 and over (denoted as "Old"). Data for "Old" are obtained from WDI (2011).

Finally, we account for the presence of economies of scale in the provision of education at the country level, by controlling (i) for population density measured by the number of people per square km (denoted as "density") and (ii) for ethnic fractionalization (denoted as "ethnic"). Data for density are obtained from the WDI (2011) whereas data for ethnic are from Alesina et al. (2003). Lower population density and higher levels of ethnic fractionalization may lead to lower quality of education due to diseconomies of scale and higher per capita cost in the provision of education. (see, for example, Alesina and Wacziarg, 1998; Alesina et al., 2003). Moreover, in more extreme circumstances, increased ethnic fractionalization may lead to ethnic hatred and, ultimately, to violent civil wars that disrupt the workings of the whole economy (see Fearon, 2003). All explanatory variables are averages over the period 1980-2002.

3.3 Empirical Findings

In the following subsections we discuss the results of our empirical analysis, which are presented in Tables 1-6.

3.3.1 Testing the effect of income inequality on the quality of education

We start by estimating equation (15), using the data and the empirical methodology outlined in the previous sub-section. The results are reported in Table 1.

In Columns (1) to (8) of Table 1, PISA(mean) is regressed on texgini as well as on a set of control variables, namely, "gdppercap", "publspending", "density", "democracy", "ethnic", "old" and "fertility"). All regressions are estimated with regional dummies and robust standard errors. The set of regional dummies includes a fixed effect for East Asia (AsiaE), Latin America or the Caribbean (LaAm), Europe and Central Asia (EurAsiaC) and North America (NAm).

As can be seen, "texgini" enters with a negative and highly significant coefficient, which remains qualitatively intact in all eight alternative specifications. This result indicates that higher income inequality is associated with lower values of PISA scores, i.e., lower educational quality. This finding is in accordance with the testable hypothesis driven by the theoretical model

As far as the rest of the explanatory variables are concerned, we observe that all of them bear the expected -based on the theory- sign. More precisely, "gdppercapita" and "democracy" bear positive and significant coefficients indicating that richer and more democratic countries are characterized by better educational systems. This result is in line with the empirical findings of Tavares and Wacziarg (2001) and Murtin and Wacziarg (2011). On the other hand, "ethnic" enters with a negative coefficient highlighting the negative effect of increased ethnic fractionalization on the quality of education. This result can be explained by taking into account the diseconomies of scale in the provision of education that come as a result of increased ethno-linguistic fractionalization (see, for example, Alesina and Wacziarg, 1998). A similar explanation can be given to the positive and significant coefficient of density; namely, increased population density ensures economies of scale in the provision of education, lower per capita cost and consequently higher quality for given level of spending. Finally, "Old" enters with negative and significant coefficient, indicating the negative effect of elderly people on the quality of education. This result is in line with the hypothesis of Poterba (1995) -concerning the effect of elderly people on the per capita spending on education- as well as the empirical findings of Poterba (1997) and Harris et al. (2001).

In Table 2, we inquire into the robustness of our baseline results by investigating whether the negative impact of inequality on the quality of education survives under alternative measures of educational quality, income inequality and alternative estimation techniques. To this end, in Column (2) we repeat the benchmark estimation presented in Column (8) of Table 1 (reproduced for convenience in Column (1) of Table 2) by keeping intact the set of the controls and excluding solely the regional dummies. Then, in Column (3) we re-estimate the equation presented in Column (1) by excluding the 10 per cent of the outliers from the sample. As can be immediately verified, our results regarding the effect of "texgini" remain qualitatively identical to those presented in Column (1).

In Columns (4) and (5) of Table 2, we employ two alternative income inequality variables in order to investigate whether our main findings remain robust under different inequality measures. Specifically, in Column (4) we re-estimate the equation presented in Column (1), by employing instead of the "texgini" the share of income held by the richest 20% of the population (denoted as "Ineq_20"), whereas in Column (5) we employ the Gini coefficient developed by Solt (2009) (denoted as "Gini_Solt"). As can be easily verified, both alternative income inequality measures bear negative and statistically significant

coefficients indicating that our benchmark results remain robust under different income inequality measures.

In Columns (6) to (10) of Table 2, we employ as dependent variables different measures of educational quality. More accurately, in Columns (6), (7) and (8) we employ the PISA Mathematics, the PISA Science and the PISA Reading, respectively, whereas in Columns (9) and (10) we employ the "cognitive skills" variables developed by Hanushek and Woessmann (2012), based on 12 different international student achievement tests (ISATs). Specifically, in Column (9) we employ the basic cognitive skills variable, which reflect the average performance in math and science in primary through the end of secondary school ("Hanushek and Woessmann Cognitive"), and in Column (10) we use the "Hanushek and Woessmann LowSec" variable, which reflects the average test score in math and science in lower secondary school. As can be seen, the coefficient on "texgini" is negative and significant at a level of one percent in most of the alternative specifications, indicating that our benchmark empirical findings are not affected by the measures of educational quality employed.

As we have already mentioned in the Introduction, there exists a potential reverse causality problem between income inequality and quality of education. This is because lower quality educational systems may result in higher income inequality within a country rather than vice versa. In Columns (11) to (16), we treat the potential reverse causality problem by employing an instrumental variables approach.[14] Two obvious choices for instrument for income inequality are: (i) the government transfers (as a share of GDP) and (ii) the progressivity of national tax system. This is because larger government transfers and higher tax progressivity is expected to be associated with lower levels of income inequality (see e.g. Barr, 1992; Mahler and Jesuit, 2006; OECD, 2008) whereas, on the other hand, government transfers and tax progressivity per se is not expected to affect the quality of education. Our data on government transfers (denoted as "Transfers") are taken from World Bank Development Indicators (2011). In order to develop an index of the tax progressivity, we construct a ratio the top statutory tax rate on corporate profits to the average corporate tax rate (denoted as "TaxProgress"). All tax data are taken from Djankov et al. (2010). "TaxProgress" captures the distance between top and average tax rate and therefore reflects the progressivity of tax system.

[14] In order to tackle the causality issue in the estimations presented in Table 1 and in Columns (1) to (10) of Table 2 we have decided to employ as dependent variables averages over the period 2002-2010 whereas our set of controls includes averages over the period 1980-2002.

We report the results in Columns (11) to (16). Estimation method is two-stage least squares (2SLS) with geographical dummies and robust standard errors. First stage results, (reported in the upper part of the columns) show that our instruments are significant determinants of income inequality. The good fit of the instruments is also confirmed by the Hansen J over-identification test, that report no rejection of the relevant hypothesis (i.e. that the over-identification restrictions are valid).[15]

Concerning the results of the second stage our findings remain qualitatively similar to those presented in previous estimations. More precisely in Column (11) the dependent variable PISA(mean) is regressed on texgini and on the standard set of control variables, namely, gdppercap, publspending, density, democracy, ethnic, old and fertility, following the empirical strategy described in the previous above. Similarly, we estimate equations (12) to (16) where the dependent variables are PISAMathematics PISAScience, PISAReading, Hanushek and Woessmann Cognitive and Hanushek and Woessmann LowSec correspondingly. As can be seen, the coefficient on "texgini" is negative and highly significant in all alternative specifications, indicating that reverse causality does not drive the findings of the main analysis above.

3.3.2 Examining the effect of governance on the nexus between income inequality and quality of education.

In this sub-section we seek to place the spotlight on the effect of governance on the nexus between income inequality and educational quality. According to our theoretical model in countries characterized by poor governance and weak institutional framework, higher income inequality results in deterioration of the quality of education. In sharp contrast, our theoretical model predicts that increases on income inequality improve the quality of education, in countries with sound institutional framework.

To identify the potential differential effect of institutional framework on the relationship between income inequality and quality of education we estimate the following equation:

$$\begin{aligned} \text{Quality}_i &= a_0 + \beta_1 \text{Gini}_i + \beta_2 \text{Institutions} + \beta_3 \text{Gini*Institutions} \\ &\quad + \beta_k \text{Controls}_i + \text{Continental Fixed Effects}_i + u_i \end{aligned} \tag{16}$$

[15] For more details on these issues see Baum et al. (2007).

Accordingly, we introduce in our basic specification a variable capturing the quality of institutions (Institutions) and an interaction term (Gini*Institutions). To allow interpreting the impact of β_1 and β_2 at their mean values, we estimate the interaction effect comprising of the mean centered Gini and Institutions.[16] More precisely, we introduce the multiplicative variables: (i) "texgini_dif*Governance_dif", (ii) "texgini_dif*Rule of Law_dif" and (iii) "texgini_dif*Accountabilty_dif". The variable "Governance_dif" is the mean-centered of the "Government Effectiveness" measure developed by Kaufmann et al. (2010) with higher values denoting better quality of governance.[17] Similarly, the "Rule of Law_dif" and the "Accountability_dif" are the mean-centered measures of the "Rule of Law" and "Voice and Accountability" variables developed by Kaufmann et al. (2010).[18]

By introducing these interaction terms we allow the effect of "texgini" to vary across countries characterized by different institutional framework. According to our theoretical model the coefficient of the interaction term must be positive and significant. Moreover, standard calculus tells us that the turning point in the data is given by the coefficient of "texgini" divided by the coefficient of the interaction term (see, for example, Dutt and Mitra 2002; Adam et al., 2012). This method allows us to examine first whether a change in the sign of "texgini" indeed exists and also to determine it endogenously.

The results of this experiment are presented on Table 3. As the reader can easily verify the coefficients of: (i) "texgini_dif*Governance_dif", (ii) "texgini_dif*Rule of Law_dif" and (iii) "texgini_dif*Accountabilty_dif" are all positive and statistically significant in all alternative specifications. These findings are in line with the implications driven by our theoretical model; namely, in countries characterized by poor (resp. sound) governance and bad (resp. good) institutional framework, higher income inequality leads to deterioration (resp. improvement) on the quality of education. What do these finding suggest about the effect of income inequality on the quality of education? Does the institutional

[16] By taking differences from the mean (mean-centered variables), we avoid the potential problem of multicollinearity between the constitutive terms and the interaction term, whereas our results do not change qualitatively.

[17] Based on Kaufmann et al. (2010) "Government Effectiveness" captures perceptions of the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

[18] According to Kaufmann et al. (2010) "Rule of Law" captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, and the courts, as well as the likelihood of crime and violence. Voice and accountability captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.

framework affect the impact of inequality on the quality of education in the real world? Focusing on the estimation presented in Column (3) we can calculate the estimated turning point on the effect of inequality which is a "Governance" value around 2.1.[19] As can be easily verified this value is larger than the maximum value of "Governance_dif" that is around 1.5.[20] Therefore, we conclude that although our empirical findings provide support in favour of our theoretical model, in the real world the turning point for the coefficient of texgini (suggested by our theoretical model) is never met. This is because even the best practice country of our sample (Finland) in which "Governance_dif" takes the maximum value 1.5) is characterized by relatively poor institutional framework (compared to that required by the theoretical model in order to generate the reverse effect). Thus, our empirical model suggests that the magnitude of the effect of income inequality on the quality of education varies with the quality of the institutions but -in practice- remains always negative.

4 Concluding Remarks

This research establishes that in the presence of weak institutions, the quality of public education is adversely affected by an increase in inequality. Moreover, the adverse effect of inequality is diminishing on the quality of institutions. This effect operates via two channels, namely via an effect on the resources allocated to public education and via an effect on the number of individuals participating in the public schooling scheme.

The empirical findings confirm the theoretical predictions, i.e., that inequality has an adverse effect on the quality of public education and this result is valid for a broad set of countries, manifesting large variation in the quality of institutions. More analytically, it is established, that the adverse effect of inequality is diminishing on the quality of institutions, thereby suggesting that for sufficiently high level of institutions, an increase in inequality would be less harmful for the quality of education, and this effect could potentially be reversed for overly good institutions.

[19] The turning point in the data is given by the coefficient of "texgini" divided by the coefficient of the interaction term "texgini_dif*Governance_dif".

[20] Since the maximum value of Governance is 2.12 and the mean value of Governance is 0.62 (see Appendix A) the maximum value for Governance_dif (which is the difference from the mean)does not exceed 1.5.

Appendix A

Proof of Proposition 1: (i) Recall that $\tilde{x}$ denotes the income level of the marginal individuals that is indifferent between choosing private or public education. Individuals with income higher than $\tilde{x}$ prefer private education, while those with income lower than $\tilde{x}$ prefer public education. It follows from equations (8) and (13) that in equilibrium

$$\tilde{x}[\Psi] = \frac{1-\eta}{\delta}\frac{1}{1+\eta\gamma\Psi}\frac{2(2\pi-1)}{4\pi-1}.$$

Let $\tilde{x}_\psi$ denote the value of $\tilde{x}$ when $\Psi = \psi$. Note that $\tilde{x}$ is decreasing in Ψ and hence $\tilde{x}_{\psi_1} > \tilde{x}_{\psi_2}$, for $\psi_2 > \psi_1$. The private regime is then the equilibrium outcome if $\tilde{x}_0 < 1-\sigma$, that is, as Ψ tends to zero the threshold level at which one is indifferent between public and private schools is below the income of the poorest person.[21] Hence, even the poorest person prefers private to public education. Solving this inequality yields $\pi < \pi_1$ presented in the proposition.

(ii) A public education regime ($\Psi = 1$) is an equilibrium if even the richest person prefers public over private schools, i.e., $\tilde{x}_1 > 1+\sigma$. Solving this inequality yields $\pi > \pi_2$ presented in the proposition.

(ii) If $\tilde{x}_0 > 1-\sigma$ and $\tilde{x}_1 < 1+\sigma$, then there is segregation, i.e., the equality

$$\Psi = \frac{\tilde{x}-(1-\sigma)}{2\sigma} = \frac{\frac{1-\eta}{\delta}\frac{1}{1+\eta\gamma\Psi}\frac{2(2\pi-1)}{4\pi-1}-(1-\sigma)}{\sigma} \tag{A1}$$

is satisfied for a value of $\Psi = \psi \in (0,1)$. In such a regime, individuals with income greater than $\tilde{x}_\psi$ prefer private education while those with income below $\tilde{x}_\psi$ prefer public education. Solving the two inequalities we get $\pi \in (\pi_1, \pi_2)$. Next, we set $\Psi = 1/2$ in (A1) and solve for π to get $\tilde{\pi}$. Solving (A1) with respect to Ψ gives two functions of $\Psi[\pi]$, only one of which takes positive values. This function is continuous and increasing in π. It follows then that if $\pi \gtrless \tilde{\pi}$, then $\Psi \gtrless 1/2$. ■

Proof of Proposition 2: The Proof is similar to that of Proposition 3 in C-D (2009). From equations (8) and (9) we obtain:

$$\Psi = \frac{\frac{1-\eta}{\phi\delta\eta}s-(1-\sigma)}{\sigma}.$$

[21] Alternatively, it suffices to show that the public education regime or any segregation are not equilibrium outcomes. The inequality $\tilde{x}_0 < 1-\sigma$ implies that $\tilde{x}_1 < 1+\sigma$ (because $\tilde{x}_1 < \tilde{x}_0$) and hence public education is not an equilibrium; when $\Psi = 1$, the richest person prefers private education. Also, $\tilde{x}_\psi < 1-\sigma$ for any $\psi > 0$ and hence segregation is not an equilibrium; when $\Psi = \psi$, even the poorest person has income above the threshold level $\tilde{x}_\psi$.

Taking the derivative with respect to σ we obtain:

$$\frac{\partial \Psi}{\partial \sigma} = \frac{1}{\sigma}(\frac{1}{2} - \Psi).$$

Thus, $\frac{\partial \Psi}{\partial \sigma} \gtreqless 0 \Leftrightarrow \frac{1}{2} \gtreqless \Psi$. It follows then from Proposition 2 that if $\pi \lesseqgtr \tilde{\pi}$, then $\frac{\partial \Psi}{\partial \sigma} \gtreqless 0$. The other results follow from equations (13) and (14). ■

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Table 1: The Effect of Income Inequality on the Quality of Education: Basic Regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PISA (Mean)	*PISA (Mean)*	*PISA (Mean)*	*PISA (Mean)*	*PISA (Mean)*	*PISA (Mean)*	*PISA (Mean)*	*PISA (Mean)*
texgini	-6.173***	-3.676***	-3.361***	-3.474***	-3.214***	-2.818***	-3.062***	-2.920***
	(-4.971)	(-4.141)	(-4.169)	(-3.796)	(-3.564)	(-3.745)	(-4.003)	(-3.706)
gdppercap		22.211***	21.194***	21.288***	15.499***	12.984***	10.788**	10.600**
		(4.938)	(4.314)	(4.240)	(3.079)	(3.313)	(2.272)	(2.299)
publspending			4.173	3.814	1.336	0.836	2.121	1.806
			(0.961)	(0.808)	(0.313)	(0.206)	(0.558)	(0.484)
density				-0.001	0.013***	0.015***	0.013***	0.012***
				(-0.352)	(3.364)	(4.882)	(3.678)	(3.061)
democracy					2.546**	2.697***	3.309***	2.727**
					(2.239)	(2.747)	(3.016)	(2.413)
ethnic						-36.059	-39.796*	-32.985
						(-1.680)	(-1.740)	(-1.400)
old							-2.281	-1.617
							(-1.337)	(-0.982)
fertility								-9.307
								(-0.859)
Geographical Dummies	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
obs	55	55	55	55	51	51	51	51
R^2	0.69	0.84	0.84	0.84	0.86	0.87	0.88	0.88

Notes: The table presents estimated coefficients and *t-statistics* in parentheses. Dependent variable is the composite PISA score average in Mathematics, Science and Reading. All regressions are estimated with regional dummies and robust standard errors. The set of regional dummies includes a fixed effect for East Asia (*AsiaE*), Latin America or the Caribbean (*LaAm)*, Europe and Central Asia (*EurAsiaC*) and North America (*NAm*)**.** The *, ** and *** marks denote statistical significance at the 10%, 5% and 1% respectively.

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Table 2: The Effect of Income Inequality on the Quality of Education: Sensitivity of Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	PISA (Mean)	*PISA (Mean)*	*PISA (Mean)*	*PISA (Mean)*	*PISA (Mean)*	*PISA Mathematics*	*PISA Science*	*PISA Reading*	*Hanushek and Woessmann Cognitive*	*Hanushek and Woessmann LowSec*
texgini	-2.920***	-3.336***	-2.243***			-2.392**	-3.577***	-2.791***	-0.021***	-0.021**
	(-3.706)	(-4.342)	(-2.782)			(-2.483)	(-4.458)	(-2.761)	(-2.796)	(-2.290)
Ineq_20				-1.955*						
				(-1.723)						
Gini_Solt					-1.100*					
					(-1.757)					
gdppercap	10.600**	12.397**	11.856***	26.097***	25.987***	10.786**	10.089**	10.926**	0.033	0.064
	(2.299)	(2.514)	(2.903)	(3.439)	(3.346)	(2.187)	(2.240)	(2.162)	(0.713)	(1.253)
density	1.806	4.247	4.353	4.091	4.499	5.337	-0.978	1.059	0.037	0.034
	(0.484)	(1.275)	(1.224)	(0.947)	(1.073)	(1.228)	(-0.265)	(0.254)	(0.917)	(0.752)
democracy	0.012***	0.013***	0.011	0.005	0.007	0.016***	0.010**	0.010**	0.001***	0.001***
	(3.061)	(3.021)	(0.242)	(0.938)	(1.104)	(4.085)	(2.570)	(2.245)	(2.844)	(2.704)
ethnic	2.727**	1.768	2.519**	1.433	1.883	2.126*	2.730**	3.324**	-0.005	-0.014
	(2.413)	(1.491)	(2.225)	(1.244)	(1.502)	(1.736)	(2.226)	(2.338)	(-0.319)	(-0.842)
publspending	-32.985	-27.819	-32.308	-8.854	-15.131	-37.793	-24.892	-36.271	-0.299	-0.322
	(-1.400)	(-1.235)	(-1.618)	(-0.428)	(-0.777)	(-1.334)	(-1.181)	(-1.340)	(-1.097)	(-1.040)
old	-1.617	-2.556	-2.941*	-4.662**	-3.957**	-2.147	-1.422	-1.283	0.025	0.024
	(-0.982)	(-1.332)	(-1.939)	(-2.172)	(-2.054)	(-1.212)	(-0.895)	(-0.707)	(1.266)	(1.041)
fertility	-9.307	-13.836	-19.882**	-9.335	-7.882	-10.109	-11.755	-6.058	-0.252**	-0.281**
	(-0.859)	(-1.316)	(-2.283)	(-0.938)	(-0.730)	(-0.921)	(-1.076)	(-0.506)	(-2.389)	(-2.524)
Geographical Dummies	*yes*	*no*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
obs	51	51	45	52	53	51	51	51	63	63
R^2	0.88	0.85	0.91	0.86	0.86	0.88	0.88	0.85	0.77	0.76

Notes: The table presents estimated coefficients and *t-statistics* in parentheses. All regressions are estimated with regional dummies and robust standard errors (except otherwise noted). The set of regional dummies includes a fixed effect for East Asia (*AsiaE*), Latin America or the Caribbean (*LaAm*), Europe and Central Asia (*EurAsiaC*) and North America (*NAm*)**.** In Columns (1)-(5), the dependent variable is the composite PISA score average in Mathematics, Science and Reading. In Column (2) the regression is estimated without regional dummies. In Column (3) a 10 percent of the outliers is excluded from our sample. We present the results of the second stage. In Columns (4) and (5) the regressions are estimated with alternative proxies for income inequality. Specifically in Column

(4) is employed the income share held by the highest 20% (*Ineq_20*) and in Column (5) is employed the Gini coefficient developed by Solt (2009) [denoted as *Gini_Solt*]. In Columns (6)-(8) the dependent variables are the PISA scores in: (i) Mathematics, (ii) Science and (iii) Reading, respectively. Finally, n Columns (9) and (10) the dependent variables are the Hanushek and Woessmann (2012) cognitive skills measure and the Hanushek and Woesmann (2012) cognitive skills measure in lower secondary school respectively. In Columns (11)-(16) regressions are estimated with two-stage least squares (2SLS). The results of the first stage are reported on the upper part of the Columns and the results of the second stage below. The *, ** and *** marks denote statistical significance at the 10%, 5% and 1% respectively.

Table 2: The Effect of Income Inequality on the Quality of Education: Sensitivity of Results

	(11)	(12)	(13)	(14)	(15)	(16)
Dependent Variable	*PISA (Mean)*	*PISA Mathematics*	*PISA Science*	*PISA Reading*	*Hanushek and Woessmann Cognitive*	*Hanushek and Woessmann LowSec*
First-stage results						
Transfers	-0.264**	-0.264**	-0.264**	-0.264**	-0.264**	-0.264**
	(-2.21)	(-2.21)	(-2.21)	(-2.21)	(-2.21)	(-2.21)
TaxProgress	-1.270	-1.270	-1.270	-1.270	-1.270	-1.270
	(-1.19)	(-1.19)	(-1.19)	(-1.19)	(-1.19)	(-1.19)
	Second-Stage Results					
texgini	-6.310**	-6.354**	-6.112**	-6.463*	-0.065*	-0.068*
	(-2.323)	(-2.503)	(-2.449)	(-1.906)	(-1.745)	(-1.760)
gdppercap	30.080**	28.625**	27.775**	33.839***	0.022	0.048
	(2.718)	(2.540)	(2.574)	(2.830)	(0.185)	(0.337)
publspending	-6.674	-4.531	-7.654	-7.838	-0.032	-0.038
	(-1.274)	(-0.900)	(-1.413)	(-1.316)	(-0.386)	(-0.423)
density	-0.006	-0.000	-0.007	-0.012	0.000	0.000
	(-0.947)	(-0.050)	(-1.041)	(-1.637)	(0.827)	(0.775)
democracy	0.170	0.586	0.133	-0.211	0.007	-0.003
	(0.086)	(0.292)	(0.068)	(-0.099)	(0.403)	(-0.124)
ethnic	11.887	13.443	10.445	11.773	-0.195	-0.250
	(0.382)	(0.400)	(0.374)	(0.339)	(-0.427)	(-0.459)
old	-7.012***	-6.874***	-6.406***	-7.757***	0.004	0.003
	(-3.821)	(-3.213)	(-3.728)	(-3.699)	(0.113)	(0.063)
fertility	3.898	3.232	-0.072	8.533	-0.128	-0.157
	(0.387)	(0.324)	(-0.007)	(0.738)	(-0.947)	(-1.046)
Geographical Dummies	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
obs	47	47	47	47	52	52
$\mathbf{R^2}$	0.87	0.88	0.87	0.81	0.76	0.75
Hansen *J*						

Notes: The table presents estimated coefficients and *t-statistics* in parentheses. All regressions are estimated with regional dummies and robust standard errors (except otherwise noted). The set of regional dummies includes a fixed effect for East Asia (*AsiaE*), Latin America or the Caribbean (*LaAm*), Europe and Central Asia (*EurAsiaC*) and North America (*NAm*)**.** In Columns (1)-(5), the dependent variable is the composite PISA score average in Mathematics, Science and Reading. In Column (2) the regression is estimated without regional dummies. In Column (3) a 10 percent of the outliers is excluded from our sample. We present the results of the second stage. In Columns (4) and (5) the regressions are estimated with alternative proxies for income inequality. Specifically in Column (4) is employed the income share held by the highest 20% (*Ineq_20*) and in Column (5) is employed the Gini coefficient developed by Solt (2009) [denoted as *Gini_Solt*]. In Columns (6)-(8) the dependent variables are the PISA scores in: (i) Mathematics, (ii) Science and (iii) Reading, respectively. Finally, n Columns (9) and (10) the dependent variables are the Hanushek and Woessmann (2012) cognitive skills measure and the Hanushek and Woesmann (2012) cognitive skills measure in lower secondary school respectively. In Columns (11)-(16) regressions are estimated with two-stage least squares (2SLS). The results of the first stage are reported on the upper part of the Columns and the results of the second stage below. The *, ** and *** marks denote statistical significance at the 10%, 5% and 1% respectively.

Table 3: The impact of institutions on the nexus between income inequality and education quality.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	PISA (Mean)	*PISA (Mean)*	*PISA (Mean)*	*PISA (Mean)*	*PISA (Mean)*	*PISA (Mean)*	*PISA (Mean)*	*PISA (Mean)*	*PISA (Mean)*
texgini	-4.409***	-3.659***	-3.634***	-4.458***	-3.822***	-3.874***	-4.412***	-3.661***	-4.045***
	(-3.961)	(-3.712)	(-3.557)	(-4.390)	(-4.135)	(-4.153)	(-5.078)	(-3.864)	(-3.853)
*texgini_dif*Governance_dif*	2.621***	2.102**	1.660*						
	(3.050)	(2.534)	(1.896)						
Governance	29.390***	22.366**	23.073***						
	(3.616)	(2.681)	(2.843)						
*texgini_dif*Rule of Law_dif*				2.663***	2.308***	1.966**			
				(3.341)	(3.097)	(2.491)			
Rule of Law				30.755***	24.916***	24.954***			
				(4.700)	(3.822)	(3.244)			
*texgini_dif*Accountabilty_dif*							2.732***	1.978**	2.121**
							(3.358)	(2.261)	(2.163)
Accountability							20.131**	24.111**	28.219**
							(2.023)	(2.403)	(2.476)
gdppercap	11.282*	8.796	5.068	9.125	7.038	4.322	17.140***	11.157**	7.805
	(1.718)	(1.557)	(0.862)	(1.619)	(1.389)	(0.744)	(3.389)	(2.705)	(1.635)
publspending	3.763	2.551	2.152	4.302	3.459	3.373	4.066	1.893	3.342
	(0.947)	(0.624)	(0.543)	(1.195)	(0.950)	(0.936)	(1.086)	(0.492)	(0.961)
density	0.001	0.010***	0.008**	0.001	0.011***	0.010**	-0.001	0.013***	0.011***
	(0.087)	(3.078)	(2.043)	(0.150)	(3.758)	(2.572)	(-0.320)	(3.892)	(3.191)
democracy		1.616*	2.156*		1.393	1.880		0.675	1.404
		(1.763)	(1.920)		(1.518)	(1.622)		(0.589)	(1.158)
ethnic		-29.022	-31.293		-26.085	-27.791		-25.665	-31.774
		(-1.424)	(-1.377)		(-1.326)	(-1.234)		(-1.306)	(-1.361)
old			-1.870			-1.717			-2.940**
			(-1.164)			(-1.182)			(-2.122)
fertility			-2.905			-1.937			4.067
			(-0.256)			(-0.202)			(0.325)
Geographical Dummies	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
obs	55	51	51	55	51	51	55	51	51

R^2	0.88	0.89	0.90	0.89	0.91	0.91	0.88	0.90	0.91

Notes: The table presents estimated coefficients and *t-statistics* in parentheses. Dependent variable is the composite PISA score average in Mathematics, Science and Reading. All regressions are estimated with regional dummies and robust standard errors. The set of regional dummies includes a fixed effect for East Asia (*AsiaE*), Latin America or the Caribbean (*LaAm*), Europe and Central Asia (*EurAsiaC*) and North America (*NAm*). In Columns (1)-(3) as proxy for the quality of institutions is employed the Government Effectiveness measure developed by Kaufmann et al. (2010) (denoted as *Governance*) whereas the interaction term comprises of the product of the mean-centred *texgini* and mean-centred *Governance*. In Columns (4)-(6) as proxy for the quality of institutions is employed the Rule of Law measure developed by Kaufmann et al. (2010) (denoted as *Rule of Law*) whereas the interaction term comprises of the product of the mean-centred *texgini* and mean-centred *Rule of Law* . In Columns (7)-(9) as proxy for the quality of institutions is employed the Voice and Accountability measure developed by Kaufmann et al. (2010) (denoted as *Accountability*) whereas the interaction term comprises of the product of the mean-centred *texgini* and mean-centred *Accountability* . The *, ** and *** marks denote statistical significance at the 10%, 5% and 1% respectively.

Table A: Data sources and descriptive statistics

Variable	Description	Obs.	Mean	Std. Dev.	min	max	Source
PISA (Mean)	Composite PISA score average in Mathematics, Science and Reading.	62	464.01	56.85	315.34	547.11	Programme for International Student Assessment (PISA), OECD (2011)
PISA Mathematics	PISA score in Mathematics (Mean)	62	463.33	60.75	320.87	562.02	Programme for International Student Assessment (PISA), OECD (2011)
PISA Science	PISA score in Science (Mean)	62	467.77	56.22	325.79	555.13	Programme for International Student Assessment (PISA), OECD (2011)
PISA Reading	PISA score in Reading (Mean)	62	460.159	54.23	299.36	543.10	Programme for International Student Assessment (PISA), OECD (2011)
Hanushek and Woessmann Cognitive	Average test score in math and science, primary through end of secondary school, all years (scaled to PISA scale divided by 100)	75	4.54	0.57	3.09	5.34	Hanushek and Woessmann (2012)
Hanushek and Woessmann LowSec	Average test score in math and science, only lower secondary, all years (scaled to PISA scale divided by 100).	75	4.54	0.61	2.68	5.51	Hanushek and Woessmann (2012)
TexGini	Texas Inequality Project Gini coefficient	77	40.05	6.80	24.46	54.78	Texas University Inequality Project
Ineq_20	Income share held by the highest 20%	69	44.66	7.54	32.51	62.94	World Bank Development Indicators (2011)
gini_Solt	Gini coefficient (before taxes and transfers) developed by Solt (2009)	77	42.33	6.96	29.38	66.12	Solt (2009)
gdppercap	Log of GDP per capita (constant 2000 US$).	85	8.46	1.36	5.44	10.90	World Bank Development Indicators (2011)
density	Population Density measured as number of people per square km	86	378.97	1596.16	2.27	13026.48	World Bank Development Indicators (2011)
ethnic	Ethnic Fractionalization.	82	0.36	0.23	0.00	0.85	Alesina et al (2003)
democracy	Polity Democracy Index	76	3.86	6.42	-10.00	10.00	Polity IV (2004) Database
publspending	Public Spending on Education (as a share of GDP)	78	4.39	1.36	0.57	7.4	World Bank Development Indicators (2011)
fertility	Fertility rate, total (births per woman)	84	2.56	1.17	1.32	6.29	World Bank Development Indicators (2011)
old	Population ages 64 and above (% Total Population)	84	26.93	3.55	14.92	36.17	World Bank Development Indicators (2011)
Governance	Quality of governance and Institutions. Government's credibility and commitment to specific policies.	82	0.62	0.90	-0.98	2.12	Kaufmann, Kray and Mastruzzi (2010), Worldwide Governance Indicators (WGI).

Rule of Law	Quality of governance and Institutions. Quality of contract enforcement, property rights and the courts.	83	0.45	0.93	-1.38	1.94	Kaufmann, Kray and Mastruzzi (2010), Worldwide Governance Indicators (WGI).
Voice and Accountability	Quality of governance and Institutions. Freedom of expression, freedom of association and free media	83	0.39	0.91	-1.51	1.65	Kaufmann, Kray and Mastruzzi (2010), Worldwide Governance Indicators (WGI).
Transfers	Government Transfers (as a share of GDP)	74	13.38	8.49	1.53	36.5	World Bank Development Indicators (2011)
TaxProgress	Ratio of statutory tax rate to average corporate tax rate	62	1.85	0.55	1.13	3.62	Own calculations based on Djankov et al (2010)