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Education Funding under Inequality

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Abstract

This paper presents a theoretical model in which income inequality affects school enrolment, tax rates, average expenditures per student and inequality in educational expenditures. In the model, tax rates are determined through majority voting, and parents take decisions for their children, choosing among different alternatives: public and private funded schooling and child labor. Parents differ with respect to income level. Low-income earning parents typically choose child labor, whilst high-income families elect privately funded options. Under this framework, it is possible to compare two different funding schemes: a mixed system where free public schools coexist with private alternatives, and a mean-tested vouchers regime. The model has no analytical solution, and results are obtained through computational experiments. A mean-tested voucher regime yields a lower tax rate and higher expenditure per student, as well as higher total welfare. In a mixed system, inequality in educational outcomes is lower for every level of income inequality and the public system has political support under higher levels of income inequality than the former. Voters always prefer mean-tested vouchers to a mixed system in a pair wise comparison. The findings are robust to different parameterizations.

Keywords: Inequality – Education – Political Economy – Funding Schemes

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1. Introduction

Schooling is publicly provided to a large extent in most countries around the globe. Friedman (1962) provides two main reasons for this phenomenon: "neighborhood effects" and paternalism. According to the author, the education of an individual is beneficial for the whole society, and it is unfeasible to compensate this individual for the benefit, generating a "neighborhood effect". Paternalism refers to a paternalistic concern for children whose parents or guardians are irresponsible or shortsighted. Public provision of education can correct both.

Despite the reasons that might motivate public funding of schooling, the current work is interested in the different funding systems to do so. Governments typically redistribute resources among citizens to ensure a minimum educational level and equalize opportunities. Redistribution in general implies taxes, which tend to distort private decisions. The design of funding schemes then faces a trade-off between taxes and level of public funding. Friedman (1962) suggests supplementable vouchers. Levin (1998) shows uniform vouchers lead to socioeconomic segregation. One response is a mean-tested vouchers regime, as found in Hoxby (1996) or selective vouchers, as called by West (1997), where vouchers are allocated on basis of income, ability, residence, etc. Bearse et al. (2000) use a political economy model to show a mean-tested voucher scheme implies lower optimal tax rate and higher average expenditure per student than a mixed public/private system or uniform vouchers.

However, this analysis fails to take into account the effect of inequality might have on education. Inequality might affect education through numerous channels. Among these channels, there is a politically motivated one, which directly affects the model presented by Bearse et al. (2000). Inequality determines the willingness to redistribute resources to finance public education: if parents can choose among sending children to work and public or private funded schooling, high inequality implies a large fraction of parents will exit the publicly funded system through both ends of the income distribution. Gutiérrez and Tanaka (2009) show that theoretically it is possible that such a large number of families opt out of the public system that there is no longer political support for public funding of education under a mixed system.

Child work is an issue in developing countries. Many families cannot overcome the costs of education, and have to send children to work. If a high percentage of children do not attend school, efforts put in improving education might not yield the desired results, as they might only increase the opportunity gap between the children left out of the system and those who attend school.

The current work shows through computational experiments how income inequality can hamper educational outcomes, and compares the consequences under different funding schemes to serve as a theory based assessment on the matter. The paper presents a model in which parents have preferences for current consumption and human capital of their children. Parents can choose between schooling and child work, and vote for their preferred tax rate to finance the public system. The government redistributes resources and provides public funding for education. The model is solved for two different funding regimes: a mixed and a mean-tested voucher scheme. A mixed system implies publicly funded schools in which children can attend free of charge and private schools for which parents have to pay the whole tuition fee. A mean-tested vouchers regime implies that each household receives a voucher inversely related to their income, which they can supplement and spend in any school. The model is solved for both funding schemes in the case child work bans are enforceable and in the case where they are not. In line with previous literature[1], taxes, public expenditure per student, enrolment rates and political support are all affected by inequality and child work.

With these results in hand, it is possible to compare both funding schemes. Previous studies merely solved the problem under a mixed system or with perfectly enforceable child work bans, whereas the paper at hand compares equilibrium taxes, child work rates, average expenditures per student, total and individual welfare, inequality in educational expenditures and political support when child work is not perfectly enforceable and under two different funding schemes. Results show a significant difference between the results under both schemes, and give theoretical evidence in favor of mean-tested voucher regimes for almost every level of inequality.

The paper is organized as follows. The next section discusses the related literature. Section 3 presents the theoretical model under both funding schemes. Section

[1] Gutiérrez and Tanaka (2009)

4 describes the numerical solution strategy and the results obtained. Section 5 compares both alternatives under tax rates, average expenditure per student, child work rates, inequality in educational expenditures, total welfare, and political support. Section 6 concludes.

2. Related Literature

This paper is related to two strings of literature. On one hand, it relates to the work on how inequality affects educational outcomes, and on the other hand, to the literature regarding public funding schemes for education.

Several papers have analyzed different education systems and their effect on inequality[2], while the reverse link has received much less attention. However, some papers have proven to be essential for the discussion.

Fernández and Rogerson (1995) analyze the implications of higher inequality when universities and technical institutes are partially publicly financed and individuals have to vote for the tax and the degree of subsidization. In case poor agents face borrowing constraints, high inequality raises the probability of poor agents being excluded from the public system. They predict an implicit transfer of resources from low-income to high-income individuals for wealthy countries. Sylwester (2002a) presents a dynamic model where income depends directly on the accumulated human capital. Agents face a subsistence constraint and school attendance deprives families of child work income. The steady-state level of human capital depends on the initial endowment, and some agents cannot forgo the opportunity costs of schooling. In this case, public education does not necessarily reduce inequality, depending on initial value of parameters. Tanaka (2003) develops a model in which parents can only choose between public education and child labor. The author finds a direct link between inequality and the amount of child labor. Gutierrez and Tanaka (2009) find that under a mixed public/private system and when child labor bans are not enforceable, families at both ends of the income distribution will exit the public system. If parents are able to vote for their preferred flat tax rate, higher inequality yields lower support for public education, lower tax rate, and lower expenditure per student.

[2] For further insights see Bearse et al. (2001, 2005), Benabou (1996), Fernández and Rogerson (1996,1997,1998), Ferreira (2001), Glomm (2004), Glomm and Ravikumar (1992, 2003), Saint-Paul and Verdier (1993), Sylwester (2000, 2002b).

Gutiérrez and Tanaka (2009) extend the work of Glomm and Ravikumar (1998) as well as Epple and Romano (1996), who endogenize the provision of public services under a majority rule. The authors allow opting out the public system only for a private option. They also provide conditions for the existence of an equilibrium when preferences are not single peaked.

This paper is also related with the literature dealing with different funding schemes. Among the different options, two main funding systems are distinguished in the literature: mixed systems and vouchers. Mixed systems imply a free public schools coexisting with private alternatives. Voucher systems imply each family receives a voucher they can spend in any school. These vouchers are typically supplementable. Uniform and universal vouchers have been proven to lead to socioeconomic segregation[3]. However, there is another option: mean-tested vouchers, as called by Hoxby (1996). The amount and the recipients of the voucher can vary based on different characteristics like income, ability, or school type. Epple and Romano (2008) and Nechyba (2000) study this type of vouchers when funding and distribution is exogenous. Bearse et al. (2000) endogenize both through majority voting in an economy where private and public educations coexist and child work bans are enforceable. They find this system is preferable to the previous one in terms of amount of the tax, inequality of educational resources and political support.

Building on this framework, the aim of the present work is to compare different funding options under inequality. Specifically, the paper compares a mixed system and a mean-tested vouchers scheme. This extends the work of Gutiérrez and Tanaka (2003) by adding the mean-tested voucher system to the analysis, and the work of Bearse et al. (2000) by allowing parents to opt out the schooling system through the left hand side of the income distribution, sending their children to work.

3. The Model

The economy is populated by a continuum of identical households differentiated only by their income, $y \in [0, \infty[$, endowed across families according to a Log Normal distribution with C.D.F $F(y; \mu, \sigma^2)$ and the P.D.F $f(y; \mu, \sigma^2)$, mean $e^{\mu+\sigma^2/2}$ and

[3] See Levin (1998), Epple and Romano (1996), Nechyba (1999) and Glomm and Ravikumar (1995)

variance $\left(e^{\sigma^2}-1\right)e^{2\mu+\sigma^2}$. Households are indexed by y. One parent and one child form each family. Without loss of generality, the mass of households is normalized to 1 and average and total income are equal, indicated by $Y=\int_0^\infty yf(y)dy$.

Parents derive utility from current consumption and human capital of their offspring. The level of human capital acquired by a child depends on the level of education he receives. As the paper is interested only in funding schemes, the level of education received is related one-to-one with parents' expenditure on acquiring education. Preferences can be described by the following utility function:

$$U(c,e)=\frac{1}{1-\rho}(c^{1-\rho}+\delta e^{1-\rho}) \qquad c,e\geq 0 \qquad (1)$$

where c stands for consumption and e for the level of human capital of the child. Parents decide how to allocate only their after tax income between current consumption and educational expenditure, due to credit constraints or the fact they cannot use their children's future human capital as a collateral.

There is a large number of public and privately funded schools, with constant returns to scale operating in a perfectly competitive market. Every school has access to the same technology, and the price of instruction is normalized to 1. This assumption ensures that the educational outcome is equal to the investment. It also does not allow for differences in school productivity. Hence, only income effects will generate differences in educational outcomes.

Child labor bans are not enforceable, and there is a developed child labor market, with an exogenously determined[4] wage $w\geq 0$. This wage reflects either money directly earned by the child, or extra money earned by the parent due to child chores. The human capital acquired by the child with no formal instruction is $b\geq 0$.

The government is concerned about the different set of opportunities faced by children, and redistributes resources among households. Parents vote for a tax rate on

[4] The mechanisms through which wages could be endogenized are not so clear. Child work is easily replaceable by unqualified work, and not every job performed by children has a direct monetary payment, as some of them help their parents in different chores. For these same reasons, exogenously fixing wages should not affect results significantly.

income $\tau \in [0,1[$ to finance education. Total tax revenue is τY, and is entirely devoted to support child instruction.

Under this setup it is possible to model the complete system under both funding schemes.

3.1 Flat tax and mixed system

The mixed system is similar to the one presented in Epple and Romano (1996), Glomm and Ravikumar (1998) and Bearse et al. (2004). The government uses the total tax revenue collected to fund public education at equal levels. However, parents are free to opt out the public system in favor of private schooling.

Given the quality of publicly provided education E and the tax rate τ, the indirect utility obtained by each parent under each alternative is equal to:

$$V^{work} = \frac{1}{1-\rho}[(y(1-\tau)+w)^{1-\rho} + \delta b^{1-\rho}] \qquad (2)$$

$$V^{pub} = \frac{1}{1-\rho}[(y(1-\tau))^{1-\rho} + \delta E^{1-\rho}] \qquad (3)$$

$$V^{priv} = \frac{1}{1-\rho}\left[\left(1+\delta^{1/\rho}\right)^{\rho}(y(1-\tau))^{1-\rho}\right] \qquad (4)$$

The indirect utility of a household with income y is equal to $W^{mix}(y;\tau,w,b,E) = max\left[V^{work}, V^{pub}, V^{priv}\right]$.

The decision rule of sending a child to school or not and the type of school is determined by comparing pair wise choices. Parents with income below the threshold level $\underline{y}$ prefer child labor to public schooling, and parents with income over $\overline{y}$ prefer private to public schooling.

$$V\left(\underline{y}(1-\tau)+w, b\right) = V\left(\underline{y}(1-\tau), E\right) \qquad (5)$$
$$(\underline{y}(1-\tau)+w)^{1-\rho} - (\underline{y}(1-\tau))^{1-\rho} = \delta(E^{1-\rho} - b^{1-\rho})$$

$$V(\overline{y}(1-\tau) - e^{*}(\overline{y}(1-\tau)), e^{*}(\overline{y}(1-\tau)) = V(\overline{y}(1-\tau), E) \qquad (6)$$

$$\left(\overline{y}(1-\tau)\right)^{1-\rho} = \frac{\delta E^{1-\rho}}{\left(1+\delta^{1/\rho}\right)^{\rho}-1}$$

The quality of education received in public schools is set equal to public expenditure per pupil. This assumption might be controversial, but it is suitable in the current framework, as the aim of the paper is to compare funding schemes over other issues.

The government's budget constraint implies the following:

$$E = \frac{\tau Y}{N} \qquad (7)$$

where Y stands for the total income, and N for the total number of children in the public system. τ is determined by majority voting, and voters recognize the public enrolment rate as:

$$N = F(\overline{y}) - F(\underline{y}) \qquad (8)$$

The optimization of each household determines the preferences over tax rates. The individual maximization satisfies:

$$\tau^{*} = \arg\max W^{mix}(y;\tau,E,w,b) \qquad (9)$$

$$s.t \qquad E = {}^{\tau Y}/_{N}$$

The majority voting equilibrium is the policy (τ, E) consistent with the government's budget constraint, which gathers a support of 50% of the voters against any other policy in a pair wise comparison. Generally, a majority voting equilibrium exists if the policy variable is scalar and preferences are single peaked. In this case, the second condition does not hold.

Parents with an income $y < \underline{y}$ and $y > \overline{y}$ prefer a zero tax rate, as their income after taxes decreases with a positive tax, and the human capital acquired by their offsprings does not rise. Among the rest, the preferred tax might either increase or decrease with income depending on the strength of income and substitution effects: a higher tax implies less disposable income for other consumptions, and higher quality of

education. However, Epple and Romano (1996) show that if the slope of the indifference curve of $U(y(1-\tau),E)$ in the (E,τ) plane is monotone in income y, it is possible to establish conditions for the existence of such an equilibrium. The slope of the indifference curve is denoted by:

$$M(E,y,\tau)=\frac{U_1(y(1-\tau),E)}{y\cdot U_2(y(1-\tau),E)} \qquad (10)$$

If the previous assumption holds, one of the following conditions must hold as well:

$$SDI \qquad \frac{\partial M(E,y,\tau)}{\partial y}\leq 0 \; for\; all\; y \qquad (11)$$

$$SRI \qquad \frac{\partial M(E,y,\tau)}{\partial y}\geq 0 \; for\; all\; y \qquad (12)$$

SDI stands for slope decreasing in income and SRI for slope increasing in income. Under SRI, the preferred tax raises with income, as the substitution effect is stronger, and the absolute value of the price elasticity of implied demand for education is smaller than the income elasticity. SDI implies the opposite, as the preferred tax rate decreases with income and the income effect is stronger[5]. In terms of this model, SRI holds when $\rho \geq 1$.

Following this approach, the equilibrium tax rate will be the one preferred by the pivotal voter, which satisfies the following condition:

$$\int_{y_p}^{\bar{y}} f(y)dy = 0.5 \;\; under\; SRI \qquad (13)$$

$$\int_{\underline{y}}^{y_p} f(y)dy = 0.5 \;\; under\; SDI \qquad (14)$$

where y_p stands for the income of the pivotal voter.

The threshold level for which households are indifferent between work or public schooling (5), and between private or public schooling (6), the government budget

[5] See Epple and Romano (2008)

constraint (7), the preferred tax rate by level of income (9) and the condition for a majority voting equilibrium (13,14) define de problem.

3.2 Flat tax and mean-tested vouchers

The mean-tested vouchers regime is similar to the one presented in Bearse et al. (2004). In this setup, parents who send their child to school receive a voucher $v(y, \alpha, \beta)$ according to their income, which can be spent only on education.

$$v(y, \alpha, \beta) = Max[\alpha - \beta y, 0] \qquad \alpha, \beta \geq 0 \qquad (15)$$

Parents are allowed to supplement the voucher with out-of the-pocket spending. Individuals with an income higher than α/β and those who send their child to work receive a voucher equal to zero.

Taking α, β and τ as given, parents obtain the following indirect utility depending on the chosen alternative:

$$V^{work} = \frac{1}{1-\rho}[(y(1-\tau)+w)^{1-\rho} + \delta b^{1-\rho}] \qquad (16)$$

$$V^{school} \begin{cases} \frac{1}{1-\rho}[(y(1-\tau))^{1-\rho} + \delta v(y,\alpha,\beta)^{1-\rho}] & y \leq \frac{\alpha}{\beta + \delta^{1/\rho}(1-\tau)} \\ \frac{1}{1-\rho}\left[(1+\delta^{1/\rho})^{\rho}(y(1-\tau)+v(y,\alpha,\beta))^{1-\rho}\right] & otherwise \end{cases} \qquad (17)$$

The indirect utility of a household with income y is characterized by $W^{M-T} = \max [V^{work}, V^{school}]$.

As in the previous case, the decision rule is sending the child to work if $y < \underline{y}$, and to school otherwise. The decision is typically characterized by equation (18):

$$V\left(\underline{y}(1-\tau)+w, b\right) = V\left(\underline{y}(1-\tau), \alpha, \beta\right) \qquad (18)$$

$$(\underline{y}(1-\tau)+w)^{1-\rho} - (\underline{y}(1-\tau))^{1-\rho} = \delta\left(\left(\alpha - \beta\underline{y}\right)^{1-\rho} - b^{1-\rho}\right)$$

A balanced budget in this case requires:

$$\alpha\left(F(^{\alpha}/_{\beta}) - F(\underline{y})\right) - \beta\int_{\underline{y}}^{^{\alpha}/_{\beta}} yf(y)dy = \tau Y \qquad (19)$$

The preferences for the tax rate can be described by the maximization problem of each household:

$$\tau^* = \arg\max W^{M-T}(y;\tau,\alpha,\beta,w,b) \qquad (20)$$
$$s.t \;\; \alpha\left(F(^{\alpha}/_{\beta}) - F(\underline{y})\right) - \beta\int_{\underline{y}}^{^{\alpha}/_{\beta}} yf(y)dy = \tau Y$$

The voting problem in this case is two-dimensional. Parents vote for their preferred β and τ. The problem is solved sequentially through backward induction. First, individuals vote for their preferred τ, and then vote for β in the second stage. α is pinned down by the government's budget. The problem is solved similarly to Bearse et al. (2004). The pair (τ, β) is determined through sequential majority voting.

The pivotal voter for the second stage will be the median voter. In this case preferences are single peaked. For a given tax, household's preferences for β decrease with income. Individuals with low income prefer a high β, as the government's budget constraint implies a higher α, and a higher voucher. For high incomes, a low β makes the received voucher higher. Households are not indifferent for any level of income, as sufficiently high/low values of β might affect their preferences for a zero tax rate in the first stage. Consequently, the median voter's choice gathers a 50% support from the voters.

In the first stage preferences, as in the previous case, are not single peaked. Voters take β as given, and vote over τ. Voters with an income $y < \underline{y}$ and $y \geq \alpha/\beta$ prefer $\tau = 0$, and the pivotal voter will be the one that satisfies the following condition:

$$\int_{y_p}^{\alpha/\beta} f(y)dy = 0.5 \;\; under\ SRI \qquad (21)$$

$$\int_{\underline{y}}^{y_p} f(y)dy = 0.5 \;\; under\ SDI \qquad (22)$$

where y_p stands for the income of the pivotal voter.

The equilibrium tax rate and the value of the voucher is determined by the threshold level for which households are indifferent between work or public schooling (18), the government budget constraint (19), the preferred tax rate by level of income (20) and the condition for a majority voting equilibrium (21,22).

At this point, it is necessary to obtain numerical values under reasonable assumptions for the parameters. The next section describes the results and the strategy used to obtain them.

4. Numerical Solution

The mean income is arbitrarily set to 1000 without loss of generality. μ and σ are obtained from the mean of a lognormal distribution, and the Gini index for the same distribution:

$$E(y) = e^{\mu+\sigma^2/2} \qquad (23)$$

$$Gini = 2\Phi\left(\frac{\sigma}{\sqrt{2}}\right) - 1 \qquad (24)^6$$

where Gini is the value of the Gini Index, and $\Phi(.)$ the cumulative distribution function of the normal standard distribution. With this set of equations, it is possible to find μ and σ and the distribution of income y is completely characterized.

The range for the remaining parameters has been discussed already in previous literature. Gutiérrez and Tanaka (2009) and Epple and Romano (1996) calibrate similar models to the data of Colombia and the USA, and obtain the empiric range of ρ, δ, w and b. The values are summarized in Table 1.

[6] The Gini for the lognormal distribution can be obtained from the previous formula. See Aitchinson and Brown (1957).

ρ	0.65	2.2
δ	0.01	0.2
w	6	75
b	4	72

Table 1. The table resumes the empiric range of $\boldsymbol{\rho}$, $\boldsymbol{\delta}$, $\boldsymbol{w}$ and $\boldsymbol{b}$ according to Gutiérrez and Tanaka (2009) and Epple and Romano (1996). Transformations of the values were made when necessary.

Gutiérrez and Tanaka (2009) use the data of Colombia in 2003 to calibrate a similar model and obtain values for ρ, δ, w and b. Values have been transformed to fit the assumptions of this model. This sample is relevant, as 9.1% of the children do not attend school arguing mainly economic reasons, and 15% of children attend private schools (and private school attendance is strongly related to income level). At that date Colombia had a more or less pure mixed funding scheme. The data comes from Encuesta de Calidad de Vida 2003 and Colombian National Statistical Office (DANE), and provided values for public school enrolment (N), private school enrolment ($\overline{y}$), share of children not attending school ($\underline{y}$), average household income (Y), Gini coefficient for income inequality (μ and σ with equations (23) and (24)) and total expenditures in education (implicit τ). The authors calibrate to find ρ, δ, w and b with equations (5), (6), (9) and the price elasticity of implied demand for education of public school users, $\varepsilon_{\hat{E},p}$:

$$\varepsilon_{\hat{E},p} = -\frac{1}{\rho}[1 - \tau(\rho - 1)] \qquad (25)^{7}$$

Empiric estimates for this elasticity range between 0.2 and 1.58[8]. Values for the parameters are calibrated for different price elasticities within this range.

Epple and Romano (1996) fit the data of the U.S. in 1989 to an analogous model. They assume anti-child work laws are enforceable, so there is no exit from the public system through the left hand side of the distribution. They use mean and median income per household and the average expenditure per student in U.S public schools to obtain the empiric range of ρ and δ. The method used is similar to the previous one: the

[7] They obtain the implied demand for education of a public school user $\hat{E}$ maximizing utility subject to a budget constraint $y = pE + c$ with $p = \tau Y/E$. For further information see Gutiérrez and Tanaka (2009).
[8] See Shapiro and Rubinsfeld (1989), Ahlin and Johansson (2001) and Gertler (1990)

authors use the conditions for majority voting and different values of price elasticity to define the problem.

With these parameters determined it is possible to solve the problem numerically. Empirical estimates are consistent with SRI[9], so the results presented are obtained under the assumption that SRI holds. This follows Gutiérrez and Tanaka (2009) and Bearse et al. (2000). The results under SDI are reported in Appendix 1.

4.1 Flat tax and mixed system

Figure 1 illustrates the results obtained under SRI ($\rho = 1.5$) for different levels of inequality. The problem was solved for different levels of income inequality measured by the Gini coefficient maintaining the mean income constant to ensure effects are only driven by inequality. Results in the case child work bans are completely enforceable are included for comparison. Robustness checks for other values of the parameters show no significant differences in results. The magnitude of the values of different variables change, but tendencies and differences between regimes persists.

The equilibrium tax rate decreases with income inequality. This is mainly due to the stronger substitution effect ($\rho > 1$) of the tax and the fact that pivotal voter's income decreases with inequality, as more parents exit the public system and median income decreases if mean income is preserved. For low levels of inequality, child work is close to zero, and results do not differ from previous models with enforceable bans. When inequality rises, more households opt for labor, and child work rates rise. The lower public school enrolment rate (N)[10] explains the higher expenditure per student (E) and the lower equilibrium tax rate (τ) when child work is an option. Higher expenditures per student explain lower private school enrolment rates, as the quality received in the public system is better, and the opportunity cost of exiting the public system is higher.

Still, tax rates and expenditure per student decrease. Child work rates rise due to lower expenditures per student, raising the opportunity cost of sending children to school, and higher mass of households with an income under the threshold level $\underline{y}$ due

[9] See Ahlin and Johanson (2001), Bergstrom et al. (1982), Denzau and Grier (1984), Fernández and Rogerson (2003), Shapiro and Rubinsfeld (1989) and Singh and Santiago (1997)

[10] Although the graph is not included, the result is straightforward from the graphs in Figure 1: private school enrolment rate, child work rate and public school enrolment rate add up to 1.

to inequality. The same mechanism explains the shape of the curve for private school enrolment rate. Thus, the enrolment rates in public schools decrease. For inequality levels over 0.77 in the Gini Index there is no longer support for the public system with the chosen values for the parameters, as a share of 50% of the households opt for private schooling or labor.

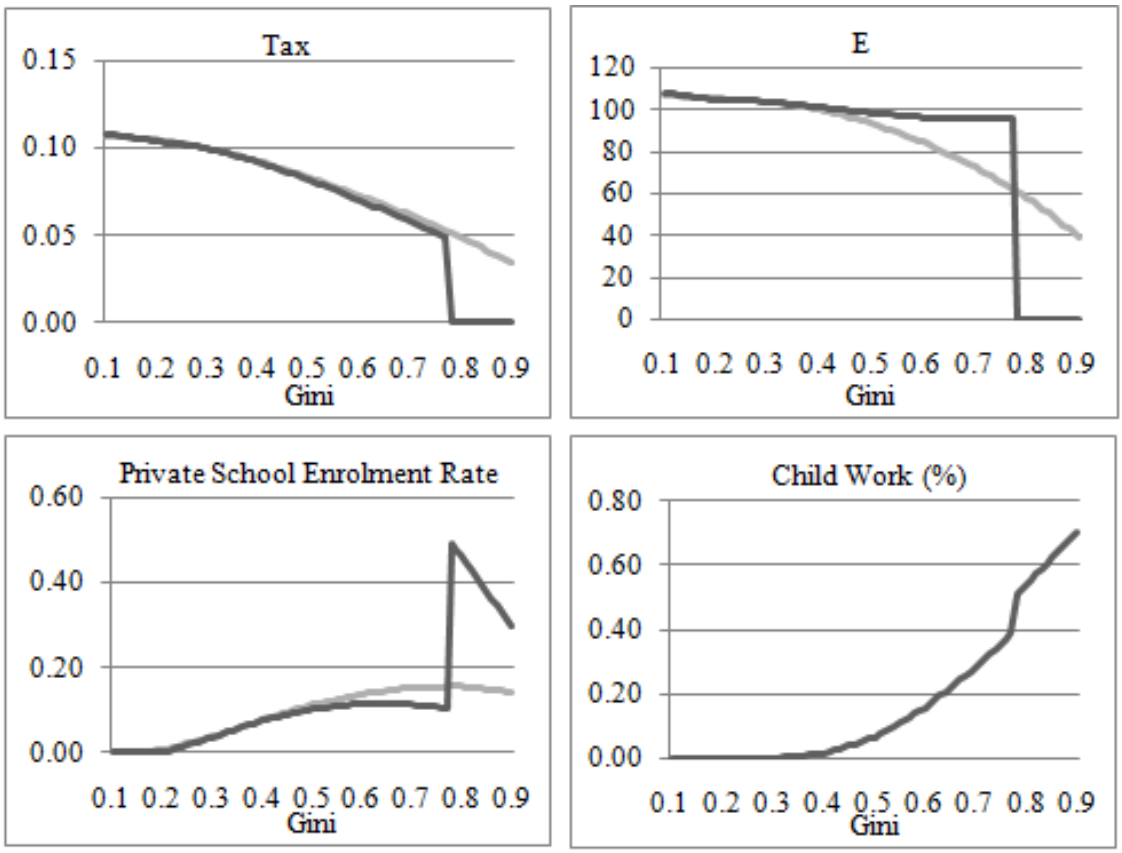

Figure 1. The graphs show the equilibrium of the mixed system for different levels of inequality measured through the Gini coefficient. $\boldsymbol{Y = 1000}$, $\boldsymbol{w = 75}$, $\boldsymbol{b = 4}$, $\boldsymbol{\delta = 0.04}$ and $\boldsymbol{\rho = 1.5}$. The results for the case where child work bans are enforceable are included in grey.

4.2 Flat tax and means-tested vouchers

The results for the case where public funding is provided through mean-tested vouchers are summarized in Figure 2. As in the previous case, robustness checks show no significant difference in the results. Magnitudes of values of equilibrium tax rates, vouchers, and child work differ when values of parameters change, but tendencies and differences between regimes remain the same.

As in the mixed regime, the equilibrium tax rate decreases with income inequality due to a stronger substitution effect. If the substitution effect generated by the tax is stronger than the income effect, the preferred tax increases with income. Pivotal voter's income decreases, as under inequality more households receive a voucher equal to zero and median income declines with inequality as mean income is held constant.

The amount of parents who send their child to work, and those with income $y > \alpha/\beta$ rises with inequality. For low levels, the rate of child work is approximately zero. Hence allowing exit of the schooling system through the left hand side of the income distribution does not alter the results considerably. For higher levels, more households opt out the public funded system and the difference between equilibrium tax rates increases.

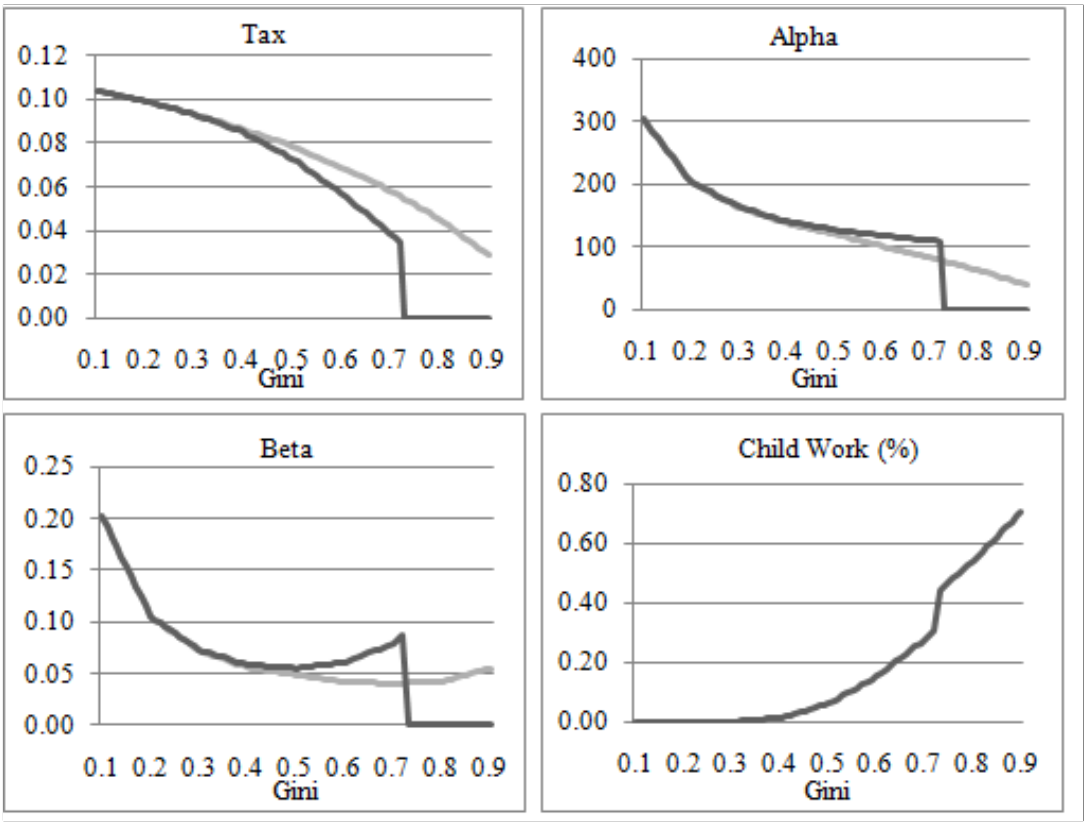

Figure 2. The graphs show the results of the mean-tested voucher system for different levels of inequality measured through the Gini Index. $\boldsymbol{Y = 1000}$, $\boldsymbol{w = 75}$, $\boldsymbol{b = 4}$, $\boldsymbol{\delta = 0.04}$ and $\boldsymbol{\rho = 1.5}$. The results for the case where child work bans are enforceable are included in grey.

The two stage voting problem determines the optimal β. In the first stage, higher inequality implies a lower tax rate, and a lower β that satisfies the government's budget constraint. In the second stage, higher inequality implies median voter's income is lower, so the equilibrium β is higher. This two opposing effects explain the "U" shape seen in Figure 2. The decreasing rate lowers with inequality, and around a Gini Index equal to 0.5 β starts increasing. When child labor is allowed, the turning point is lower as the budget effect is smaller than in the other case. The declining of α is easily explained through the budget constraint: if the total tax collection decreases, and β does not increase enough, α must decrease.

Child work increases with inequality due to a lower opportunity cost of sending a child to school[11] and a higher mass of households with an income lower than the threshold level $\underline{y}$. As in the previous case, the option to opt out of the educational system is used by more families as the voucher they receive declines, and there is no longer support for the mean tested voucher for a Gini higher than 0.72 for the parameters chosen.

The results show an important effect of child work on the equilibrium tax rates, average spending per student and support of the funding system. Therefore, in line with Gutiérrez and Tanaka's (2009) findings, two important conclusions can be drawn: enforcing child work bans pays off, and external aid must consider children usually have the option to work in developing countries. Rising funds externally to the system and increasing vouchers will just generate a crowding-out effect, and equilibrium tax rates will decrease almost in the same amount. On the other hand, if the same amount of money is given as a grant to households who chose work over schooling, compensating them for the lost salary, the final result of the measure will be closer to the one expected: more children will attend school and future opportunities will be more equal.

In the following section, both schemes are compared to determine which one is more eligible to mitigate these effects.

5. Comparing Funding Schemes

Once the basic problem is solved, it is possible to compare both funding schemes. To ease the discussion, both schemes are presented graphically in Figures 3 and 4.

The black line in Figure 3 represents the total expenditure in education under a mean-tested voucher scheme. The grey line represents the total expenditure in a mixed regime. The grey area behind represents the lognormal distribution: the probability of having an income equal to y is the height of the grey area. The expenditure per student is higher under the first scheme almost for every income level and strictly higher for the

[11] The voucher received by households with income equal to the threshold income $\underline{y}$ is lower, as α is lower.

pivotal voter (0-2% higher). The threshold level $\underline{y}$ is higher in the former, as the opportunity cost of schooling is lower[12] for every level.

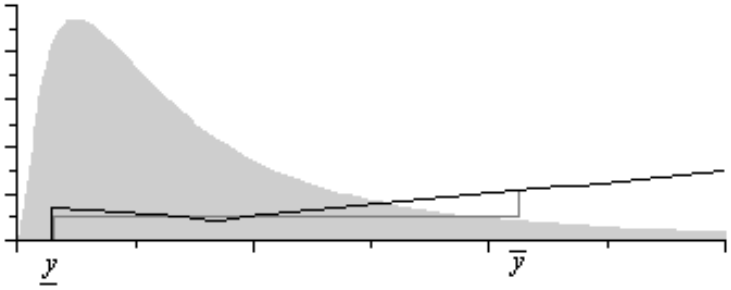

Figure 3. In black we can see the amount of money spent in education (private and public) by level of income under mean-tested vouchers. In grey we see the amount of money spent in education under a mixed system. Both lines converge over $\overline{y}$. The light grey curve represents population density for every income level, characterized by a lognormal distribution.

The contributions to this spending are both private and public. Figure 4 shows how this contribution is shared. The area in dark grey represents public spending in education, and the one in light grey is the private contribution. The graph on the left represents the mixed system, and the one on the right the mean-tested voucher scheme.

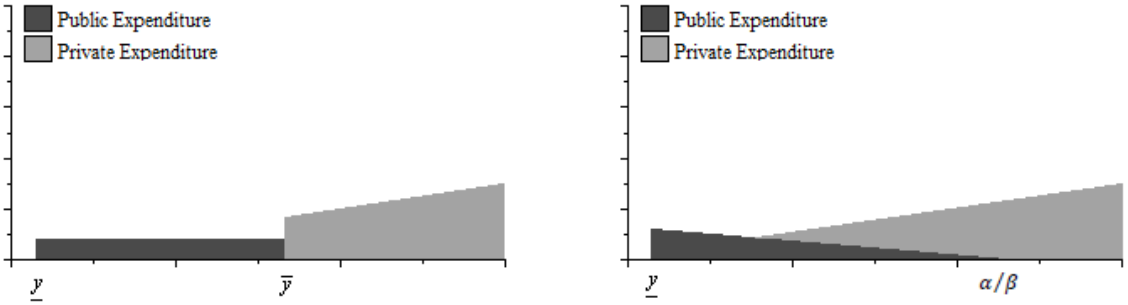

Figure 4. The area in dark grey represents the public expenditure in education, and the light grey area the private spending. The graph on left hand represents the mixed system, and on right hand, the mean-tested vouchers.

Under a mixed system, parents with an income $y < \underline{y}^{mix}$ send their child to work, and education expenditure is zero. If income rises above this threshold level, children are sent to school. For $\underline{y}^{mix} < y < \overline{y}^{mix}$ the education received is equal to *E,* in free public schools. As parents cannot supplement the educational level received in the public system, it is not possible for them to choose the preferred educational level. For income levels higher than $\overline{y}^{mix}$ this restriction is too binding, and parents opt out

[12] $E < v\left(\underline{y}, \alpha, \beta\right)$ for every income inequality level.

the public system for the private alternative. The level of expenditure rises non-continuously at this point: opting out implies giving up E, and financing the whole tuition with out-of-pocket spending.

In a mean-tested vouchers system, $y < \underline{y}^{mt}$ again is too low to overcome the opportunity cost of studying and children are sent to work. When income rises over this threshold level, the child is sent to school. In addition, when the desired level of education is higher than the received voucher, parents supplement to obtain the optimal level. Lifting the non-supplementation restriction allows educational expenditures to rise continuously for income levels $y > \frac{\alpha}{\beta+\delta^{1/\rho}(1-\tau)}$ [13]. Spendings rise linearly with income since the utility function has a constant elasticity of substitution between consumption and child's human capital.

Intuitively one might think that the necessary budget to finance the mean-tested vouchers regime is smaller. Comparing equilibrium tax rates will confirm which scheme is cheaper in these terms.

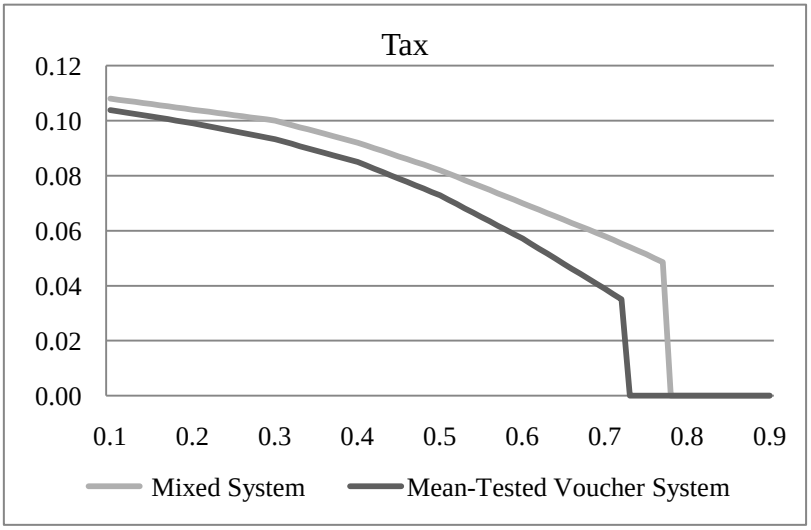

Figure 5. The graph compares the equilibrium tax rate under both funding schemes. The dark line represents the mean-tested scheme and the grey one the mixed system. $\boldsymbol{Y = 1000}$, $\boldsymbol{w = 75}$, $\boldsymbol{b = 4}$, $\boldsymbol{\delta = 0.04}$ and $\boldsymbol{\rho = 1.5}$.

Figure 5 shows optimal taxes under both regimes. Mean-tested vouchers regime is cheaper and less distortive than the mixed system. Allowing supplementation lowers the burden on the government, as it is now shared with households. Furthermore, tax

[13] See equation (17). For $y = \frac{\alpha}{\beta+\delta^{1/\rho}(1-\tau)}$ households are indifferent between supplementing the voucher received or not.

rates decline at a lower rate under the former case. The optimal β decreases at a lower rate as inequality rises, even increasing for sufficiently high levels. α/β decreases for levels of inequality higher than 0.4, decreasing the necessary budget to cover the total funding of the system. This effect and the stronger substitution effect explain why the rate of decline is higher under the mean-tested voucher regime.

A lower tax rate could imply a lower average expenditure per student[14]. Allowing supplementation from the parents makes the later untrue. Parents pay for the difference with out-of-pocket spending, and the average expenditure per student is higher. This can be seen in Figure 6.

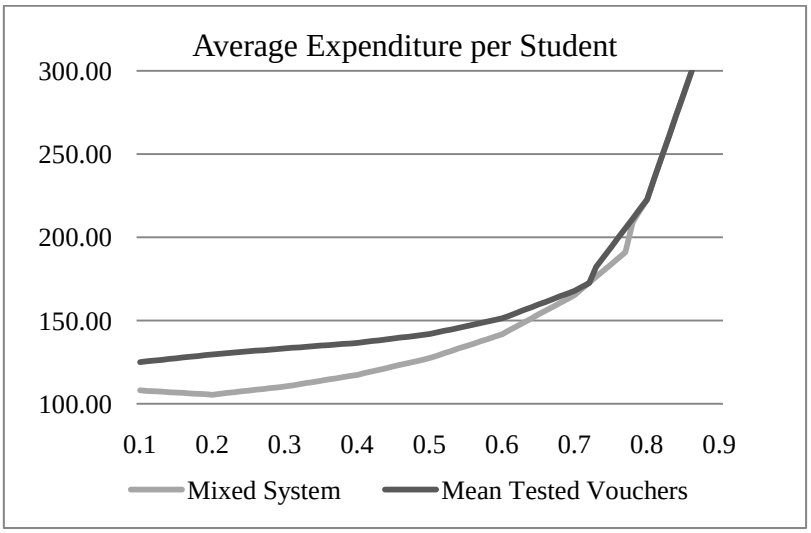

Figure 6. The graph compares the average expenditure per student under both funding schemes. The dark line represents the mean-tested scheme and the grey one the mixed system. $\boldsymbol{Y = 1000}$, $\boldsymbol{w = 75}$, $\boldsymbol{b = 4}$, $\boldsymbol{\delta = 0.04}$ and $\boldsymbol{\rho = 1.5}$. Both lines converge when there is no longer support for public funding.

The increasing difference in taxes explains the decreasing difference between average education expenditure in both cases. A lower fiscal contribution affects the total spending in education.

The effects of inequality on the percentage of child work are summarized in Table 2. Under the mean-tested system child work is lower. The reason for this can be found in opportunity costs of working. The funding provided by this system is higher

[14] Average expenditure per student is calculated adding the spendings in formal education for each income level y weighted by the probability density function divided by the percentage of children attending school (public or private). As total mass of households is normalized to 1, total spendings are equal to average expenditures per student.

for income levels close to the threshold level. This explains why $\underline{y}^{mt} < \underline{y}^{mix}$ for every inequality level and child work rates are lower.

	Child Work (%)	
Gini	**Mixed System**	**Mean-Tested Vouchers**
0.1	0%	0%
0.2	0%	0%
0.3	0.07%	0.05%
0.4	1.5%	1.3%
0.5	6.6%	6.1%
0.6	15.7%	15.2%
0.7	28.2%	27.6%

Table 2. The table compares the percentage of children working under both funding schemes for different levels of income inequality measured through the Gini Index. $\boldsymbol{Y = 1000}$, $\boldsymbol{w = 75}$, $\boldsymbol{b = 4}$, $\boldsymbol{\delta = 0.04}$ and $\boldsymbol{\rho = 1.5}$. Over the values in the table there is no longer support for public funding, and values rise and converge.

The mixed system has political support for higher levels of inequality than mean-tested vouchers. On one hand, $\underline{y}^{mix} > \underline{y}^{mt}$, so the percentage of households exiting the system through the left side of the distribution is higher for the former system. On the other hand, for sufficiently high levels of inequality $\overline{y}^{mix} > \alpha/\beta$, and the mass of households exiting the system through the right hand side of the income distribution is larger. The mean-tested voucher scheme collapses faster, as 50% of the population receives a voucher equal to zero for lower levels of inequality.

In order to allow for a thorough comparison, the inequality in education expenditures has to be taken into account. The Gini Index for spending in education is summarized in Table 3. Mixed systems generate lower inequality than voucher schemes. On one hand, mean-tested vouchers allow higher levels of redistribution, making inequality of education lower. On the other hand, the system allows parents to supplement the voucher they receive, making inequality in education higher**.** The option of child work makes inequality higher in every case, as the "labor force" has no formal education at all. The difference is zero for low levels of inequality, as school attendance is complete.

Inequality in expenditures in education, holding everything else constant, might reduce inequality in the future. The model is static, and therefore fails to internalize subsequent periods, but if income earned by an agent depends positively on the human capital he has accumulated through his life, the model shows that public funding of schooling equalizes opportunities. Higher equality in education today might turn out in lower income inequality in the future. Nevertheless, we must recall that almost every child receives a higher education, and the voucher received by low-income households is higher under a mean-tested voucher regime. The lower inequality generated by the mixed system is also caused by the lower but constant expenditure in education in the public system, therefore, not necessarily better for the economy.

	Gini of Expenditures in Education			
	With Child Work		**Without Child Work**	
Income Gini	**Mixed System**	**Mean-Tested Vouchers**	**Mixed System**	**Mean-Tested Vouchers**
0.1	0	**0.07**	0	0.07
0.2	0.01	**0.09**	0.01	0.09
0.3	0.06	**0.13**	0.06	0.12
0.4	0.14	**0.20**	0.13	0.18
0.5	0.26	**0.30**	0.22	0.25
0.6	0.40	**0.43**	0.31	0.32
0.7	0.55	**0.59**	0.40	0.42
0.8	0.85	0.85	0.52	0.53
0.9	0.93	0.93	0.66	0.68

Table 3. The table compares inequality in educational expenditures under different funding schemes for different levels of income inequality measured through the Gini Index. The values for the case with enforceable child work bans are included for comparison. $\boldsymbol{Y = 1000}, \boldsymbol{w = 75}, \ \boldsymbol{b = 4}, \boldsymbol{\delta = 0.04}$ and $\boldsymbol{\rho = 1.5}$. The highest inequality is highlighted in black.

Finally, it is possible to compare the total welfare under both schemes. As mean-tested vouchers are more redistributive and allow supplementation, letting more parents choose the optimal level of education, this system translates into higher total welfare for every level of income inequality.

Under a mixed system the economy obtains a lower level of utility than under a voucher system. To obtain the same level of total welfare with the mixed system, the

government should raise its budget in about 2-10.5% without increasing taxes[15]. The percentages are summarized per level of income inequality in Table 4.

Gini	Raise in Fiscal Budget
0.1	1.88%
0.2	7.19%
0.3	9.57%
0.4	9.57%
0.5	9.87%
0.6	10.47%
0.7	8.79%

Table 4. Under a mixed system, the fiscal budget should rise in the percentage showed in the table to leave families with the same utility level they obtain with a mean-tested voucher scheme. $\boldsymbol{Y = 1000}$, $\boldsymbol{w = 75}$, $\boldsymbol{b = 4}$, $\boldsymbol{\delta = 0.04}$ and $\boldsymbol{\rho = 1.5}$

When comparing individual welfare, the utility under mean-tested vouchers is not higher for every agent. Households which opted out the public system under a mixed system are better, as tax rates are lower, as well as the ones who receive a voucher higher than E. Those who receive a lower voucher are better off if the non-supplementation restriction was binding enough, and if not they are worse off, as they have to pay for their offsprings education now.

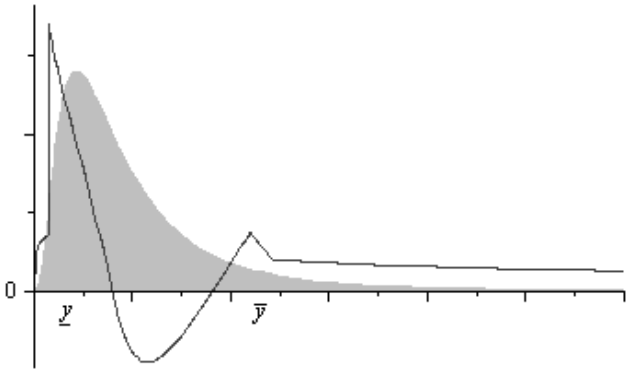

Figure 7. The dark line represents the difference between utility under a mean-tested voucher and a mixed scheme for different levels of income. In grey, the population density for each level. $\boldsymbol{Y = 1000}$, $\boldsymbol{w = 75}$, $\boldsymbol{b = 4}$, $\boldsymbol{\delta = 0.04}$, $\boldsymbol{Gini = 0.4}$ and $\boldsymbol{\rho = 1.5}$.

[15] Results are obtained finding the necessary $\tilde{E}$ to obtain the same total welfare level both systems, fixing the welfare level obtained under a mean-tested voucher regime. The total budget will be $N \cdot \tilde{E}$, and the raise in fiscal budget in percentage is equal to $N \cdot \tilde{E} / \tau^{mix} \cdot Y$.

Figure 7 plots the difference between the utility under a mean-tested voucher and a mixed scheme to income level y. As explained above, for low and high levels of income the difference is positive, and households prefer the first funding scheme. The difference turns negative in the middle, as households receive a smaller voucher from the government and have to supplement with out-of-pocket spending.

If households have to choose between both systems, they would elect the mean-tested voucher scheme, as the percentage of households better off under this regime is larger than 50% for every income level. Table 5 resumes the percentage of households better off under a mean-tested voucher scheme for every level of income inequality.

Gini	% of households better off
0.1	53.4%
0.2	56.5%
0.3	59.8%
0.4	64.9%
0.5	67.5%
0.6	68.4%
0.7	69.4%

Table 5. Percentage of households better under a mean-tested voucher scheme, compared to a mixed system by level of inequality. $\boldsymbol{Y = 1000}$, $\boldsymbol{w = 75}$, $\boldsymbol{b = 4}$, $\boldsymbol{\delta = 0.04}$ and $\boldsymbol{\rho = 1.5}$

It can be stated that the majority is better off, and that a change from a mixed system to a mean-tested vouchers scheme is optimum in a kaldorian sense, as the total utility gained by those who win is higher than the utility lost by those who loose. Anyways, the policy will never be Pareto optimal.

A switch from a mixed system to a mean-tested voucher scheme when child labor bans are not enforceable is welfare enhancing for almost every household, and will have political support for every level of inequality. Child work and equilibrium tax rates are lower for the former and average expenditure per student and total welfare is higher. However, inequality in educational expenditures, and the future income inequality is lower under a mixed system, and there is enough political support for the financing tax under higher levels of inequality for the later.

6. Conclusions

The purpose of this paper is to understand how inequality and child work affect education, and which funding scheme is more appropriate under high levels of inequality. The paper presents a theoretical model, in which education funding is determined through majority voting. Schools have the same productivity and child work bans are not enforceable. Previous literature[16] had assumed child labor as inexistent, assumption quite unrealistic in developing countries. Gutierrez and Tanaka (2009) include this option for the first time, and show inequality does affect educational outcomes. They solve the model under a mixed system. In this paper, the model is solved for a mixed system and a mean-tested voucher regime, to compare the results under both funding schemes. Although the model is highly stylized, it does shed some light on the questions underlying the correct policy design of education funding schemes. Results presented in the text depend on the parameterization, but robustness checks show that tendencies and differences between schemes persist under different values of child wages, informal education, and preferences.

In terms of financing, the theoretical findings suggest mean-tested vouchers and child work bans enforcement. When funding is determined through majority voting, child work lowers both tax rates and funds devoted to education. For sufficiently high levels of inequality, there is no longer support for the public system independent from the chosen funding scheme. Banning child labor and stricter enforcement of the law might not be optimal at an individual level, but it seems to be at an aggregate one. In case the latter is not feasible, giving grants to the families who prefer work to school might do the trick. Devoting more resources to the public funding program will just reduce optimal tax while it will not change child work rates significantly.

A mean-tested voucher regime is less distortive, generates lower rates of child work, average expenditure per student is higher, and is preferred by households for any level of inequality. Despite this, a mixed system has political support under higher levels of inequality, and is preferable for certain levels, depending on child wages, education acquired with no formal instruction and preferences over consumption and human capital.

[16] See Glom and Ravikumar (1998), Epple and Romano (1996) and Bearse et al. (2000).

The current paper also leaves some questions unanswered. Altering some assumptions might give a deeper understanding of the problem. Productivity typically differs among schools, especially between private and public schooling in developing countries. Progressive taxation is less distortive and more redistributive. Families do not have the same preferences and the design of a subsidy for those who choose child work might generate moral hazard and several inefficiencies. These questions present interesting future research directions.

7. Appendix

Results under SDI

Flat tax and free Public System

The results obtained under SDI ($\rho = 0.8$) can be summarized in the following graphs.

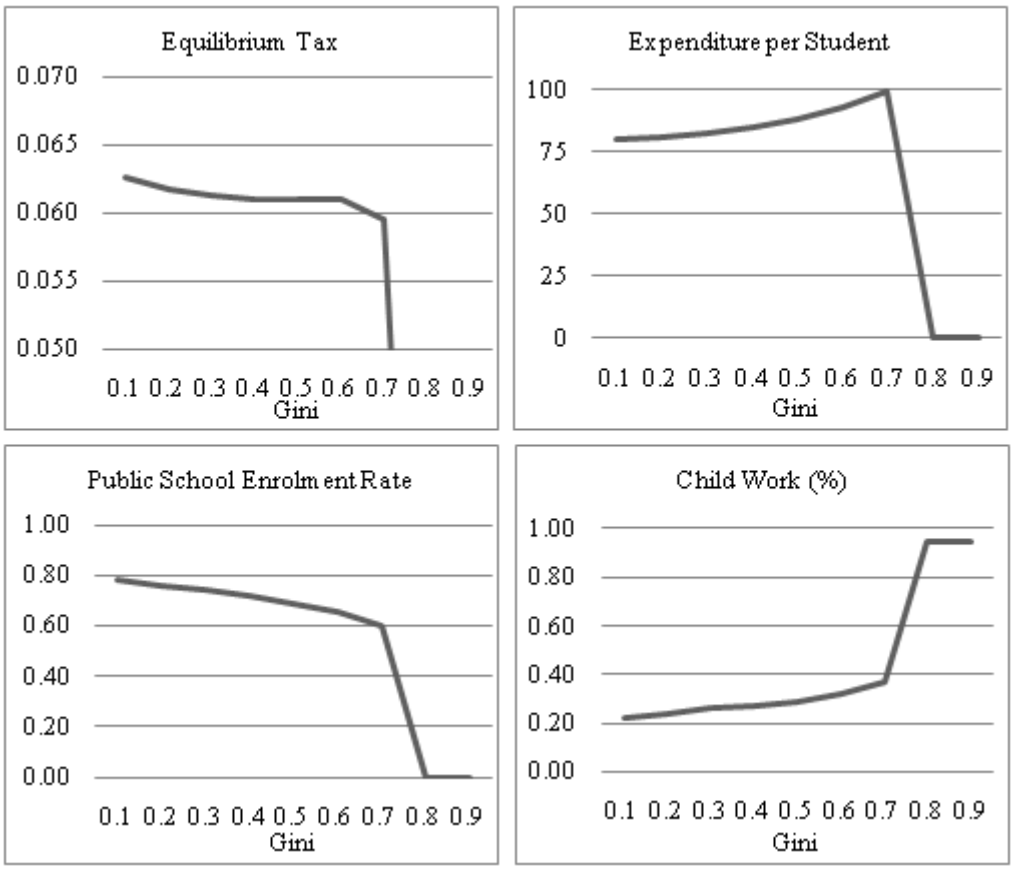

Figure 8. The graphs show the equilibrium of the mixed system for different levels of inequality measured through the Gini coefficient. $\boldsymbol{Y = 1000}$, $\boldsymbol{w = 75}$, $\boldsymbol{b = 4}$, $\boldsymbol{\delta = 0.04}$.

Flat tax and means-tested vouchers

The results obtained under SDI ($\boldsymbol{\rho = 0.8}$) can be summarized in the following graphs.

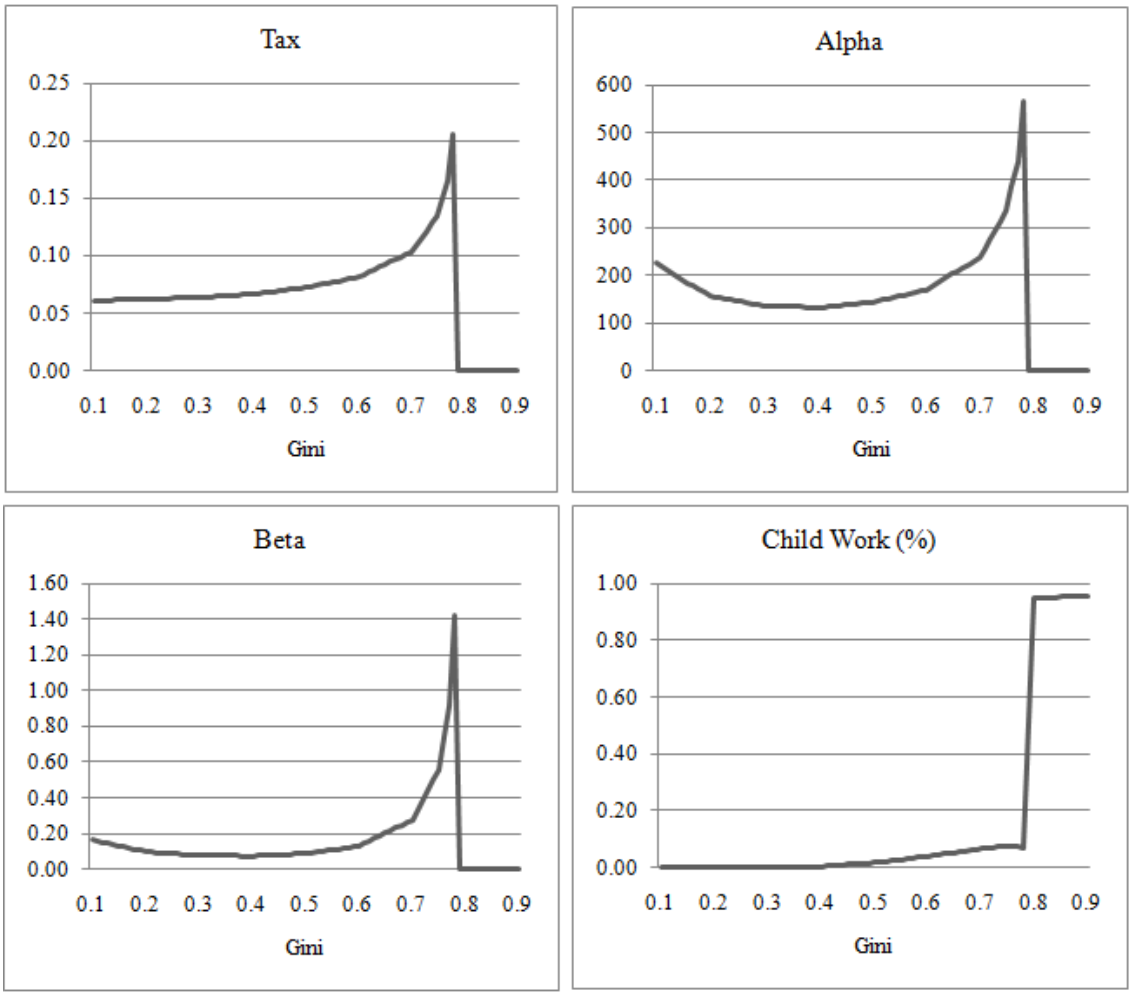

Figure 9. The graphs show the equilibrium of the mean-tested voucher for different levels of inequality measured through the Gini coefficient. $\boldsymbol{Y = 1000}$, $\boldsymbol{w = 75}$, $\boldsymbol{b = 4}$, $\boldsymbol{\delta = 0.04}$.

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