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Why does education expenditure differ across countries? The role of income inequality, human capital and the inclusiveness of education systems**

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Abstract: This paper provides a simple model of hierarchical education to study the political determinants of the public education budget and its allocation between different stages of education (basic and advanced). The model integrates private education decisions by allowing parents, who are differentiated according to income and human capital, to opt out of the public system and enrol their offspring at private universities. Majority voting decides the size of the budget allocated to education and the expenditure composition. The model exhibits a potential for multiple equilibria and 'low education' traps. Income inequality, the distribution of the adult population's human capital and the inclusiveness of the education system play a fundamental role in deciding the equilibrium public education budget and its allocation between different tiers of education. The main predictions of the theory are broadly consistent with cross-country evidence collected for OECD countries and help to explain why some OECD countries, such as Italy, seem to remain stuck in a 'low education' equilibrium.

Keywords: Education Funding, Political Economy, Majority Voting, Opting Out, Income Inequality, Redistribution.
JEL codes: H23, H26, H42, H52, I28.

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1. Introduction

Why does education expenditure substantially differ among developed countries? Not only does the proportion of GDP devoted to education vary but also the type of financing (public vs. private) and education expenditure allocation across hierarchical stages (primary/secondary vs. tertiary). This study endeavours to provide a positive theory of education spending by integrating the political determination of public education funding and its allocation between different stages of education with households' private education decisions. We adopt a political economy approach, recognising that public education funding and the allocation of the public budget across education stages is the result of the interaction of market forces and political decisions involving groups with conflicting preferences. Against this background, our research questions are fourfold. What is the majority-preferred level of funding for public education when private options for advanced education are available? What is the majority-preferred allocation of public funds across educational tiers? How do income inequality and households' heterogeneity in human capital affect political equilibrium? How do features of the education system, such as inclusiveness, influence the political equilibrium?

The public provision of education is usually justified as a means of in kind income redistribution. Accordingly, households' position on the income ladder should determine conflicting preferences for public investment in education, and in majority voting settings, substantial income inequality should create strong support for public education.[1] However, empirical evidence does not fully support these predictions. Benabou (1997) and Soares (1998) demonstrated that more unequal and more heterogeneous societies spend less on public goods. De la Croix and Doepke (2009) focused on education expenditures for primary and secondary schools, finding that average public funding is lower in countries with higher income inequality. In addition, regression results have demonstrated that societies that are more unequal tend to spend comparatively more on higher levels of education,

[1] For example, see Saint-Paul and Verdier (1993), Gradstein and Justman (1997) and Epple and Romano (1996a).

revealing a less redistributive way of spending (Zhang, 2008). Analogous results were found for developing countries (Birdsall, 1996; Gradstein, 2003).

The point made in this paper is that to address the political economy of public education funding, the hierarchical nature of the education process must be explicitly recognised. Tertiary education is very different from K-12 education: first, it is not mandatory, and most importantly, access is generally not universal. The level of educational attainment during the first stage rations the participation in the second stage, generating an endogenous participation constraint that is stricter for children from households of lower socioeconomic status.[2] The same applies to the college drop-out phenomenon. The importance of the family background in withdrawal decisions has been well documented in the literature, indicating that students with low educated parents have a higher probability of dropping out of college compared to those with graduate parents.[3] Thus, not only the size but also the composition of public spending across educational tiers is a critical policy issue.

The majority of the theoretical literature on the political economy of education funding (see Glomm et al., 2011) has assumed a single type of education or focused on the political economy of spending on a particular stage, such as higher education.[4] However, some recent works have begun to model the hierarchical nature of education applying explicit two-stage technology. In these models, the skills acquired during the first stage of education are used as inputs in the production of higher education.[5] This framework includes the research of Blankenau et al. (2007), Viane and Zilcha (2013), Naito and Nishida (2017), Romero (2009) and Sue (2006). Our model builds on these contributions, but in

[2] See Glomm and Ravikumar, (1992, 2003). In addition, empirical evidence has demonstrated that even when education fully relies on public funding, children from families with a lower socioeconomic status have lower enrolment rates at higher levels of education. See De Fraja (2004) and Cunha and Heckman (2007). See Lagravinese et al. (2020) for recent evidence of the effect of economic, social and cultural status on educational performance.

[3] For example, see Aina (2005), who found that ‘poor’ family environment in Italy affects the probability of enrolling at university as well as the probability of dropping out. See also Aina et al. (2021) for a review of the socioeconomic literature on drop-out rates.

[4] For example, see Fernandez and Rogerson (1995), Beviá and Iturbe-Ormaetxe (2002), Levy (2005), De la Croix and Doepke (2009), Gradstein and Justman (2004), Di Gioacchino and Sabani (2009), Haupt (2012), Arcalean and Schiopu (2016), Lasraman and Laussel (2019) and Hatsor and Zilcha (2021).

[5] Considering the hierarchical nature of the education process, Su (2004), Restuccia and Urria (2004), Arcalean and Schiopu (2010) and Sarid (2017) examined how exogenous policy changes in different education sectors affect economic growth and aggregate welfare.

contrast, we also integrate private education decisions by allowing parents to opt out of the public system and enrol their offspring in private universities. The opting out decision is modelled referencing the voting models of De la Croix and Doepke (2009) and Arcalean and Schiopu (2016); however, rather than the probabilistic voting framework used in these studies, we use the median voter approach as in Romero (2009) and Naito and Nishida (2017).

We develop a two-period economy model, in which households consist of one parent and one child and are differentiated according to parents' income and human capital. Children are educated in a hierarchical schooling system that features two levels of education, including the lower level (K-12), which is mandatory and exclusively funded by the government, and the higher level (tertiary education), which can be funded either privately or publicly. For simplicity, we assume that access to tertiary education is universal, but the probability of dropping out of college is influenced by parental human capital.[6] However, the importance of family background on children's performance at university can be mitigated by the education system design. Inclusive school systems featuring a relatively even standard of basic education and few possibilities for schools to select pupils could dampen the relative importance of inherited human capital in educational attainments.[7] Accordingly, we assume that the share of children who complete the tertiary education cycle is determined by the initial distribution of human capital in the adult population and by the education system design.

In our model, majority voting determines the size of the budget allocated to education and the expenditure composition. Affluent parents may find public funding of tertiary education insufficient; in which case, they opt out of the public system and enrol their children in a private university. This feature endogenously separates public and private university students according to household income.

[6] This assumption simplifies analytical complexity but does not qualitatively affect the results; rather, the latter would be strengthened by introducing non-universal university access.

[7] The features of an inclusive education system are a high degree of program comprehensiveness, a relatively even standard of education, a low percentage of private schools and limited possibilities for schools to select their pupils. In contrast, low inclusiveness features include formal differentiation (students are separated by ability through early tracking) and/or informal differentiation (socioeconomic segregation among schools).

Finally, we assume that private education expenditures are tax deductible. This assumption is a feature observed in many OECD countries and is a driver of some of the results.

The model exhibits a potential for multiple equilibria and 'low education' traps. If households anticipate a low level of public spending on tertiary education, affluent families will opt out of the public system and the public budget will be reduced due to the tax deductibility of private education expenditure. The economy falls into a self-reinforcing 'vicious circle' with low levels of public spending confirming initial expectations (self-fulfilling prophecies). Other key results suggest that public education spending and its allocation between different education tiers are affected by income inequality and the inclusiveness of the education system.

The contributions of this study are relevant from political and theoretical perspectives. From the political side, because of the significant involvement of governments in the education sector, understanding the political economy constraints of public education policy is crucial. Theoretically, our study helps explain the documented differences in education expenditure across OECD countries. Specifically, the role of agents' expectations in the multiplicity-of-equilibria result may explain the observed persistence of different education regimes and why some countries, such as Italy, seem to remain stuck in a 'low education' equilibrium. Furthermore, the study results could explain trends in education policy within a country over time.

The remainder of this paper is organised as follows. Section 2 presents descriptive evidence regarding education expenditure in OECD countries. Section 3 illustrates our theoretical model, and section 4 demonstrates that the model's results are broadly consistent with cross-country evidence collected on OECD countries. Finally, section 5 concludes and highlights policy implications.

2. Stylised facts

In this section, we illustrate OECD countries' heterogeneity regarding education expenditure (levels and composition) and sources of education financing (private vs. public) in 2016.[8] Figure 1 presents education expenditure as a share of GDP and its private and public funding composition. On average, the share of GDP devoted to education in 2016 was 5%, ranging from low values in the Czech Republic (3.4%), Italy (3.6%) and Greece (3.6 %), up to 6.5% in Norway and Denmark. In terms of composition 17% of education expenditure was from private funding, on average, with the highest values in Chile (37%), the United States (32%), the United Kingdom (32%), Australia (32%), Japan (29%) and South Korea (29%). At the other extreme, in Nordic countries, education expenditure was almost entirely financed with public funds.[9]

Figure 1. Public and private education expenditure, % of GDP.

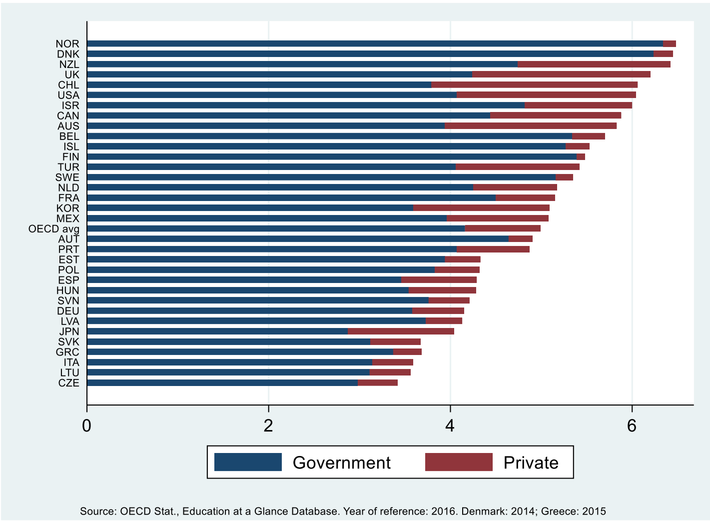


Figure 1 and the additional data summarised in Appendix 1 demonstrate the substantial variability in education expenditure and significant differences in the source of funding among OECD countries. All Nordic and some continental European countries (e.g. Austria, Belgium and France) are high spenders, primarily using public funds. Anglo-Saxon countries (Australia, the United Kingdom, the

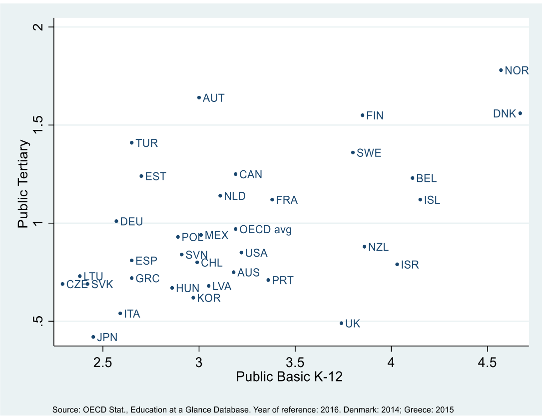
[8] Unless otherwise stated, data are from OECD (2019) and from http://stats.oecd.org/. Tables A1(a) and A1(b) in Appendix 1 summarise the variables used in this section.

[9] We do not consider Luxembourg and Ireland because they are outliers in terms of GDP. In the case of Ireland, GDP is not a satisfactory measure of the country's income because of the large income outflow (in 2015, Ireland's GDP was over 150% of its GNI). We also exclude Switzerland because data on private expenditure is missing over the period 2010–2016.

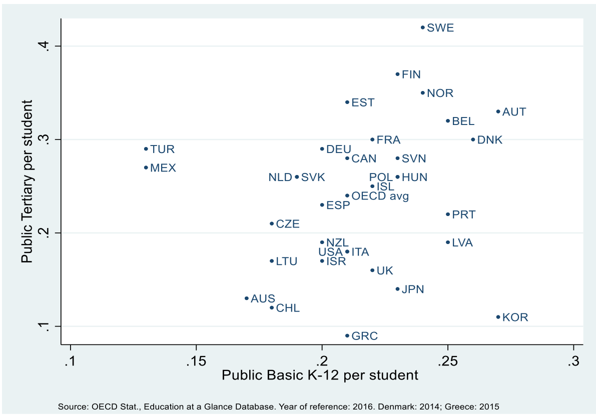
United States and New Zealand), Chile, South Korea and Japan are high spenders in terms of spending per student, but with a relevant share of private funding (above 29% of total spending, on average). Finally, countries such as the Czech Republic, Greece, Italy, Lithuania and Slovakia are low spenders in terms of both funding sources.

Figure 2 presents the allocation of public expenditure on basic and tertiary education, measuring public expenditure as a share of GDP and public expenditure per student as a share of GDP per capita (panels *a* and *b*, respectively).[10] A positive relationship is observed between public spending on the two tiers of education: countries spending more on basic education also tend to spend more on tertiary education. Moreover, high private spenders tend to concentrate public spending on basic education (e.g. the United Kingdom), which is expected because private spending is concentrated on tertiary education. High public spenders (e.g. Nordic countries, France, Belgium and Austria) tend to either have a balanced composition or be slightly biased towards tertiary education. Low spenders, particularly low public spenders, are biased towards basic education. The exceptions are Turkey and Mexico, which are biased towards tertiary education.

Figure 2. Public spending on basic versus tertiary education



Panel a: expenditure as % of GDP



Panel b: expenditure per student as % of GDP per capita

[10] Compared with panel a, panel b also considers the amount of the student population; thus, indirectly, the demographic structure and length of compulsory education periods. Furthermore, spending per student is sometimes considered a proxy for education quality (for example, see De la Croix and Doepke, 2009). An open question is which variable should be considered when investigating political preferences for education spending. For example, in Japan, education spending is extremely low if considered as a share of GDP, but less so when examining per capita values, particularly those from private funding. Another example is Israel, where education expenditure as a share of GDP is high (almost 6%), but public spending per student as a share of GDP per capita is relatively low.

To examine the composition of public spending more deeply, in Tables A1(a) and A1(b) in Appendix 1, we have computed a 'public tertiary bias' index for each country, comparing the ratio of tertiary to basic public spending with the OECD average ratio. A value of the index greater (smaller) than 1 suggests that a country is biased towards tertiary (basic) education. The values of this index confirm our analysis.

In summary, the evidence presented in this section highlights the existence of four education models (see Di Gioacchino et al., 2022). In the first model, education spending is high, almost entirely financed by public funds, and the budget is balanced between the two tiers of education. In the second model, education spending is high, but a large part, which is primarily at the tertiary level, is financed by private funds. In the third model, spending is low from both funding sources and biased towards basic education. In the fourth model, spending is relatively low and biased towards tertiary education. The first model includes Nordic countries and some European nations. The second model includes Anglo-Saxon countries, Chile, Japan and South Korea. The third model includes Italy, Greece and the Czech Republic as the most significant examples. The fourth model consists of Turkey and Mexico.

In the next section, we present a political economy model that helps explain the evidence discussed in this section.

3. The model

We consider a two-period economy with a continuum of households of mass one, in which each household comprises one parent and one child.[11] Parents are differentiated according to human capital and income, which are exogenously given. Human capital has two levels: high ($h_p = 1$) if the parent has graduated from university and low ($h_p = h < 1$) if the parent has not. Let K be the share of graduate parents, while the complementary share $1 - K$ is that of non-graduate parents. Parents'

[11] We are aware of the trade-off between quantity and quality when choosing to bear children but we do not address fertility decisions in this model.

income consists of a common stochastic rate x multiplied by parents' human capital h_p.[12] The common stochastic rate x is uniformly distributed over the interval $[(m-\delta),(m+\delta)]$, with $0 < \delta \leq m$. The parameter δ can be considered a measure of income inequality.[13] Thus, the economy's average income is $M = (1-K)hm + Km$.[14]

We assume that parents save the whole of their income in the first period, consuming only in the second period.[15] Household utility is derived from consumption of the numeraire good (c) and the child's human capital (h_c) according to the following utility function:

$$U(c, h_c) = ln(c) + \gamma\,[ln(h_c)] \qquad \textbf{(1)}$$

where the parameter $\gamma \in R{+}{+}$ is the weight attached to the child's human capital.

3.1 Children's human capital formation

This section describes children's human capital formation, emphasising its dependence on parental education and the potential role of the education system in mitigating this dependence. Human capital formation is modelled as a two-stage process. The first stage (basic education) corresponds to primary and secondary education, which is mandatory and depends on the government's expenditure on basic education ($G_B > 0$), with no direct costs to parents.[16] The human capital accumulated in the first stage also depends on parental human capital (h_p).[17] This dependence (intra-family externality), is mitigated by the inclusiveness of the school system, and in a perfectly inclusive system, all children can fully exploit returns from public education, independent of their parent's education. We denote by h_B the (basic) human capital accumulated during the first stage and assume the following production function:

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[12] This assumption is consistent with the idea of efficiency units of labour. We thank a referee for this suggestion.

[13] We select a uniform distribution of income for analytical tractability. We are aware that under majority voting the standard Metzler and Richard (1981) redistribution issue disappears. As we later discuss, in our model, the effect of income inequality on public education budget does not depend on the distance between median and average income, but on the parameter δ.

[14] Income consists of a general consumption good that serves as the numeraire.

[15] A sure-return linear storage technology exists which earns a gross return equal to 1, for each unit of income saved.

[16] We assume $G_B > 0$, and we will verify that this is always true in equilibrium. In addition, hereafter we assume that the price of one unit of education (both public and private) is equal to 1 in terms of the numeraire good.

[17] We do not consider the role of children's innate abilities. Although this is obviously an important factor of the learning process, it is realistic to imagine that they are equally distributed among children with different social backgrounds.

$$h_B = \begin{cases} h_p {G_B}^{\alpha} & if\ the\ system\ is\ non-inclusive \\ {G_B}^{\alpha} & if\ the\ system\ is\ inclusive \end{cases}$$

where $\alpha > 0$, the elasticity of human capital with respect to spending on basic education, is an efficiency parameter.

For simplicity, we assume that all children enrol at university, but only a proportion of them complete their advanced studies.[18] The probability of completing a tertiary education cycle depends on human capital accumulated in the first stage of education. In a non-inclusive system, the level of human capital accumulated in the first stage depends on parental education. This implies that the probability of completing a tertiary education cycle depends on family background.[19] Specifically, regarding the probability of graduating from university, denoted by $\eta(h_B)$, we assume the following:

$$\eta(h_B) = \begin{cases} \eta & if\ h_B = h{G_B}^{\alpha} \\ 1 & if\ h_B = {G_B}^{\alpha} \end{cases}$$

with $0 < \eta < 1$ .Thus, in a non-inclusive system, children with a non-graduate parent have a probability η of graduating from university (the drop-out rate is 1- $\eta > 0$), whereas children whose parents have a university degree complete tertiary education with a probability equal to 1.[20] The probability η can be interpreted as a measure of the inclusiveness of the education system. Indeed, in a perfectly inclusive system, the probability of graduating from university should not depend on parental education, as the human capital accumulated in the first stage would not depend on family background.

We assume that parents can opt out of the public university system and pay for their children's tertiary education. In this case, they freely choose the amount of private education expenditure, which is

[18] We do not consider the enrolment decision, assuming that the opportunity cost to enrol at university is zero and overlooking the trade-off involved in balancing (opportunity) costs and benefits from enrolment in higher education. As explained in footnote 6, this assumption simplifies the analysis but does not affect qualitative results.

[19] In addition to accumulated education, other (non-modelled) inherited cultural and economic factors could affect university achievement, justifying the assumption that children with non-graduate parents have a higher probability of dropping out than graduate parents'children have (see Lagravinese et al., 2020 and Aina, 2021). Allowing the probability of dropping-out to depend also on the common stochastic income rate x would not change qualitative results. However, the analysis of the voting game would be more complex.

[20] To have a share of graduate parents that does not change over time and remains less than 1, we would need to introduce a positive rate of dropping out for children with graduate parents; however, assuming a dropping out probability equal to zero for children with graduate parents allows for a simpler notation without changing qualitative results.

denoted by e. We assume that e is tax deductible, which simplifies the analysis and is a feature observed in many OECD countries. In contrast, the public university system provides a uniform education that depends on the level of public expenditure G_T.[21]

Denoting by h_T the human capital accumulated at the second stage, we posit:

$$h_T = \begin{cases} e & if\ private\ university \\ G_T & if\ public\ university \end{cases}$$

and assume that youngster's human capital accumulates as follows:

$$h_c = \begin{cases} max\ (h_B h_T, h_B) & if\ tertiary\ education\ is\ completed \\ h_B & otherwise \end{cases}$$

In summary, a given level of tertiary spending -either private or public- adds to the human capital accumulated through basic education. Note that higher education is effective (that is, $h_B h_T > h_B$) if h_T is greater than 1. Therefore, the household expected utility function is as follows:

$$\begin{aligned} EU(c, h_B, h_T) &= (1 - \eta(\, h_B)\,)[ln(c) + \gamma\, ln(h_B)] \\ &\quad + \eta(h_B)\left[ln(c) + \gamma\, [ln(h_B) + \ \boldsymbol{I} ln(h_T)]\right] \\ &= \ ln(c) + \gamma\, [ln(h_B) + \ \boldsymbol{I}\eta(\, h_B)\, ln(h_T)] \end{aligned} \qquad \textbf{(2)}$$

where **I** = 0 for $0 \leq h_T < 1$ and **I** = 1 for $h_T \geq 1$.[22]

Total public education expenditure is financed by a proportional income tax $\tau \in [0, 1)$. This tax represents the incremental impact of public education financing needs on the overall tax system. The tax rate (τ) and the allocation of tax revenue between basic and tertiary education are determined through a voting process which is described in section 3.6.

3.2 Timing of events.

In the first period, parents decide whether to enrol the child at a public or a private university, then majority voting determines τ and the allocation of tax revenue between G_B and G_T. When making the

[21] We overlook the congestion effect in higher education and assume that individual capital accumulation depends on public expenditure (G_T) and not on public expenditure per student. We justify this assumption by referring to empirical evidence that class size does not affect educational outcomes in undergraduate classes. On this point, see Naito and Nishida (2017) and the references cited therein.

[22] If $h_T = 0$ (which can happen in equilibrium), then **I** = 0 and $EU(c, h_B, h_T) = ln(c) + \gamma\, ln(h_B)$.

education decision, parents have perfect foresight regarding the outcome of the voting process and the resulting public tertiary spending.[23] In the second period, households consume and children acquire basic education and may or may not complete tertiary education.

3.3 Private education choice.

Hereafter, we consider a non-inclusive education system. We discuss the case of a perfectly inclusive system in section *3.7*.

Parents who are planning to opt out of the public system choose e to maximise expected utility, as given by eq. (2), under the budget constraint

$$c = (1 - \tau)(h_p x - e) \tag{3}$$

and under the condition $c > 0$.

Substituting eq.(3) into eq. (2) and setting $\boldsymbol{I} = 1$, we obtain the household expected utility if choosing private tertiary education as follows:

$$EU(c, h_B, h_T = e) = ln[(1 - \tau)(h_p x - e)] + \gamma\,[ln(h_B) + \eta(h_B)\ ln(e)] \tag{4}$$

Straightforward computation indicates that the optimal level of private education spending e^* is given by

$$e^* = \frac{\eta(h_B)\,\gamma}{1 + \eta(h_B)\,\gamma} h_p x \tag{5}$$

Note that the option of not investing is always open, even in the absence of public tertiary education. This means that setting I=0 in (2), parents might opt to invest e^*in private advanced education only if

$$EU(c, h_B, e^*) \geq U(c, h_B,, h_T = 0) = ln((1 - \tau)(h_p x)) + \gamma\,[ln(h_B)]$$

From the above condition, we find that their income must be greater than the threshold

[23] Referencing De la Croix and Doepke (2009), such timing is motivated by the observation that public education spending can be adjusted more frequently than the choice between public vs. private education, which might entail substantial switching costs.

$$h_p\hat{x} = \frac{1+\eta(h_B)\gamma^{\frac{1+\eta(h_B)\gamma}{\eta(h_B)\gamma}}}{\eta(h_B)\gamma}$$

in order to guarantee a level of private investment in private education which dominates the option of not investing. Therefore, if $h_p x < \frac{1+\eta(h_B)\gamma^{\frac{1+\eta(h_B)\gamma}{\eta(h_B)\gamma}}}{\eta(h_B)\gamma}$, $e^* = 0$.

Parents, who are deciding whether to opt out of the public system and privately pay for their children's tertiary education, must compare the level of expected utility from opting out of the public system with the expected utility from opting into it. In doing so, they have perfect foresight regarding the expected level of public tertiary spending, which is denoted by G_T^e, determined by the outcome of the voting process.

For this comparison, we use the following lemma:

Lemma 1. Opting out decision

There exists a threshold of the common stochastic income rate x:

$$\hat{x}\left(G_T^e, h_p, \eta(h_B)\right) = \frac{(1+\eta(h_B)\gamma)^{\frac{1+\eta(h_B)\gamma}{\eta(h_B)\gamma}}}{h_p\eta(h_B)\gamma} max(1, G_T^e)$$

with $G_T^e \geq 0$, *such that households, whose human capital is* h_p, *strictly prefer private education if and only if* $x > \hat{x}\left(G_T^e, h_p, \eta(h_B)\right)$.

Proof. *See Appendix 2.*

The threshold increases with the expected level of public tertiaty spending. This implies that more affluent parents are more demanding in terms of expected public education expenditure. If $x = \hat{x}\left(G_T^e, h_p, \eta(h_B)\right)$, we assume that households opt out of the public system.

To simplify the notation, we denote the threshold for graduate parents ($\eta(h_B) = 1$; $h_p = 1$) as follows:

$$\hat{x}(G_T^e) = \frac{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}{\gamma} max(1, G_T^e) \tag{6a}$$

while the threshold for non-graduate parents ($\eta(h_B) = \eta$; $h_p = h$) is denoted as follows:

$$\hat{x}(G_T^e, h, \eta) = \frac{(1+\eta\gamma)^{\frac{1+\eta\gamma}{\eta\gamma}}}{h\eta\gamma} ma\,x(1, G_T^e) \tag{6b}$$

Note that $\hat{x}(G_T^e, h, \eta) > \hat{x}(G_T^e)$, as non-graduate parents, whose children complete the tertiary cycle with a probability $\eta < 1$, have a higher opportunity cost of investing in private tertiary education than graduate parents. We now posit the following assumption:

Assumption 1:

(i) $\frac{(1+\eta\gamma)^{\frac{1+\eta\gamma}{\eta\gamma}}}{\eta\gamma} > h(m+\delta)$

(ii) $\frac{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}{\gamma} < m+\delta$

Assumption 1(i) implies that $\forall\, G_T^e \geq 0$ non-graduate parents never enrol their children at a private university.[24] In contrast, Assumption 1(ii) implies that $\forall\, G_T^e \geq 0$, there are some graduate parents who enrol their children at private universities.

3.4 Opting out and the public education budget

To compute the rate of opting out we must distinguish between non-graduate and graduate parents. Given Assumption 1(i), non-graduate parents never opt out. The opting out rate of children with graduate parents, denoted by Ω, is given by the following expression:

$$\Omega(G_T^e, \delta) = \begin{cases} 1 & \hat{x}(G_T^e) \leq m-\delta \\ 1 - \dfrac{\hat{x}(G_T^e) - (m-\delta)}{2\delta} & m-\delta < \hat{x}(G_T^e) \leq m+\delta \\ 0 & \hat{x}(G_T^e) > m+\delta \end{cases} \qquad \textbf{(7)}$$

It is straightforward to verify that $\Omega(G_T^e, \delta)$ is monotone nonincreasing in G_T^e.[25]

We next define the income threshold level as a function of the opting out rate as follows: [26]

$$\tilde{x} = (m+\delta) - 2\delta\Omega(G_T^e; \delta)$$

The government education budget is then as follows:

[24] Assumption 1(i) is introduced to simplify the analysis of the voting game and is justified by the the fact that non-graduate parents have a higher opportunity cost of enroling their children at private universities. Relaxing Assumption 1(i) and allowing some non-graduate parents to enrol their children at private universities would require taking into account the impact of their decision on the public education budget, as private education expenditure is tax deductible. We investigate this scenario in section 3.7.

[25] Note that if the outcome of the voting process is such that the equilibrium level of public tertiary spending is not effective, non-graduates and those graduates not opting out will not attend university.

[26] We introduce the new notation $\tilde{x}$ for the income threshold level that separates public and private university pupils because $\tilde{x}$ and $\hat{x}$ do not exactly coincide: when $\hat{x} > m+\delta$, $\tilde{x} = m+\delta$ and when $\hat{x} < m-\delta$, $\tilde{x} = m-\delta$.

$$F(\tau, G_T^e, \delta) = (1-K)h\int_{(m-\delta)}^{(m+\delta)} \tau x \frac{1}{2\delta} dx + K\left[\int_{m-\delta}^{m+\delta} \tau x \frac{1}{2\delta} dx - \int_{\tilde{x}}^{m+\delta} \tau\left(\frac{\gamma}{1+\gamma}\right) x \frac{1}{2\delta} dx\right]$$

where the second term in the square brackets on the right-hand side is due to deductibility of private education expenditures, which reduces the available budget.

By solving the integral, we obtain

$$F(\tau, G_T^e, \delta) = \tau\left[M - K\frac{\gamma}{1+\gamma}[\Omega(G_T^e, \delta)\ (m + \delta(1 - \Omega(G_T^e, \delta)\ ))]\right] \qquad \textbf{(8)}$$

and substituting eq.(7) into eq. (8), we obtain the following expression for the budget for $G_T^e \geq 0$:

$$F(\tau, G_T^e, \delta) = \begin{cases} \tau\left[M - K\frac{\gamma}{(1+\gamma)} m\right] & \hat{x}(G_T^e) \leq m - \delta \\ \tau\left[M - K\frac{\gamma}{4\delta(1+\gamma)}\left((m+\delta)^2 - \left(\hat{x}(G_T^e)\right)^2\right)\right] & m - \delta < \hat{x}(G_T^e) < m + \delta \\ \tau M & \hat{x}(G_T^e) \geq m + \delta \end{cases} \qquad \textbf{(9)}$$

We can then prove the following lemma:

Lemma 2

The public budget increases with the tax rate ($\frac{\partial F}{\partial \tau} > 0$) and is monotone nondecreasing in G_T^e, ($\frac{\partial F}{\partial G_T^e} \geq 0$). If $m - \delta < \hat{x}(G_T^e) < m + \delta$, the public budget decreases with δ, ($\frac{\partial F}{\partial \delta} < 0$), iff $\hat{x}(G_T^e)^2 > m^2 - \delta^2$. ***Proof****. See Appendix 2.*

The dependence of the budget on the tax rate is obvious. The budget is positively related to G_T^e, because the opting out rate decreases with the expected level of tertiary public spending. As a consequence, the lower the opting out rate is, the lower the level of private education expenditure deducted from taxpayers' gross income is. Finally, the lemma states the condition in which the budget is negatively related to income inequality. Note that this condition is clearly satisfied when $\hat{x}(G_T^e) > m$ and it is more likely met as the inequality increases.

The public education system operates under a balance-budget rule. Hence, given the budget $F(\tau, G_T^e, \delta)$, a share ϕ is spent on basic education; thus, $G_B = \phi\, F(\tau, G_T^e, \delta)$. The complementary share $(1-\phi)$ determines the level of public spending on tertiary education; thus, $G_T = (1-\phi)F(\tau, G_T^e, \delta)$. Majority voting decides τ and ϕ.

3.5 Preferred policies.

We distinguish three groups. The first group (A) comprises non-graduate parents *(h_p =h<1)* whose share in the population is $(1-K)$. The second group (B) comprises graduate parents *(h_p =1)* whose income is below $\hat{x}(G_T^e)$ and their measure is equal to $K(1-\Omega(G_T^e,\delta))$. Groups A and B never enrol their children at a private university. The third group (C) comprises graduate parents with incomes above or equal to $\hat{x}(G_T^e)$ who opt out of the public system and their measure is equal to $K\,\Omega(G_T^e,\delta)$. We now compute each group's preferred tax rate and allocation of public budget between the two education tiers; that is, the pair (τ^P, ϕ^P) for $P \in \{A, B, C\}$. We preliminarily assume that if the public tertiary education expenditure preferred by group P, for $P \in \{A, B, C\}$, is positive, it is also effective (greater than 1). In other words, we assume that $\forall\, G_T^e \geq 0$ there is enough fiscal room to guarantee the effectiveness of public tertiary expenditure.[27] At the end of this subsection, we establish the parameters' restriction for this assumption to hold in the model.

Group A's preferred policies (h_p = h)

Taking $\Omega(G_T^e,\delta)$ as given, group A's preferred tax rate and public budget allocation, τ^A *and* ϕ^A, are obtained as follows:

$$\tau^A = arg \max_{0\leq\tau\leq1}[ln(1-\tau)hx + \gamma(ln\, h + \alpha ln\phi\; F(\tau, G_T^e,\delta) + \eta ln(1-\phi)\; F(\tau, G_T^e,\delta))]$$

$$= \frac{\gamma(\alpha+\eta)}{1+\gamma(\alpha+\eta)}$$

$$\phi^A = arg \max_{0\leq\phi\leq1}[ln(1-\tau)hx + \gamma(ln\, h + \alpha ln\phi\; F(\tau, G_T^e,\delta) + \eta ln(1-\phi)\; F(\tau, G_T^e,\delta))] = \frac{\alpha}{\alpha+\eta}$$

[27] If this were not the case, there would be some values of G_T^e such that the public budget would not be high enough to allow an effective public tertiary investment and therefore agents would maximise an expected utility function obtained from eq. (2) setting $\mathbf{I} = 0$.

Thus, group A's preferred level of public university funding is $G_T^A = (1-\phi^A)F(\tau, G_T^e, \delta)$, where $F(\tau^A, G_T^e, \delta)$ is obtained by eq. (9), substituting $\tau = \tau^A$.

Group B's preferred policies (h_p=1 and $x < \hat{x}(G_T^e)$)

Taking $\Omega(G_T^e, \delta)$ as given, group B's preferred tax rate and public expenditure allocation, τ^B and ϕ^B, are obtained as follows:

$$\tau^B = arg\max_{0\le\tau\le1}[ln(1-\tau)x + \gamma(\alpha\, ln\,\phi\, F(\tau, G_T^e, \delta) + ln(1-\phi)\, F(\tau, G_T^e, \delta))]$$

$$= \frac{\gamma(\alpha+1)}{1+\gamma(\alpha+1)}$$

$$\phi^B = arg\max_{0\le\phi\le1}[ln(1-\tau)x + \gamma(\alpha\, ln\,\phi\, F(\tau, G_T^e, \delta) + ln(1-\phi)\, F(\tau, G_T^e, \delta))] = \frac{\alpha}{\alpha+1}$$

Thus, group B's preferred level of public university funding is $G_T^B = (1-\phi^B)F(\tau, G_T^e, \delta)$, where $F(\tau^B, G_T^e, \delta)$ is obtained by eq. (9), substituting $\tau = \tau^B$.

Group C's preferred policies ($\left(h_p = 1 \text{ and } x \ge \hat{x}(G_T^e)\right)$

Taking $\Omega(G_T^e, \delta)$ as given, group C's preferred tax rate and public budget allocation, τ^C and ϕ^C, are obtained as follows:

$$\tau^C = arg\max_{0\le\tau\le1}\left[ln(1-\tau)\frac{1}{\gamma+1}x + \gamma\left(\alpha\, ln\,\phi\, F(\tau, G_T^e, \delta) + ln\frac{\gamma}{\gamma+1}x\right)\right] = \frac{\gamma\alpha}{1+\gamma\alpha}$$

$$\phi^C = arg\max_{0\le\phi\le1}\left[ln(1-\tau)\tfrac{1}{\gamma+1}x + \gamma\left(\alpha\, ln\,\phi\, F(\tau, G_T^e, \delta) + ln\tfrac{\gamma}{\gamma+1}x\right)\right] = 1$$

Thus, group C's preferred level of public university funding is $G_T^C = (1-\phi^C)F(\tau, G_T^e, \delta)$=0.

Note that given any ϕ the Bs prefer τ^A to τ^C, and the Cs prefer τ^A to τ^B. In addition, given any τ, the Bs prefer ϕ^A to ϕ^C and the Cs prefer ϕ^A to ϕ^B. Hence, we can order the preferred policies of the three groups as follows:

$$\begin{gathered}\tau^B > \tau^A > \tau^C \\ \phi^B < \phi^A < \phi^C = 1\end{gathered} \quad \textbf{(10)}$$

To assure that for each $P \in \{A, B\}$ and $\forall\ G_T^e \ge 0$ there is enough fiscal room to guarantee that $G_T^P > 1$, we must assume the following parameters' restriction:

Assumption 2.[28]

$$M - \frac{1+\gamma(\alpha+\eta)}{\eta\gamma} > K\frac{\gamma}{4\delta(1+\gamma)}\left((m+\delta)^2 - \max\left(m-\delta;\ \frac{(1+\ \gamma)^{\frac{1+\gamma}{\gamma}}}{\gamma}\right)^2\right)$$

The above condition is obtained from the budget expression in eq. (9) by considering its minimum value and the preferences of group A. Consequently, it holds *a fortiori* when the budget increases, and given the ranking of the preferred policies in (10), it is satisfied *a fortiori* for $P = \mathrm{B}$.[29]

3.6 Political equilibrium.

Thus far, we have taken the rate of opting out $\Omega(G_T^e, \delta)$ as given and solved for each group's preferred pair $(\tau^P,\ \phi^P)$ with $P \in \{A, B, C\ \}$. We now consider the political process in which parents vote on the income tax to finance public education and on public budget allocation between the two education tiers. Since the policy space is bidimensional, majority voting might lead to cycles and non-existence of a (Condorcet) winner. To overcome this problem, we impose institutional restrictions, referencing Shepsle (1979), assuming that the voting procedure prescribes voting both separately and simultaneously on each policy dimension. In our political game, issue-by-issue voting requires two reaction functions for each group of households: $\tau(\phi)$ and $\phi(\tau)$. The first obtains the preferred value of τ for every value of ϕ; the second is the preferred value of ϕ for every value of τ. The voting outcome is a Nash-like solution in which τ^* is the best response to ϕ^* and ϕ^* is the best response to τ^*.[30] As it is easy to verify from section 3.5, our groups' reaction functions are vertical and horizontal lines; thus, if an equilibrium of the voting game exists (see Propositions 1 and 3 below), it reflects the preferences of the median voter in each dimension (Persson and Tabellini, 2000).[31] Therefore, if one group is majoritarian, the equilibrium voting outcome reflects the preferences of this group. If none

[28] The parameter set satisfying Assumption 2 is nonempty, as it is demonstated in the numerical examples in section 3.6.

[29] As it will be shown below (see Proposition 1), Assumption 2 is important to assure the existence of at least one fixed point with an effective level of tertiary education spending for each $P \in \{A, B\}$.

[30] That is $\tau^* = \tau(\phi^*)$ and $\phi^* = \phi(\tau^*)$

[31] Moreover, with vertical and horizontal reaction functions, sequential voting would lead to the same result (see Persson and Tabellini, 2000).

of the groups is majoritarian, the equilibrium of the voting game reflects the preferences of the median voter who, given the preferred policies ranking in expression (10), belongs to group A for both policy dimensions.

In this framework, we define a political equilibrium in which the choice of opting out of the public system must be optimal and the expectations must be rational.

Definition 1. Political equilibrium.

A political equilibrium comprises:

- *(i) an income threshold $\hat{x}$ satisfying eq.(6a);*
- *(ii) a private education spending decision for graduate parents ($e^* = 0$ for $x < \hat{x}$, and $e^* = \frac{\gamma}{\gamma+1}x$ for $x \geq \hat{x}$);*
- *(iii) aggregate variables $(\tau^*, \phi^*, \Omega(G_T^e, \delta))$, where $\Omega(G_T^e, \delta)$ is defined by eq. (7), and the pair (τ^*, ϕ^*) is the outcome of the majority voting game.*

In addition, denoted by $G_T^* = (1 - \phi^*)F(\tau^*, G_T^e, \delta)$ the equilibrium public tertiary education spending:

- *(iv) the perfect foresight condition $G_T^* = G_T^e$ must hold;*
- *(v) G_T^* must be a focal point and if positive must be greater than 1 (effectiveness).[32]*

We define $z^P = (1 - \phi^P)\tau^P$ and note that $z^B > z^A > z^C$ from the ranking of preferred policies in expression (10). For each $P \in \{A, B, C\}$, we can construct a continuous and nondecreasing function $\Delta^P(G_T^e)$ mapping expected into actual public tertiary education spending, which is obtained using eq. (8) as follows:

$$\Delta^P(G_T^e) = z^P \left[M - K\frac{\gamma}{1+\gamma}\Omega(G_T^e, \delta)\big(m + \delta(1 - \Omega(G_T^e, \delta)\big)\right] \quad \textbf{\textit{(11)}}$$

Thus, actual public tertiary education spending is $G_T^P = \Delta^P(G_T^e)$ with $G_T^e \in \mathbb{R}_+$

If group P is the political winner, an equilibrium is characterised by a fixed point of $\Delta^P(G_T^e)$, that is a public tertiary education spending G_T^{P*} that satisfies $G_T^{P*} = \Delta^P(G_T^{P*})$, so that the public tertiary

[32]A focal point (or Schelling point) is a solution that economic agents tend to choose by default in the absence of communication (see Shelling (1960)).

education spending expected by parents is identical to the one actually implemented in the political process.

Proposition 1. Existence of fixed points.

Consider $P \in \{A, B\}$

If $z^P M < \frac{\gamma(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}$

a unique fixed point of $\Delta^P(G_T^e)$ *exists with* $G_T^{P*} = G_T^e$, *and* $1 < G_T^{P*} < z^P M$ *(interior fixed point).*

If $z^P M \geq \frac{\gamma(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}$

$G_T^{P*} = G_T^e = z^P M$ *is always a fixed point of* $\Delta^P(G_T^e)$. *Two additional fixed points might exist inside the interval* $(1, z^P M)$.

For P = C, there exists a unique fixed point of $\Delta^C(G_T^e)$ *with* $G_T^{C*} = G_T^e = 0$

Proof. *See Appendix 2.*

Suppose $z^P M < \frac{\gamma(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}$. In this case, Proposition 1 establishes that a unique fixed point exists. Thus, if parents anticipate that group P will be the political winner, their expectations about the public tertiary education spending converge to G_T^{P*} with $1 < G_T^{P*} < z^P M$.

Suppose $z^P M \geq \frac{\gamma(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}$. In this case, multiple fixed points might exist. The following lemma establishes that the only focal point is $G_T^{P*} = z^P M$.

Lemma 3. Focal point.

Suppose that $z^P M \geq \frac{\gamma(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}$. *If multiple fixed points exist, the only focal point is* $G_T^{P*} = z^P M$.

Proof. *Suppose that parents anticipate that the winner of the voting game will be group P. By comparing the fixed points of* $\Delta^P(G_T^e)$, *parents'expectations would reasonably converge on the fixed point associated to the highest value of public tertiary spending; that is,* $G_T^{P*} = z^P M$. *Indeed, all fixed points feature the same level of taxation* τ^P; *however, the budget is higher when* $G_T^e = z^P M$, *as the opting out rate is zero. Hence, if agents anticipate that group P will be in power, they will also reasonably expect that public tertiary education expenditure will be set equal to* $z^P M$, *which guarantees the highest level of utility to group P (focal point).*

Proposition 2. C***omparative statics***.

Focusing on focal points, the following inequalities hold:

2.1 $G_T^{B*} > G_T^{A*} > G_T^{C*} = 0$

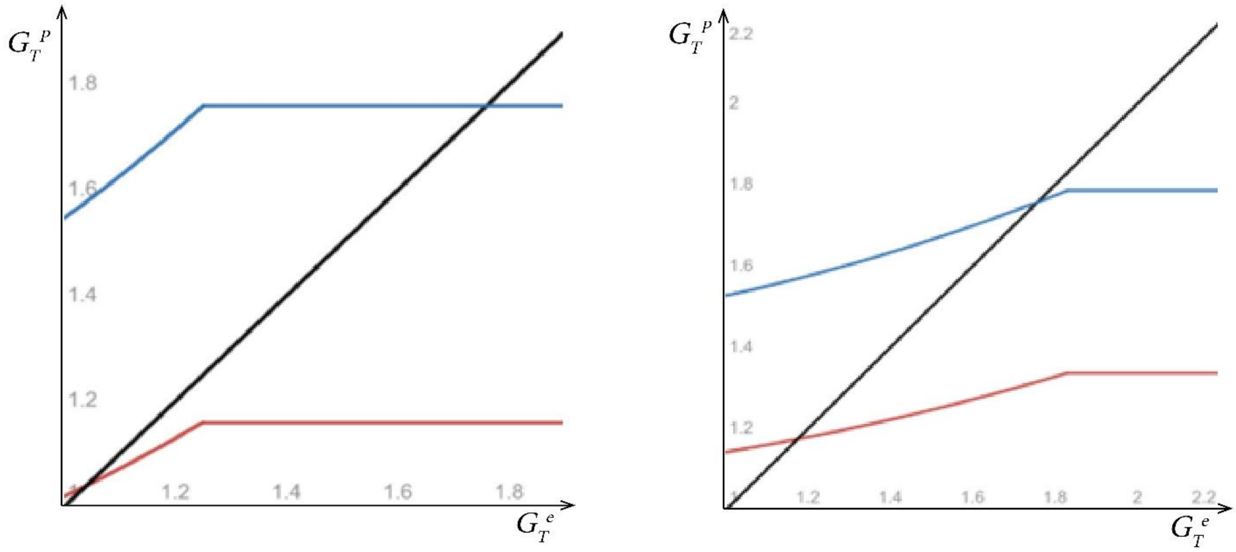
2.2 $\frac{dG_T^{A*}}{d\eta} > 0$

2.3 If $1 < G_T^{P*} < z^P M$, $\frac{dG_T^{P*}}{d\delta} < 0$ *iff* $\hat{x}(G_T^{P*})^2 > m^2 - \delta^2$

Proof. *See Appendix 2.*

Figures 3 and 4 below present a graphical illustration of Proposition 1 showing the fixed points for various values of the model parameters. In Figure 3, $\Delta^A(G_T^e)$ for group A is in red and $\Delta^B(G_T^e)$ for group B is in blue. In the left panel, the parameters' set is ($\alpha = 0.5$; $\gamma = 0.33$; $h = 0.5$; $\delta = 2$; $K = 0.6$; $m = 10$; $\eta = 0.6$). In this case, the fixed points are: G_T^{A*} =1.04 and $G_T^{B*} = z^P M = 1.77$. In the right panel, the parameters' set is ($\alpha = 0.5$; $\gamma = 0.3$; $h = 0.3$; $\delta = 7$; $K = 0.6$; $m = 12$; $\eta = 0.7$). For these parameters' values, the fixed points are: G_T^{A*} =1.17 and G_T^{B*} =1.76.

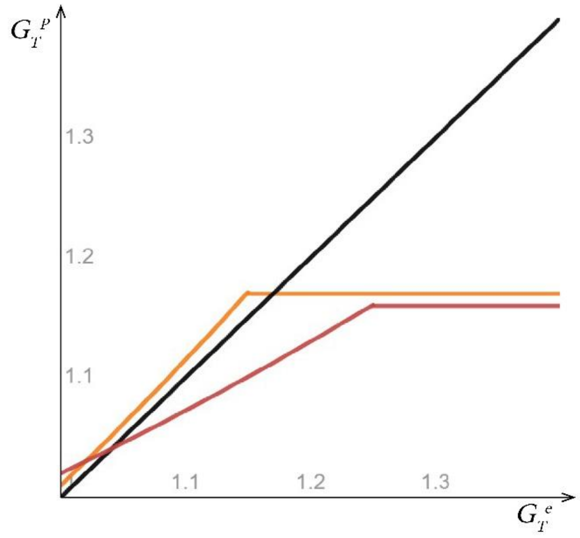
Figure 3. Groups A (red) and B (blue) fixed point mapping.

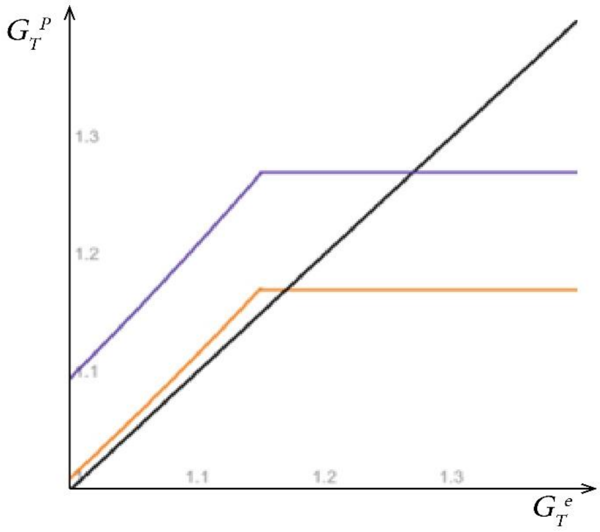


Focusing on group A, Figure 4 illustrates how the fixed point G_T^{A*}changes with δ and η.[33] Keeping constant the parameters' set ($\alpha = 0.5$; $\gamma = 0.33$; $h = 0.5$; $K = 0.6$; $m = 10$), the left panel suggests that decreasing δ the fixed point G_T^{A*} increases; the right panel shows that increasing η the fixed point G_T^{A*} decreases.[34] Note that in our numerical examples when $z^P M > \frac{\gamma(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}$ only one fixed point exists.

[33] Analogous graphs can be obtained changing δ for group B.
[34] Note that the condition $\hat{x}\,(G_T^{*P})^2 > m^2 - \delta^2$ is always satisfied in our numerical examples.

Figure 4. Group A's fixed point mapping.





Panel A ($\eta = 0.6$): Red $\delta = 2$; Orange $\delta = 1$

Panel B ($\delta = 1$): Purple $\eta = 0.67$; Orange $\eta = 0.6$

In the next proposition, we focus on focal points.

Proposition 3. Existence of political equilibria.

3.1 If group A is majoritarian (i.e. $1 - K > \frac{1}{2}$) a unique equilibrium of the voting game exists: $[\tau^* = \tau^A,\ \phi^* = \phi^A]$ with $G_T^e = G_T^{A*}$.[35]

3.2 If group A is not majoritarian, then multiple political equilibria might arise as self-fulfilling prophecies, with three possible outcomes:

(i) $[\tau^* = \tau^A,\ \phi^* = \phi^A]$ with $G_T^e = G_T^{A*}$, if $1 - \Omega(G_T^{A*}, \delta) \leq \frac{1}{2K}$ and $\Omega(G_T^{A*}) \leq \frac{1}{2K}$;

(ii) $[\tau^* = \tau^B,\ \phi^* = \phi^B]$ with $G_T^e = G_T^{B*}$, if $1 - \Omega(G_T^{B*}, \delta) > \frac{1}{2K}$;

(iii) $[\tau^* = \tau^C,\ \phi^* = \phi^C]$ with $G_T^e = G_T^{C*}$, if $\Omega(G_T^{C*}, \delta) > \frac{1}{2K}$.

Finally, at least one political equilibrium always exists.

***Proof**. See Appendix* 2.

3.6.1 *Discussion of the political outcomes.*

We have demontrated that if group A is majoritarian, the unique political equilibrium features a lower level of public education expenditure relative to what group B prefers. This suggests that in countries where the share of the population with tertiary education is low and the education system is non-

[35] Notably, in the extreme case of $\eta = 0$, the preferences of non-graduates (group A) regarding public tertiary spending would coincide with those of the affluent educated élite (group C). This result recalls Epple and Romano's (1996b) 'ends-against-the-middle' type of equilibrium.

inclusive, we expect to observe low investments in public education, particularly at the tertiary level. This policy choice is self-reinforcing insofar as it prevents the graduate population from growing and it keeps the economy from switching to an equilibrium supported by a graduate pivotal voter, likely belonging to group B, with a strong preference for tertiary public education.[36] However, even when graduate households are the majority, our model demonstrates that the economy could remain stuck in an equilibrium characterised by low public education spending. Indeed, in this case, the model exhibits a potential for multiple equilibria, and a low public education spending equilibrium would be consistent with low public education budget expectations. This scenario could describe the circumstances observed in countries characterised by high private education expenditure. Importantly, the potential for multiple equilibria suggests that policymakers could establish the conditions to switch to a higher public spending equilibrium by affecting expectations about public education expenditure. Specifically, by announcing policies directed to increase the investment in public education, particularly at the tertiary level, a higher share of households would opt for the public system, which would make the increase in public spending feasible**.** The likelihood of a high public spending equilibrium would also increase if the education system were more inclusive. In this case, the interests of low-socioeconomic status households would be closer to those of the educated middle class. Thus, by improving the inclusiveness of the education system, a policy-maker can again affect political support for high public education spending, particularly at tertiary level.[37] Note also that, according to the model, the share of the budget allocated to tertiary spending depends on the return to basic education relative to tertiary education (that is the country specific parameter α). Finally, whenever $\frac{dG_T^{B*}}{d\delta} < 0$ (see Proposition 2), a reduction in income inequality increases the

[36] This result is confirmed by Dragomirescu-Gaina et al. (2015)'s empirical analysis. They focus on Europe and highlight the growing divide between the best and the low-performing countries in terms of tertiary educational attainment. Their calculations show a slower expected progress for lagging countries and a faster expected progress for high-performing countries.

[37] Note that a political equilibrium featuring high public spending on tertiary education could also be consistent with a circumstance in which the private university system is absent or not sufficiently developed, the education system is not inclusive and the pivotal voter belongs to the high social status élite, as in Su (2006). For example, this scenario might reflect the circumstance observed in Turkey or Mexico.

likelihood of the emergence of an equilibrium supported by group B. Indeed, the condition $1 - \Omega(G_T^{B*}, \delta) > \frac{1}{2K}$ is more likely satisfied, as G_T^{B*} increases.[38]

Finally, it is interesting to note that the share of graduate parents in the population (*K*) has two conflicting effects on the public budget. On the one hand, a higher *K* indicates that a higher share of households opt out of the public system, and because they deduct private education expenditures from their tax burden, this reduces the overall budget (see eq. (9)). On the other hand, a higher share of graduates has a positive effect on the budget as it increases average income. Moreover, a higher share of the population with a university degree reduces the size of group A, making it more likely for group B to be majoritarian, which implies higher public education expenditure than in the equilibrium where group A is pivotal.

3.7 *Inclusive education system*

In a perfectly inclusive system, the level of human capital accumulated in the first stage and the probability of completing the tertiary education cycle is the same for all children. In this setting, there are only two groups: those who opt for the public system and those who opt for a private university. Those who opt for the public system share the same preferences regarding the size and the allocation of the public education budget as group B in the non-inclusive system. Similarly, parents opting out of the public system have the same preferences as group C in the non-inclusive system; thus, we still denote these two groups by the letters B and C.

In terms of the common stochastic income rate, the threshold separating the two groups is the same as eq. (6a) for graduate parents, while, since η =1, the threshold for non-graduate parents in eq. (6b) becomes the following:

[38] In a non-majoritarian political setting, in which income inequality increases the political power of the rich educated élite, the increase in income inequality could reduce the public budget even without the tax deductibility of private education expenditure. For example, see the probabilistic voting model of De la Croix and Doepke (2009).

$$\hat{x}(G_T^e, h)) = \frac{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}{h\gamma}\max(1, G_T^e)$$

To characterise the political equilibria, we must analyse the following two cases:

a) $\frac{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}{h\gamma} > m + \delta$

b) $\frac{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}{h\gamma} \leq m + \delta.$

a) In this scenario, non-graduate parents cannot afford to enrol their children at a private university, although their opportunity cost is lower than in the non-inclusive case. As all non-graduate parents opt for public university, $\forall\ G_T^e$ the public education budget is the same as in the non-inclusive system. Therefore, apart from the fact that group A no longer exists, the analysis developed in section 3.5 can be applied to this case. Specifically, using the results in Proposition 1, Lemma 3 and Proposition 3, we can prove that if non-graduate parents are majoritarian (i.e. $1 - K > \frac{1}{2}$), then a unique equilibrium of the voting game exists: $[\tau^* = \tau^B,\ \phi^* = \phi^B]$ with $G_T^e = G_T^{B*}$. In contrast, if graduate parents are majoritarian and the conditions $1 - K\Omega(G_T^{B*}, \delta) > \frac{1}{2}$ and $\Omega(G_T^{C*}, \delta) > \frac{1}{2K}$ are simultaneously satisfied, two political equilibria might arise as self-fulfilling prophecies: $[\tau^* = \tau^B, \phi^* = \phi^B]$ with $G_T^e = G_T^{B*}$ and $[\tau^* = \tau^C,\ \phi^* = \phi^C]$ with $G_T^e = G_T^{C*}$. Since at least one of the two conditions is satisfied, an equilibrium always exists.[39]

Relative to the non-inclusive case, it is straightforward to conclude that group B, and therefore the political equilibrium $[\tau^* = \tau^B, \phi^* = \phi^B]$ with $G_T^e = G_T^{B*}$, is now more likely to become the political winner, as its size increases by $1 - K$.

[39] Suppose that $1 - K\Omega(G_T^{B*}, \delta)) \leq \frac{1}{2}$, then $K\Omega(G_T^{B*}, \delta) \geq \frac{1}{2}$. Noting that, $G_T^{B*} > G_T^{C*} = 0$ and therefore $\Omega(G_T^{C*}, \delta) > \Omega(G_T^{B*}\delta)$, we have $K\Omega(G_T^{C*}, \delta) > \frac{1}{2}$ (group C is majoritarian). If $K\Omega(G_T^{C*}, \delta) \leq \frac{1}{2}$, then, by the same argument, it follows that $K\Omega(G_T^{B*}, \delta) < \frac{1}{2}$ and therefore $1 - K\Omega(G_T^{B*}, \delta)) > \frac{1}{2}$ (group B is majoritarian).

b) In this scenario, some non-graduate and affluent enough parents might afford to opt out of the public system. They join group C, as they have the same preferences regarding the public budget size and allocation. Non-graduate parents who opt for the public system will continue to share the same preferences as group B and therefore join this group. Due to tax deductibility, the public education budget will now differ from the budget in the case *(a)*. Denoting by F^i the budget in this scenario, F^i is obtained as follows:

$$F^i(\tau, G_T^e, \delta) = \begin{cases} F(\tau, G_T^e, \delta) - \tau(1-K)hm\left[\frac{\gamma}{(1+\gamma)}\right] & \hat{x}(G_T^e, h) \le m - \delta \\ F(\tau, G_T^e, \delta) - \tau(1-K)\frac{\gamma h}{4\delta(1+\gamma)}\left((m+\delta)^2 - \left(\hat{x}(G_T^e, h)\right)^2\right) & m - \delta < \hat{x}(G_T^e, h) \le m + \delta \\ F(\tau, G_T^e, \delta) & \hat{x}(G_T^e, h) > (m+\delta) \end{cases}$$

where $F(\tau, G_T^e, \delta)$ is the budget in the non-inclusive system given by eq. (9). $F^i(\tau, G_T^e, \delta)$ keeps the same properties of $F(\tau, G_T^e, \delta)$: it is increasing in τ and monotone nondecreasing in G_T^e. The maximum value of the budget ($\max F^i(\tau, G_T^e, \delta) = \max F(\tau, G_T^e, \delta) = \tau M$) is reached when $\hat{x}(G_T^e) > m + \delta$, where $\hat{x}(G_T^e)$ is given by eq. (6a).

Assume that $\forall\, G_T^e \ge 0$ fiscal room is enough to guarantee that $(1-\phi^B)\, F^i(\tau^B, G_T^e) > 1$. Slightly modifying Proposition 1, using Lemma 3, and denoting by G_T^{iP*} the fixed point for $P \in \{B, C\}$, we have the following two propositions:

Proposition 4. Existence of fixed points.

For $P = B$.

(i) If $z^B M \ge \frac{\gamma(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}$, *there might be a multiplicity of fixed points, but only* $G_T^{iB*} = z^B M$ *is a focal point.*

(ii) If $z^B M < \frac{\gamma(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}$, *a unique fixed point exists:* $1 < G_T^{iB*} < z^B M$.

For $P = C$, *since* $z^C = 0$, *the only fixed point is* $G_T^e = G_T^{iC*} = 0$.

Proof*. The proof uses the same arguments as Proposition 1 and Lemma 3.*

Proposition 5. Political equilibria.

Two political equilibria are possible as self-fullfilling prophecies:

(i) $[\tau^* = \tau^B, \phi^* = \phi^B]$ *with* $G_T^e = G_T^{iB*}$, *if* $1 - \Omega\left(G_T^{iB*}, \delta\right) > \frac{1}{2}$;

(ii) $[\tau^* = \tau^C, \phi^* = \phi^C]$ *with* $G_T^e = G_T^{iC*} = 0$, *if* $\Omega\left(G_T^{iC*}, \delta\right) > \frac{1}{2}$.

In addition, since at least one of the two conditions is satisfied, an equilibrium always exists

Proof*. The proof follows the arguments developed in the proof of Proposition 3. The two conditions* $1-\Omega\left(G_T^{iB*},\delta\right)>\frac{1}{2}$ *and* $\Omega\left(G_T^{iC*},\delta\right)>\frac{1}{2}$ *can be simultaneously satisfied, thus two political equilibria might emerge as self-fulfilling prophecies. See the argument in footnote 39 to prove that at least an equilibrium always exists.*

To compare the political outcomes in the inclusive case where some non-graduates opt out of the public system and the non-inclusive one, we look at the level of public tertiary spending associated to each interest group's equilibrium candidate. For group *C*, since $G_T^{C*}=G_T^{iC*}=0$, there is no difference between the inclusive and the non-inclusive cases. For group B, we must compare G_T^{iB*} with G_T^{B*} which is accomplished in the following proposition:

Proposition 6.

If $G_T^{iB*}>\frac{\gamma h(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}$, *then* $G_T^{iB*}=G_T^{B*}$

If $G_T^{iB*}\leq\frac{\gamma h(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}$, *then* $G_T^{iB*}<G_T^{B*}$

Proof.

If $G_T^{iB*}>\frac{\gamma h(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}$, *then when* $G_T^{e}=G_T^{iB*}$ *all non-graduate parents opt for the public system. Consequently, the public budget in the inclusive and in the non-inclusive cases is the same; hence,* $G_T^{iB*}=G_T^{B*}$. *In contrast, if* $G_T^{iB*}\leq\frac{\gamma h(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}$, *some non-graduate parents opt out of the public system; therefore, due to tax deductibility,* $F^i\left(\tau^B,G_T^{iB*},\delta\right)<F\left(\tau^B,G_T^{iB*},\delta\right)$. *It follows that* $G_T^{iB*}<G_T^{B*}$.

Although group A no longer exists in the inclusive case, we can compare G_T^{iB*} with G_T^{A*}. If $G_T^{iB*}=G_T^{B*}$, it is straightforward that $G_T^{iB*}>G_T^{A*}$. In contrast, if $G_T^{iB*}<G_T^{B*}$, to have $G_T^{iB*}>G_T^{A*}$ requires that $(1-\phi^B)F^i(\tau^B,G_T^{A*},\delta)>(1-\phi^A)F(\tau^A,G_T^{A*},\delta)$. This condition is more likely to be met the greater the difference between z^B and z^A is, that is the lower the probability of completing the tertiary cycle for non-graduate offspring in the non-inclusive scenario is.

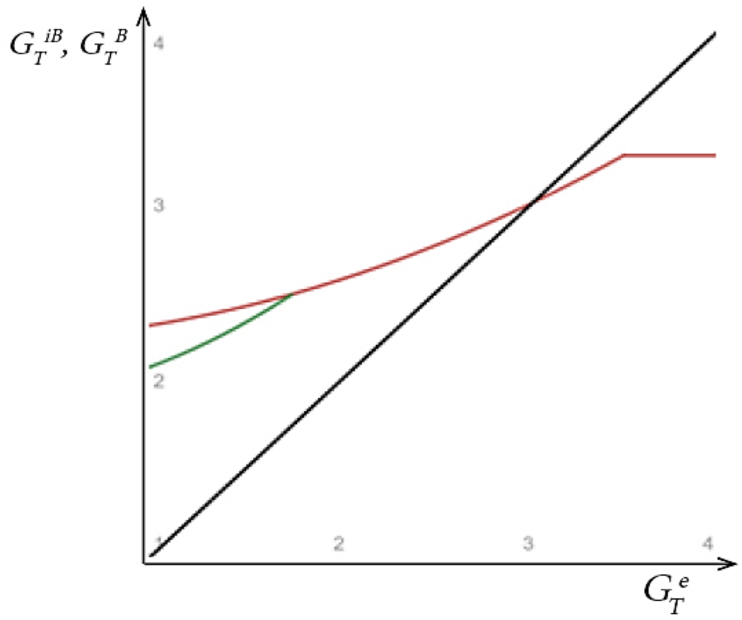
Note that if $z^B M\geq\frac{\gamma(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}$, then $G_T^{B*}=z^B M$ and therefore also $G_T^{iB*}=z^B M$. This means that the non-inclusive system might "dominate" the inclusive one, in terms of public education spending, only in the case that G_T^{B*} and therefore G_T^{iB*} are inside the interval $(1,z^B M)$. The occurrence of such circumstance is less likely the higher the return to tertiary education relative to basic education is (the lower the parameter α is) and the more equal the distribution of the common income rate is (the lower is the parameter δ is). Moreover, even in the case of interior solutions, the "dominance" happens only if $G_T^{B*} < \frac{\gamma h(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}$.

In summary, although Proposition 6 does not allow excluding that the non-inclusive system might "dominate" the inclusive one for some set of parameters, we deem this circumstance very unlikely in the real world. Recall that group B is the interest group that prefers public education the most, especially at the tertiary level. Therefore, if the relative return to higher education is reasonably high, the equilibrium level of tertiary education spending associated with this group would likely be high enough to induce all non-graduate parents (which, by assumption, have a lower average income than graduates) to opt for the public system. Consequently, relative to the non-inclusive case, group B, and therefore the pair $[\tau^* = \tau^B, \phi^* = \phi^B]$ with $G_T^e = G_T^{B*}$, is now more likely to become the political winner, since the size of the group supporting these policies increases by $1 - K$.

Figure 5 below presents a graphical illustration, for the parameters' set ($\alpha = 0.4$; $\gamma = 0.66$; $h = 0.5$; $\delta = 7$; $K = 0.6$; $m = 12$), where the result $G_T^{iB*} = G_T^{B*}$ holds when G_T^{iB*} is inside the interval $(1, \mathrm{z^B M})$. The red line represents $\Delta^B(G_T^e)$ when all non-graduate parents opt for the public system. In contrast, the green line represents the same function when some non-graduate parents opt out. The two functions intersect (and coincide from there after) when $G_T^e = \frac{\gamma h(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}} = 1.75$, which is lower than the fixed point $G_T^{B*} = 3.02$; thus, $G_T^{iB*} = G_T^{B*} = 3.02$. In other words, in this numerical example, if parents anticipate that the political winner will be group B, the expected level of public tertiary spending is high enough to induce all non-graduate parents to opt for the public system. [40]

[40] By computer simulations, we can show that $G_T^{iB*} < G_T^{B*}$ for the parameter set ($\alpha = 1$; $\gamma = 0.66$; $h = 0.5$; $\delta = 12$; $K = 0.6$; $m = 12$) . In this case, we obtain G_T^{B*} =2.1 and G_T^{iB*} = 2.05 (figure available upon request). To obtain such result, keeping constant the parameters $\gamma, h,$ K and m of the previous numerical example, we have set the return to basic education equal to the return to tertiary education ($\alpha = 1$) and income inequality equal to its maximum value ($\delta = m$).

Figure 5. Group B's fixed point mapping (red: non-inclusive; green: inclusive)



4. Empirical evidence

Building on our theoretical results, in this section, we endeavour to explain countries' differences, as detailed in section 2, by examining the variations in income inequality, education systems' inclusiveness and the proportion of tertiary education graduates in the adult population. We collected data on three education-spending variables (public basic, public tertiary and total private) and the proportion of public basic education expenditure (public basic/total public) for 33 OECD countries covering two time periods. In the first period, expenditures are computed as averages over the years 2000 to 2006, and in the second period, averages are computed over the years 2010 to 2016 (see Table A3 in Appendix 3).

To support our arguments, we examine the correlations between education expenditure and the variables in our model that affect the level and composition of expenditures in the political equilibrium: income inequality, education system inclusiveness and the share of graduates in the population**.** One concern regards a potential reverse causality link whereby low public expenditure in education leads to more inequality, lower inclusiveness and a lower proportion of graduates. To try to address this problem, and strengthen our interpretation of the results in terms of the effects of these variables on the equilibrium outcome of the political game, we consider the values of income inequality, education system inclusiveness and share of tertiary education graduates that precede the observed values of education expenditure.[41] Income inequality is measured by the variable GINI, which is the Gini index of disposable income for the years 2000 and 2010.[42] To assess inclusiveness, we use the variable COR, which measures the correlation between the years spent on education by parent and child. We obtain data from the 2018 Global Database on Intergenerational Mobility from the World Bank (GDIM, 2018) for the 1970s and 1980s cohort.[43] Higher COR indicates higher intergenerational persistence in education, lower relative mobility and lower inclusiveness.[44] Finally, the variable SHARE refers to the share of tertiary education graduates in the adult population in 2000 and 2010, respectively, for the first and second periods (see Table A2 in Appendix 3).

Table 1 presents the outcome of a pooled linear regression between the four education spending variables (public basic, public tertiary, total private and public basic/total public) and our two main variables of interest (COR and GINI). To control for time effects, we add a dummy that takes value 0 in the first period and value 1 in the second. Consistent with the model's results, public expenditure on education (as percentage of GDP) is negatively correlated with COR and GINI, indicating that higher persistence in education and higher income inequality are associated with lower public education expenditure at both education levels. COR is significant in the relationship with basic education (column 1), while GINI is relevant in both equations (columns 1 and 2). In column 3, we add an interaction term between COR and GINI. The coefficient is positive and significant, implying

[41] A similar approach is followed by De la Croix and Doepke (2009).
[42] As discussed in section 4, in our model, income inequality only affects the public budget through the tax deductibility of private expenses, which are decided based on perfectly foresighted public expenses. Therefore, redistribution affects private expenditure decisions. For this reason, we use the Gini index computed for disposable income in our correlations.
[43] COR measures intergenerational persistence in education using Pearson's correlation coefficient between parents'and children's years of education. In the GDIM (2018), data are available for different cohorts; the 1980s (1970s) cohort refers to the generation born between 1980 (1970) and 1989 (1979) and their parents. For parents' educational attainment, we take the subpopulation 'max', which represents the greatest available values among parents. For children's educational attainment, we consider 'all' the respondents who belong to the cohort. Further information is available on the Description of Global Database on Intergenerational Mobility (GDIM, 2018).
[44] All the results in this section are unchanged if using the beta coefficient between the years of parents' and children's schooling available in the GDIM (2018).

that the negative relationship between COR and public tertiary spending lessens as inequality increases.[45] To clarify this relationship, we computed marginal effects (Figure A1 in Appendix 3). For tertiary education, these marginal effects suggest that the effect of COR on public tertiary spending depends on income inequality. The sign of the marginal effect of COR on public tertiary spending is negative for low values of GINI and becomes positive for high values. In light of the descriptive evidence reported in section 2, our suggested interpretation is that countries with a level of income inequality above the OECD average are also biased towards private expenditure at the tertiary level (e.g. the UK and the US). The relationship between COR and public tertiary spending is very weak in these countries. This interpretation is consistent with the regression considering private education spending as the variable of interest (column 4). Finally, and most notably, the marginal effect of COR on tertiary public spending becomes significantly positive for very high levels of income inequality. This fact seems to capture what we previously found for Mexico and Turkey, where the inclusiveness of the education system is extremely low (very high COR), and despite a remarkably high level of income inequality, the private education sector is not well developed. Therefore, only the élite benefit from public tertiary spending. A political equilibrium with public spending biased towards tertiary education therefore seems to be supported by the well-educated élite in these countries.[46]

As further evidence, in the last column of Table 1, we examine the share of public education spending devoted to basic education. As previously observed, spending on both education levels increases if the system is more inclusive (a negative sign in the COR coefficient); however, our model suggests that spending on tertiary education increases more; thus, the share of basic education decreases. The negative sign in column 5 is consistent with this theoretical result. Finally, the time dummy suggests

[45] In addition, the negative relationship between GINI and public tertiary spending is less strong when COR increases.
[46] As rightly emphasised by a referee, the rich may send children overseas for private education. Looking at the outbound mobility ratio, which is the 'number of students from a given country studying abroad, expressed as a percentage of total tertiary enrolment in that country', in 2016 Mexico and Turkey had very low mobility in comparison to the other countries in our dataset (UNESCO Institute for Statistics (http://data.uis.unesco.org/)).

a negative trend in basic education expenditure and a positive, although not always significant, trend in tertiary education expenditure, both public and private, whereas the share of basic public expenditure consistently presents a small decrease.

Table 1

	(1) Basic K-12 Public	(2) Tertiary Public	(3) Tertiary Public	(4) Total Private	(5) Basic Public/Total Public
Cor	-1.721**	-.046	-5.629***	-1.473*	-.089
	(.851)	(.401)	(2.048)	(.761)	(.066)
Gini	-2.179*	-2.014***	-10.118***	5.877***	.237**
	(1.187)	(.559)	(2.969)	(1.06)	(.093)
d2010	-.268*	.019	.014	.122	-.017
	(.151)	(.071)	(.068)	(.135)	(.012)
Cor#Gini			17.805***		
			(6.416)		
_cons	4.877***	1.655***	4.174***	-.597	.739***
	(.449)	(.212)	(.93)	(.401)	(.035)
Observations	66	66	66	66	66
R-squared	.168	.188	.279	.343	.122

*Notes:Standard errors are in parentheses. *** p<.01, ** p<.05, * p<.1*
COR is the Pearson's coefficient between parents' and children's years of education. The values of COR refer to individuals born in the 1970s and 1980s cohorts. GINI is the GINI net disposable in 2000 and 2010. d2010 is a time dummy that takes the value 0 in the first period and 1 in the second period. All expenditures are computed as averages over the years 2000–2006 and 2010–2016. See Tables A2 and A3 in Appendix 3 for further details. Source: author elaboration based on OECD, Eurostat, Barro–Lee (2013), World Bank and GDIM (2018) data.

We next consider the role of the proportion of tertiary education graduates in the adult population. Adding SHARE as a third variable in the regressions for the years 2000 and 2010 results in most coefficients of COR being insignificant. This is not surprising, given the high correlation between SHARE and COR (−0.50).[47] Table 2 presents the coefficients of the linear regressions using SHARE instead of COR, which suggest a positive and significant relationship between the share of graduates in the adult population and spending on education. According to our model, this result indicates that where the education level of the population is higher, the median voter is more educated and the demand for education is higher.

Table 2

	(1)	(2)	(3)	(4)	(5)

[47] The results are available from the authors upon request.

	Basic K-12 Public	Tertiary Public	Tertiary Public	Total Private	Basic Public/Total Public
Share	.026***	.007*	.09***	.022***	0
	(.008)	(.004)	(.018)	(.007)	(.001)
Gini	-2.009*	-1.801***	2.963***	6.009***	.21**
	(1.109)	(.535)	(1.1)	(.998)	(.093)
d2010	-.425***	-.036	-.054	-.009	-.017
	(.154)	(.074)	(.064)	(.138)	(.013)
Share#Gini			-.249***		
			(.052)		
_cons	3.547***	1.411***	-.227	-1.722***	.706***
	(.434)	(.209)	(.388)	(.39)	(.036)
Observations	66	66	66	66	66
R-squared	.253	.235	.443	.401	.098

*Notes:Standard errors are in parentheses. *** p<.01, ** p<.05, * p<.1*

SHARE is the share of population aged 25–64 with tertiary education in 2000 and 2010. Source: author elaboration based on OECD, Eurostat, Barro–Lee (2013), World Bank and GDIM (2018) data.

Adding an interaction term between SHARE and GINI confirms our theoretical conjecture that as income inequality increases, the positive effect of a high share of graduates on tertiary public expenditure becomes weaker, up to the point at which it becomes negative (Figure A2 in Appendix 3). This is because, in the presence of higher income inequality, a high share of graduates in the population boosts private expenses and reduces the public budget allocated to advanced studies.

The empirical evidence presented here is consistent with the results of our model as summarised in section 3.6.1. Countries with public expenditure that is remarkably high, where private expenditure is almost non-existent, have very inclusive education systems (low COR), high shares of tertiary education graduates in the population and low levels of inequality. In contrast, high private spenders have a Gini index and a COR value above the OECD average. Moreover, a high share of graduates boosts both public and private education expenditure. In low-spending countries, except for Turkey and Mexico, income inequality is around the average or slightly above, the inclusiveness of the education system is generally low and the countries have a level of graduates around or below the average. Congruent with our model, these features translate into a political equilibrium featuring low education expenditure, particularly at the tertiary level. In contrast, Turkey and Mexico, where income inequality is remarkably high, are biased towards public tertiary education. We interpret these circumstances as the equilibrium outcome obtained when political power is granted to the rich and well-educated élite and private alternatives in the tertiary sector are not fully developed (Su, 2006).

5. Conclusion and policy implications

In this study, following a political economy approach, we investigate OECD countries' differences in education systems. The aim is to present a positive theory to explain the observed mix of public and private education spending and the allocation of public funds between basic (primary plus secondary) and tertiary education. To analyse this issue, we propose a model wherein the public education budget and its allocation are endogenously determined through majority voting. Our model predicts that in countries characterised by a non-inclusive education system and a low share of graduates in the population, the public education budget is kept at a low level and public funding for higher education is scarcely supported. The empirical evidence seems to confirm this conjecture, indicating that the amount of resources devoted to education is low in poorly educated societies, precisely where more investment in public education is needed. This policy choice is self-reinforcing, as it prevents aggregate human capital accumulation and could lock countries into 'low education' equilibria (for example, Italy). In contrast, in countries characterised by a high share of graduates in the population, our model exhibits multiple equilibria. Such countries may either have a strong public system in which many or all affluent households participate (for example, Nordic European countries), or a system characterised by low public education expenditure (unbalanced towards basic education), where wealthy families use private education providers, particularly at the tertiary level. The divide between the two education models appears to be related to the level of income inequality. The relationship is confirmed by cross-country data collected for 33 OECD countries and appears to explain the falling political support for public tertiary education as income inequality increases; for example, this is a phenomenon observed in the US, despite the growing number of university graduates over time.[48]

[48] We thank Professor Joseph Joyce for stressing this point.

In summary, the main policy message of our analysis is that increasing public expenditure to favour educational upward mobility might not be politically sustainable. Contrary to conventional wisdom, low social status households might oppose a rise in the level of education expenditure, particularly at the tertiary level. This position can obtain the political support of the more affluent segment of the population interested in reducing the public budget in favour of private expenditure. To escape the low education equilibrium, rather than a generic increase in public education spending, reforms are needed to improve the inclusiveness of the education system. Even if these reforms are not cost-cutting, they could receive the political support of the low educated majority, as greater inclusiveness allows these families to benefit longer from public spending on education. In this way, a virtuous circle could be triggered that could lead to a significant increase in educational upward mobility and the share of tertiary education graduates in the adult population over time.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available at

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Appendix 1
TABLE A1 (a): Education expenditures as share of GDP

Country	Year	Total education expenditure %GDP	Public education expenditure % GDP	Public education expenditure %GDP K-12	Public education expenditure % GDP Tertiary	Bias public tertiary/public K-12	Private education expenditure %GDP	Private education expenditure %GDP K-12	Private education expenditure %GDP Tertiary
Australia	2016	5.83	3.94	3.18	0.75	0.78	1.89	0.73	1.15
Austria	2016	4.89	4.64	3.00	1.64	1.79	0.26	0.14	0.11
Belgium	2016	5.70	5.34	4.11	1.23	0.98	0.36	0.14	0.22
Canada	2016	5.88	4.44	3.19	1.25	1.29	1.44	0.34	1.10
Chile	2016	6.06	3.79	2.99	0.80	0.88	2.27	0.60	1.67
Czech Republic	2016	3.42	2.98	2.29	0.69	0.99	0.44	0.22	0.22
Denmark	2014	6.45	6.24	4.67	1.56	1.10	0.21	0.12	0.09
Estonia	2016	4.33	3.94	2.70	1.24	1.51	0.39	0.20	0.19
Finland	2016	5.48	5.39	3.85	1.55	1.32	0.09	0.03	0.06
France	2016	5.15	4.50	3.38	1.12	1.08	0.65	0.35	0.31
Germany	2016	4.15	3.58	2.57	1.01	1.28	0.57	0.38	0.19
Greece	2015	3.67	3.37	2.65	0.72	0.89	0.31	0.19	0.11
Hungary	2016	4.27	3.54	2.86	0.67	0.77	0.74	0.36	0.37
Iceland	2016	5.53	5.27	4.15	1.12	0.88	0.26	0.16	0.10
Israel	2016	6.00	4.82	4.03	0.79	0.64	1.18	0.51	0.68
Italy	2016	3.59	3.14	2.59	0.54	0.69	0.45	0.13	0.32
Japan	2016	4.04	2.87	2.45	0.42	0.57	1.17	0.21	0.96
South Korea	2016	5.09	3.59	2.97	0.62	0.68	1.50	0.48	1.02
Latvia	2016	4.13	3.73	3.05	0.68	0.73	0.40	0.08	0.32
Lithuania	2016	3.57	3.11	2.38	0.73	1.00	0.45	0.11	0.34
Mexico	2016	5.08	3.96	3.01	0.94	1.03	1.12	0.70	0.42
Netherlands	2016	5.16	4.25	3.11	1.14	1.21	0.92	0.42	0.50
New Zealand	2016	6.42	4.74	3.86	0.88	0.75	1.68	0.82	0.86
Norway	2016	6.48	6.34	4.57	1.78	1.28	0.14	0.02	0.11
Poland	2016	4.31	3.83	2.89	0.93	1.06	0.49	0.27	0.22
Portugal	2016	4.87	4.07	3.36	0.71	0.69	0.80	0.44	0.36
Slovak Republic	2016	3.67	3.12	2.42	0.69	0.94	0.55	0.27	0.28
Slovenia	2016	4.21	3.76	2.91	0.84	0.95	0.45	0.30	0.14
Spain	2016	4.29	3.46	2.65	0.81	1.01	0.83	0.42	0.41
Sweden	2016	5.34	5.16	3.80	1.36	1.17	0.19		0.19
Turkey	2016	5.42	4.06	2.65	1.41	1.74	1.36	0.88	0.48
United Kingdom	2016	6.19	4.24	3.74	0.49	0.43	1.96	0.67	1.29
United States	2016	6.04	4.07	3.22	0.85	0.87	1.97	0.31	1.66
OECD 33 average		4.99	4.16	3.19	0.97	1.00	0.83	0.34	0.50

Source: OECD Statistics and Education at a Glance Database (http://stats.oecd.org/).

Table A1 (b): Education expenditures per student as share of GDP per capita

Country	Year	Total education expenditure per student %GDP per capita	Public education expenditure per student % GDP per capita	Public education expenditure per student %GDP per capita K-12	Public education expenditure per student % GDP per capita Tertiary	Bias public tertiary/public K-12	Private education expenditure per student %GDP per capita	Private education expenditure per student %GDP per capita K-12	Private education expenditure per student %GDP per capita Tertiary
Australia	2016	0.53	0.30	0.17	0.13	0.64	0.23	0.04	0.19
Austria	2016	0.64	0.60	0.27	0.33	1.05	0.04	0.01	0.02
Belgium	2016	0.63	0.57	0.25	0.32	1.09	0.07	0.01	0.06
Canada	2016	0.76	0.49	0.21	0.28	1.13	0.27	0.02	0.25
Chile	2016	0.58	0.30	0.18	0.12	0.57	0.28	0.04	0.25
Czech Republic	2016	0.47	0.39	0.18	0.21	0.98	0.08	0.02	0.07
Denmark	2014	0.59	0.56	0.26	0.30	0.99	0.02	0.01	0.02
Estonia	2016	0.61	0.54	0.21	0.34	1.40	0.07	0.02	0.05
Finland	2016	0.61	0.60	0.23	0.37	1.40	0.02	0.00	0.01
France	2016	0.62	0.52	0.22	0.30	1.16	0.10	0.02	0.08
Germany	2016	0.57	0.49	0.20	0.29	1.27	0.08	0.03	0.05
Greece	2016	0.32	0.30	0.21	0.09	0.39	0.02		0.02
Hungary	2016	0.67	0.49	0.23	0.26	1.00	0.18	0.03	0.15
Iceland	2016	0.49	0.46	0.22	0.25	0.99	0.03	0.01	0.02
Israel	2016	0.52	0.36	0.20	0.17	0.72	0.16	0.03	0.13
Italy	2016	0.51	0.39	0.21	0.18	0.74	0.12	0.01	0.11
Japan	2016	0.71	0.37	0.23	0.14	0.54	0.34	0.02	0.32
South Korea	2016	0.60	0.38	0.27	0.11	0.33	0.22	0.04	0.18
Latvia	2016	0.53	0.44	0.25	0.19	0.65	0.10	0.01	0.09
Lithuania	2016	0.44	0.35	0.18	0.17	0.81	0.09	0.01	0.08
Mexico	2016	0.55	0.40	0.13	0.27	1.76	0.15	0.03	0.12
Netherlands	2016	0.58	0.45	0.19	0.26	1.16	0.14	0.03	0.11
New Zealand	2016	0.63	0.40	0.20	0.19	0.83	0.23	0.04	0.19
Norway	2016	0.61	0.59	0.24	0.35	1.29	0.02	0.00	0.02
Poland	2016	0.57	0.49	0.23	0.26	0.97	0.08	0.02	0.06
Portugal	2016	0.61	0.47	0.25	0.22	0.75	0.14	0.03	0.11
Slovak Republic	2016	0.58	0.45	0.19	0.26	1.14	0.13	0.02	0.10
Slovenia	2016	0.58	0.51	0.23	0.28	1.03	0.07	0.02	0.05
Spain	2016	0.57	0.43	0.20	0.23	0.96	0.14	0.03	0.11
Sweden	2016	0.71	0.65	0.24	0.42	1.53	0.06		0.06
Turkey	2016	0.57	0.42	0.13	0.29	1.98	0.14	0.04	0.10
United Kingdom	2016	0.79	0.37	0.22	0.16	0.62	0.41	0.04	0.37
United States	2016	0.75	0.39	0.21	0.18	0.76	0.36	0.02	0.34
OECD 33 average		0.59	0.45	0.21	0.24	0.99	0.14	0.02	0.12

Source: Own elaboration based on OECD Statistics and Education at a Glance Data (http://stats.oecd.org/).

Appendix 2

Proof Lemma 1

Assuming that the household is planning to choose public tertiary education, the expected utility is given by eq. (2) substituting $h_T = G_T^e$

$$EU(c, h_B, G_T^e) = ln\left((1-\tau)h_p x\right) + \gamma\, ln(h_B) + \boldsymbol{I}\gamma\eta(h_B)\, ln(G_T^e)$$

with **I** =0 for $G_T^e < 1$ and **I**=1 for $G_T^e \geq 1$.

The expected utility of the opting out decision is instead given by eq. (2) setting $h_T = e^*$

$$\begin{aligned} EU(c, h_B, e^*) &= ln\left((1-\tau)\left(h_p x - e^*\right)\right) + \gamma\,[ln(h_B) + \eta(h_B)\, ln(e^*)] \\ &= ln(1-\tau) + ln\left(\frac{1}{\gamma+1}h_p x\right) + \gamma\, ln\,(h_B) + \gamma\eta(h_B) ln\left(\frac{\gamma}{\gamma+1}h_p x\right) \end{aligned}$$

Imposing $EU(c, h_B\,, G_T^e) = EU(c, h_B, e^*)$, we obtain eq. 6(a) and eq. 6(b).

Proof Lemma 2

It is straightforward to show that the budget increases with the tax rate τ. To prove that the budget is monotone nondecreasing in G_T^e, note that the rate of opting out decreases with G_T^e ($\frac{\partial\Omega}{\partial G_T^e} \leq 0$). This implies that the level of private expenditures in tertiary education (which are tax deductible) decreases with G_T^e. To prove that the budget decreases with δ when $\hat{x}(G_T^e)^2 > m^2 - \delta^2$, it is sufficient to take the first derivative of the budget in eq. (9) with respect to δ, when $m - \delta < \hat{x}(G_T^e) < m + \delta$.

Proof Proposition 1

For each $P \in \{A, B\}$, given Assumption 2, $\Delta^P(G_T^e) > 1$ and it is continuous monotone nondecreasing in G_T^e (see lemma 2), with $G_T^e \in \mathbb{R}_+$.[49] Its minimum value is obtained for $0 \leq G_T^e \leq 1$

$$\min \Delta^P(G_T^e) = z^P \left[M - K\frac{\gamma}{4\delta(1+\gamma)}\left((m+\delta)^2 - max\left[m-\delta, \left(\frac{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}{\gamma}\right)\right]^2\right)\right]$$

The maximum value is obtained when $\hat{x}(G_T^e) \geq m + \delta$. In this case, public tertiary education spending is equal to its maximum

$$\max \Delta^P(G_T^e) = z^P M$$

There are two possibilities:

(i) $z^P M < \frac{\gamma(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}$

(ii) $z^P M \geq \frac{\gamma(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}$

First, we have to show that the function $\Delta^P(G_T^e)$ crosses the 45-degree line exactly once when $z^P M < \frac{\gamma(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}$. In this case, $\Delta^P(G_T^e) < G_T^e$ when $G_T^e = \frac{\gamma(m+\delta)}{(1+\gamma)^{\frac{1+\gamma}{\gamma}}}$, while $\Delta^P\,(G_T^e) > G_T^e$ when $0 \leq G_T^e \leq 1$. We can exclude that $\Delta^P(G_T^e)$ crosses more than once, as the relationship between the budget and G_T^e is quadratic, and it is easy to verify that first derivative of the function $\Delta^P(G_T^e)$ with respect to G_T^e is monotone nondecreasing. Therefore, $\Delta^P(G_T^e)$ crosses the 45-degree line only once and the fixed point G_T^{P*} lies in the interval $1 < G_T^{P*} < z^P M$.

In the case (ii), there is instead the possibility of triple crossing.[50] $\Delta^P(G_T^e)$ will certainly cross the 45-degree line at $G_T^e = z^P M$ and therefore the fixed point $G_T^{P*} = z^P M$ always exists. The function might

[49] Being $\Delta^P(G_T^e)$ a monotone transformation of the budget function *F*, its continuity and monotonicity follows from continuity and monotonicity of *F* (see eq. (9) in section 3).

[50] By utilizing the same argument as in the case (i), we can exclude the existence of more than three fixed points.

double cross below $z^P M$ and in this case, we might have two additional interior fixed points with $1 < G_T^{P*} < z^P M$.
For $P = C$, as $\Delta^C(G_T^e) = 0$ $\forall G_T^e$, there exists a unique fixed point $G_T^{C*} = 0$ for $G_T^e = 0$.

Proof Proposition 2
2.1 To prove that $G_T^{B*} > G_T^{A*}$ recall that $z^B > z^A$. When $G_T^{P*} = z^P M$ the result is obvious.
Suppose that $G_T^{P*}$is an interior fixed point and consider the following function

$$Z\left(G_T^P, \Delta^P(G_T^P)\right) = G_T^P - z^P\left[\left[M - K\frac{\gamma}{1+\gamma}\Omega(G_T^P,\delta)\left(m + \delta\left(1 - \Omega(G_T^P,\delta)\right)\right)\right]\right] = 0 \quad \text{(A.1)}$$

As G_T^{P*} is a solution of (A.1), by the implicit fuction theorem, we can write

$$\frac{dG_T^{P*}}{dz^P} = -\frac{\frac{\partial Z}{\partial z^P}}{\frac{\partial Z}{\partial G_T^{P*}}} < 0$$

Indeed, the numerator ($\frac{\partial Z}{\partial z^P}$) has negative sign. The denominator ($\frac{\partial Z}{\partial G_T^{P*}}$) has positive sign because, when $G_T^{P*}$is an interior solution and a focal point, the function $\Delta^P(G_T^e)$ has a positive slope smaller than 1 in G_T^{P*}.
2.2 To prove that for $P = A$ $\frac{dG_T^{A*}}{d\eta} > 0$, we first note that $\frac{dz^A}{d\eta}$>0. Hence, the result is obvious when $G_T^{A*} = z^A M$. Suppose that G_T^{A*} is an interior solution, and consider the function (A.1). By the implicit function theorem, we can write:

$$\frac{dG_T^{A*}}{d\eta} = -\frac{\frac{\partial Z}{\partial \eta}}{\frac{\partial Z}{\partial G_T^{P*}}}$$

The numerator ($\frac{\partial Z}{\partial \eta}$) has negative sign for *P=A*. The denominator ($\frac{\partial Z}{\partial G_T^{P*}}$) has positive sign because, when $G_T^{P*}$is an interior solution and a focal point, the function $\Delta^P(G_T^e)$ has a positive slope smaller than 1 in G_T^{P*}; thus, $\frac{dG_T^{A*}}{d\eta} > 0$.
2.3 Firstly note that when $G_T^{P*} = z^P M$, $\frac{dG_T^{P*}}{d\delta} = 0$. Focusing on interior solutions, to prove that $\frac{dG_T^{P*}}{d\delta} \leq 0$, iff $\hat{x}(G_T^{P*})^2 \geq m^2 - \delta^{\,2}$, consider the function (A.1) . By the implicit fuction theorem, we can write

$$\frac{dG_T^{P*}}{d\delta} = -\frac{\frac{\partial Z}{\partial \delta}}{\frac{\partial Z}{\partial G_T^{P*}}}$$

The numerator sign depends on the sign of the public budget derivative with respect to inequality. Therefore, from Lemma 2 $\frac{\partial Z}{\partial \delta} > 0$ iff $\hat{x}(G_T^{P*})^2 > m^2 - \delta^{\,2}$. The denominator ($\frac{\partial Z}{\partial G_T^{P*}}$) has positive sign because, when $G_T^{P*}$is an interior solution and a focal point the function $\Delta^P(G_T^e)$has a positive slope smaller than 1; thus, $\frac{dG_T^{P*}}{d\delta} < 0$ iff $\hat{x}(G_T^{P*})^2 > m^2 - \delta^{\,2}$

Proof Proposition 3
Consider only focal fixed points.

3.1 For $[\tau^* = \tau^A,\ \phi^* = \phi^A]$ to be a political equilibrium of the voting game, with $G_T^e = G_T^{A*}$, it must be $\Omega(G_T^{A*}, \delta) \leq \frac{1}{2K}$ (group C is not majoritarian), and $1 - \Omega(G_T^{A*}, \delta) \leq \frac{1}{2K}$ (group B is not majoritarian). Recalling that the measure of group A does not depend on the opting out rate, if A is majoritarian ($1-K>\frac{1}{2}$), these two conditions are always satisfied for any $1< G_T^{A*} \leq z^A M$; thus, $[\tau^* = \tau^A,\ \phi^* = \phi^A]$ is the unique political equilibrium.

3.2 From Proposition 1 and Proposition 2, $G_T^{C*} < G_T^{A*} < G_T^{B*}$ and $\Omega(G_T^{C*},\delta) > \Omega(G_T^{A*},\delta) > \Omega(G_T^{B*},\delta)$. To show that at least one political equilibrium exists, note that if neither $[\tau^* = \tau^C,\ \phi^* = \phi^C]$ nor $[\tau^* = \tau^B,\ \phi^* = \phi^B]$ are political equilibria, that is if $1-\Omega(G_T^{B*},\delta) \leq \frac{1}{2K}$ and $\Omega(G_T^{C*},\delta) \leq \frac{1}{2K}$, then $[\tau^* = \tau^A,\ \phi^* = \phi^A]$ is certainly a political equilibrium with $G_T^e = G_T^{A*}$. In fact, $1-\Omega(G_T^{B*},\delta) \leq \frac{1}{2K}$ implies $1-\Omega(G_T^{A*},\delta) < \frac{1}{2K}$ (group B is not majoritarian); whereas $\Omega(G_T^{C*},\delta) \leq \frac{1}{2K}$ implies $\Omega(G_T^{A*},\delta) < \frac{1}{2K}$ (group C is not majoritarian). In this political equilibrium, group A is pivotal, although not majoritarian (see preferred policies ranking in expression (10) in the text).

To show that a multiplicity of political equilibria might arise, note that for the fixed points $G_T^{A*}, G_T^{B*}, G_T^{C*}$ to be associated with political equilibria the following conditions must be satisfied:

(i) $1-\Omega(G_T^{A*},\delta) \leq \frac{1}{2K}$ and $\Omega(G_T^{A*},\delta) \leq \frac{1}{2K}$ for G_T^{A*};

(ii) $1-\Omega(G_T^{B*},\delta) > \frac{1}{2K}$ for G_T^{B*}; and

(iii) $\Omega(G_T^{C*},\delta) > \frac{1}{2K}$ for G_T^{C*}.

These conditions might be simultaneously satisfied.

Appendix 3
Table A2

Country	COR	Gini net disposable income[51]	Share of graduates aged 25-64[52]	COR[53]	Gini net disposable income[54]	Share of graduates aged 25-64[55]
	Cohort 1970s	2000		Cohort 1980s	2010	
Australia	0.22	0.32	27.5	0.25	0.33	37.6
Austria	0.32	0.24	24.8	0.46	0.28	27.7
Belgium	0.49	0.30	27.1	0.49	0.26	35.0
Canada	0.32	0.32	40.1	0.32	0.32	50.3
Chile	0.56	0.53	10.1	0.51	0.51	17.1
Czech Republic	0.46	0.25	11.0	0.38	0.26	16.8
Denmark	0.35	0.23	25.8	0.17	0.25	33.3
Estonia	0.29	0.36	28.7	0.32	0.32	35.4
Finland	0.36	0.26	32.6	0.30	0.27	38.1
France	0.45	0.29	21.6	0.39	0.30	29.0
Germany	0.37	0.26	23.5	0.32	0.29	26.6
Greece	0.53	0.33	17.7	0.49	0.34	24.7
Hungary	0.54	0.29	14.0	0.63	0.27	20.1
Iceland	0.33	0.26	26.9	0.38	0.25	32.6
Israel	0.50	0.35	42.1	0.40	0.38	45.6
Italy	0.51	0.32	9.4	0.45	0.32	14.8
Japan	0.32	0.34	33.6	0.31	0.34	44.8
South Korea	0.36	0.31	23.8	0.35	0.31	39.0
Latvia	0.33	0.34	18.2	0.38	0.36	26.9
Lithuania	0.34	0.31	12.5	0.39	0.34	32.4
Mexico	0.46	0.51	14.6	0.50	0.47	14.7
Netherlands	0.40	0.29	23.4	0.38	0.28	32.4
New Zealand	0.21	0.34	22.8	0.21	0.32	40.6
Norway	0.41	0.26	30.7	0.28	0.25	37.3
Poland	0.48	0.30	11.4	0.45	0.31	22.5
Portugal	0.51	0.36	8.8	0.40	0.35	15.4
Slovak Republic	0.43	0.27	10.4	0.42	0.26	17.3
Slovenia	0.43	0.22	15.7	0.31	0.25	23.7
Spain	0.47	0.32	22.7	0.43	0.34	31.0
Sweden	0.45	0.24	30.1	0.39	0.27	33.9
Turkey	0.43	0.46	8.3	0.51	0.42	13.1
United Kingdom	0.38	0.35	25.7	0.27	0.34	38.2
United States	0.47	0.36	36.5	0.41	0.38	41.7
OECD 33 average	0.41	0.32	22.2	0.38	0.32	30

Source: OECD Statistics (http://stats.oecd.org/) and Education at a Glance; GDIM (2018), Barro-Lee (2013), Eurostat, World Bank data.

[51] Data for South Korea refer to 2006, for Czech Republic refer to 2001, for Iceland and Slovak Republic refer to 2004 and for Turkey to 2002. For Austria, Belgium, Czech Republic, Estonia, Greece, Latvia, Lithuania, Poland, Portugal, Slovenia, Spain and Turkey we take the Gini of equivalised income available at the Eurostat Database (https://ec.europa.eu/eurostat/data/database)because of the unavailability of the OECD data. For Chile, we take the value of Gini index from the World Bank Open Data (https://data.worldbank.org/).

[52]The value for Israel refers to 2002, for Iceland to 2003 and for Austria to 2004. Data for Lithuania, New Zealand and Chile are taken from Barro-Lee (2013) dataset on educational attainment of people aged 25-64.

[53] The correlation coefficient for New Zealand is available only for the 1970s cohort. We use the same value also for the 1980s cohort.

[54] Data for Chile, Japan, and New Zealand refer to 2009.

[55] Data for Chile refer to 2009.

Table A3

Country	Average Public Education Expenditure %GDP K-12	Average Public Education Expenditure % GDP Tertiary	Average Basic K-12/ Total Public Education Expenditure	Average Private Education Expenditure %GDP	Average Public Education Expenditure %GDP K-12	Average Public Education Expenditure % GDP Tertiary	Average Basic K-12/ Total Public Education Expenditure[56]	Average Private Education Expenditure %GDP
	2000-2006				2010-2016			
Australia	3.51	0.79	0.82	1.48	3.34	0.74	0.82	1.74
Austria	3.65	1.16	0.76	0.20	3.01	1.64	0.65	0.24
Belgium	3.90	1.20	0.76	0.27	4.14	1.23	0.77	0.32
Canada	3.22	1.48	0.69	1.22	3.31	1.33	0.71	1.56
Chile	2.96	0.41	0.88	2.56	2.70	0.70	0.80	2.32
Czech Republic	2.81	0.86	0.77	0.39	2.43	0.86	0.74	0.48
Denmark	4.22	1.70	0.71	0.13	4.46	1.59	0.74	0.22
Estonia	3.61	0.91	0.80	0.08	3.04	1.17	0.72	0.41
Finland	3.78	1.69	0.69	0.04	3.91	1.70	0.70	0.10
France	3.90	1.07	0.78	0.40	3.45	1.14	0.75	0.64
Germany	2.85	0.96	0.75	0.74	2.70	1.02	0.73	0.58
Greece	2.48	1.15	0.68	0.17	2.65	0.70	0.79	0.32
Hungary	3.14	0.91	0.78	0.45	2.60	0.73	0.78	0.61
Iceland	5.11	1.01	0.84	0.26	4.29	1.08	0.80	0.27
Israel	4.48	1.13	0.80	1.06	3.93	0.83	0.82	1.17
Italy	3.38	0.72	0.82	0.30	2.80	0.60	0.82	0.45
Japan	2.65	0.48	0.85	1.02	2.60	0.47	0.85	1.19
South Korea	3.42	0.54	0.86	2.84	2.97	0.62	0.78	1.50
Latvia	2.07	0.72	0.74	0.64	3.07	0.87	0.78	0.48
Lithuania	3.31	0.88	0.79	0.47	2.66	1.13	0.70	0.50
Mexico	3.55	0.87	0.80	0.95	3.17	0.93	0.77	1.09
Netherlands	3.20	1.03	0.76	0.46	3.19	1.14	0.74	0.95
New Zealand	4.26	0.92	0.82	0.82	3.96	0.94	0.81	1.71
Norway	4.10	1.33	0.75	0.01	4.65	1.60	0.74	0.08
Poland	3.86	1.02	0.79	0.37	3.08	1.01	0.75	0.54
Portugal	4.00	0.96	0.81	0.19	3.56	0.77	0.82	0.96
Slovak Republic	2.61	0.79	0.77	0.36	2.46	0.81	0.76	0.57
Slovenia	3.84	1.02	0.79	0.30	3.22	0.95	0.77	0.48
Spain	2.85	0.93	0.75	0.46	2.74	0.90	0.75	0.71
Sweden	4.36	1.51	0.74	0.19	3.71	1.42	0.72	0.17
Turkey	2.40	0.95	0.71	0.12	2.50	1.30	0.66	1.28
United Kingdom	3.73	0.81	0.82	0.90	3.84	0.61	0.87	1.77
United States	3.69	1.04	0.78	2.11	3.31	0.97	0.77	1.98
OECD 33 Average	3.48	1.00	0.78	0.66	3.26	1.02	0.76	0.83

Source: Own elaboration based on OECD Statistics (http://stats.oecd.org/) and Education at a Glance, various years.
Notes: Total public is computed as the sum of basic K-12 public and tertiary public. Total private is calculated as the sum of basic K-12 private and tertiary private.

[56] Since the indicator is constructed as a ratio of basic K-12 spending over public spending, we rule out values referred to a specific year whenever one of the two values is not available for that year.

Notes to Table A3

Austria	Data for 2010 and 2011 are missing.
Canada	Data for 2003 are missing.
Chile	Data for 2001 are missing.
Denmark	Data for 2015 and 2016 are missing.
Estonia	Data for 2001, 2002, and 2003 are missing. Data for 2000 and 2004 are missing for total private and tertiary private.
Greece	Data for 2006, 2010 and 2011 are missing. Data for 2016 are missing for private expenditures.
Hungary	Data for 2010 and 2011 are missing for private spending.
Japan	Data for 2013, 2014, 2015 are missing.
Korea	No data on education spending are available over the period 2010-2015.
Latvia	Data for 2001, 2002, 2003, 2004 and 2006 are missing.
Lithuania	Data for 2001, 2002, 2003, 2004 and 2006 are missing. Data for 2000 and 2005 are missing for total private and basic private. Used the tertiary private value in 2005 as a proxy for total private.
Mexico	Data for 2012 are missing for tertiary private and total private.
New Zealand	Data for 2010 and 2011 are missing. Data for 2000 and 2001 are missing for private spending.
Norway	Data for 2003, 2004, 2005, 2006 are missing for private spending.
Poland	Data for 2000 and 2001 are missing for private spending.
Portugal	Data for 2010 and 2011 are missing for private spending.
Slovenia	Data for 2000, 2001, 2002, 2003 are missing.
Turkey	Data for 2003 and 2005 are missing. Data for 2001, 2006 and 2010 are missing for private spending.
United Kingdom	Data for 2010 are missing. Data for 2011 are missing for public tertiary spending.

Table A4

Variable	Definition
COR	Pearson's correlation coefficient between parents' and children's years of education
GINI	Gini coefficient on net disposable income
SHARE	Share of population aged 25–64 with tertiary education
d2010	Time dummy that takes value 0 in the first period and 1 in the second period
Basic K-12 Public	Public expenditure in primary, secondary education and post-secondary non-tertiary education (ISCED 2011, levels 1 to 4) as a share of GDP
Tertiary Public	Public expenditure in tertiary education (ISCED 2011, levels 5 to 8) as a share of GDP
Total Private	Private expenditure in primary, secondary education, post-secondary education and tertiary education (ISCED 2011, levels 1 to 8) as a share of GDP
Basic Public / Total Public	Share of basic K-12 public on total public expenditure in education

Figure A1. Average marginal effects of COR on Public Tertiary spending for increasing values of GINI

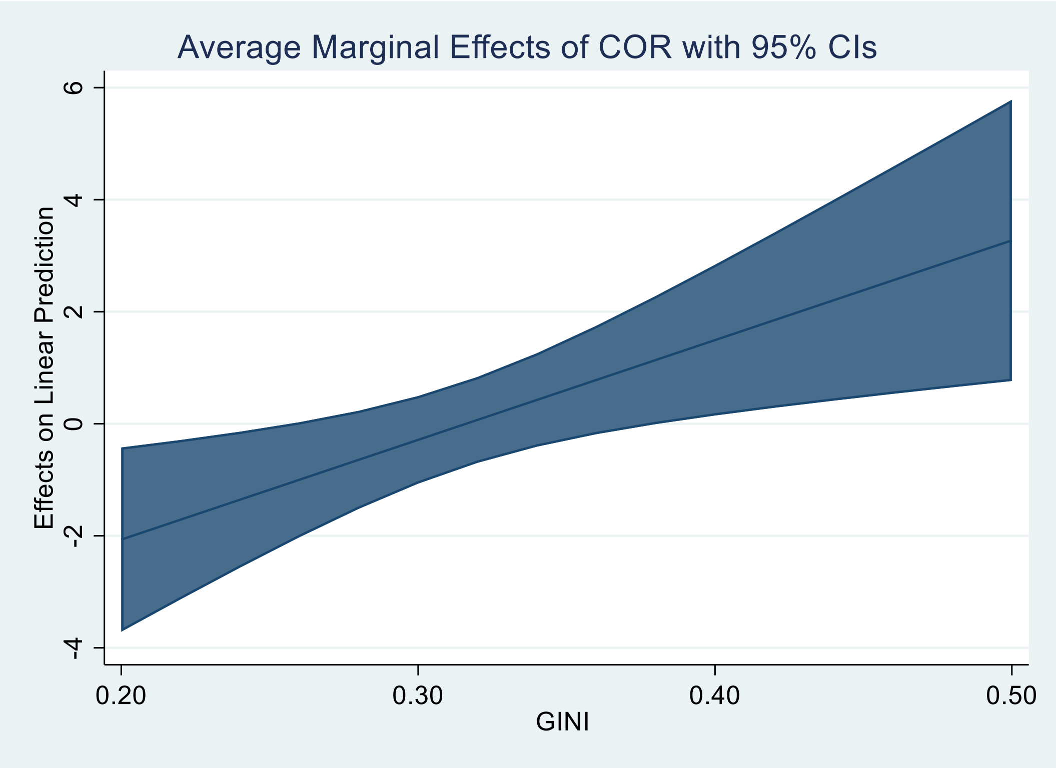

Figure A2. Average marginal effects of SHARE on Public Tertiary spending for increasing values of GINI