Inequality and Education Spending in a Greying Society*

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May 3, 2019

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Abstract

Increasing income inequality and population ageing are two major trends in developed countries. These trends intensify both the intragenerational conflict between rich and poor and the intergenerational conflict between young and old. In this paper, we consider these conflicts simultaneously and analyse the effect of inequality and ageing on the level of public education and pensions spending. For this, we develop an overlapping generations model with public and private education, a pay-as-you-go pension system, endogenous fertility, and probabilistic voting on pensions and education spending. In this model, an increase in income inequality increases public education and pensions spending per enrolled student and retiree, respectively. An increase in the share of retirees in the economy decreases the per student spending on public education and pensions. The results from a panel data analysis on OECD countries are mostly in line with our theoretical predictions regarding public education spending.

Keywords: Education Spending, Pay-As-You-Go Pension System, Inequality, Population Ageing, Intergenerational Conflict, Voting.

JEL Classifications: D72, E62, H52, H55, I24, J11.

*We are grateful for the comments from Concepció Patxot, Gemma Abió, and Matthias Doepke.

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1 Introduction

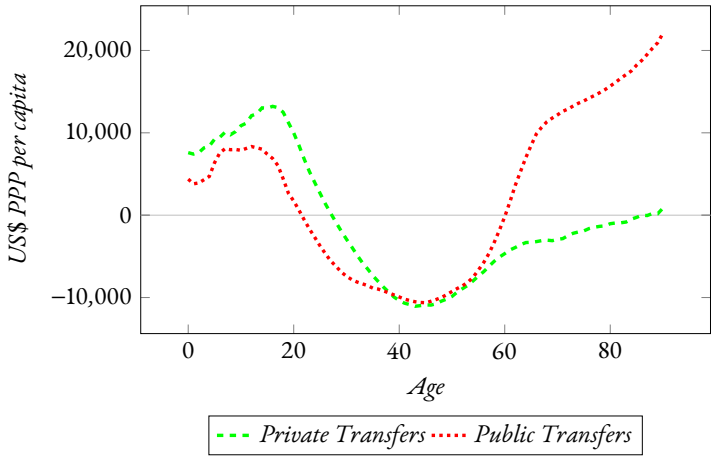
Population ageing has become an issue of growing concern for OECD countries, especially as the generation of "baby boomers" reach retirement age, putting considerable pressure on pensions system and the welfare state. Parallel to this, during the last decades there was a strong increase in income inequality. These trends have drawn attention to the public finance of education and the sustainability of public pensions as they aggravate two of the main political conflicts over the welfare state. The increase in income inequality intensifies the intragenerational conflict between rich and poor over redistribution in the form of public education. Population ageing exacerbates the intergenerational conflict over the allocation of resources between elderly and young.

These conflicts are examined in the literature on the political economy of pensions and education. In this literature, most of the studies consider these conflicts in isolation. Studies on the intergenerational conflict use a one dimensional voting process where voters decide either on the allocation or the size of government spending on pensions and education (Soares, 2006; Kaganovich and Zilcha, 2012; Naito, 2012). Other studies consider two dimensional voting models where the allocation and the size are determined jointly (Rangel, 2003; Lancia and Russo, 2016; Ono and Uchida, 2016). In the literature on the intragenerational conflict parents are allowed to opt-out of public education by sending their children to private schools, which generates diverging interests between rich and poor (Stiglitz, 1974; Glomm and Ravikumar, 1992; Levy, 2005; De La Croix and Doepke, 2009).

This paper is most related to Naito (2012); Ono and Uchida (2016); Levy (2005) and De La Croix and Doepke (2009). In Naito (2012) these conflicts are boiled down to a political dispute between a coalition of retirees and poor middle-aged and a coalition of rich middle-aged. This study shows that in a repeated majority voting game there is a politico-economic equilibrium where a high initial level of income inequality reduces the size of public education and pensions. Ono and Uchida (2016) consider the intergenerational conflict over pensions and education spending in a probabilistic voting setting. An increase in longevity increases total public pension spending, but the effect of longevity on education is hump shaped. Levy (2005) introduces a model of endogenous political party formation, where there is income redistribution between rich and poor as well as redistribution between young and old in the form of public education. There are four voting groups as agents are differentiated according to their income and age. In this model, if the young are in a minority there is high level of public education provision but the opposite outcome occurs when the young constitute a majority in population. De La Croix and Doepke (2009) show that in an probabilistic voting setting with private and public education, an increase in income inequality that decreases public education participation increases public education quality, but private education can crowd out public education if the political process is dominated by the rich.

We contribute to this literature by augmenting the probabilistic voting model on public and private education developed in De La Croix and Doepke (2009) by the dimension of a pay-as-you-go pension system. This allows us to consider the two political conflicts together and investigate the effect of income inequality and population ageing on education and pension spending. Moreover, we depart from Naito (2012) and Ono and Uchida (2016) by allowing agents to opt-out of public education, and from Levy (2005) by considering pensions for the old. In our model the preferences of heterogeneous agents are aggregated through probabilistic voting. Our goal is to determine simultaneously the size of the government and the allocation

Figure 1: *The Life Cycle of Intergenerational Transfers*



NOTE: *This graph depicts the allocation of private and public intergenerational transfers among generations through life. Source: National Transfer Accounts (NTA) data are taken from Lee and Mason (2011).*

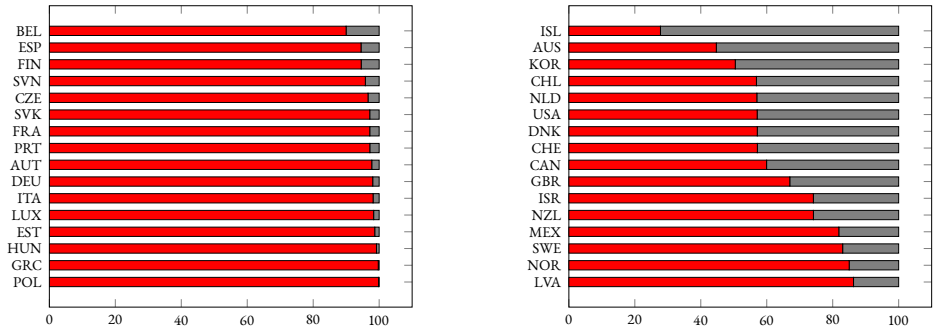
of public spending. We find that the education spending per student and pensions per retiree are affected by income inequality and ageing in the same direction. An increase in income inequality increases both per student public education spending as well as public pensions per pensioner, whereas an increase in the share of the population that is retired decreases both public education spending and pensions.

In our overlapping generations (OLG) model agents are heterogeneous with respect to their income. They live for three periods – young, adults (parents) and elderly – and each period they make sequentially two kind of choices, private and public. First, parents decide on the number of children and they choose whether to send them to a public or private school. Afterwards, the electorate (working age adults and pensioners) chooses the level of taxes and their allocation between pension and education spending according to a probabilistic voting model (Lindbeck and Weibull, 1987; Persson and Tabellini, 2000). In this setting, on the one hand, an increase in income inequality increases the level of per student public education spending and pensions. On the other hand, an increase in the retired population decreases both the level of public education and pensions. The former operates through the channel of a decreasing public education participation due to the substitution of public by private schooling freeing public resources for higher per student spending. At the same time, some of the resources that are not used for public schooling any more are used in order to finance more generous pensions. The latter works directly via the budget constraint. The increased proportion of elderly burdens the government's budget, inducing cuts in the expenditure on pensions and education per beneficiary.

We conduct a panel data analysis using OECD countries to examine if an increase in income inequality increases, and population ageing decreases public spending per student in primary and secondary education. More specifically, we employ two different specifications, a fixed effects approach and a dynamic panel analysis. We find evidence in favour of a negative effect of population ageing on education spending per student, but we obtain mixed results regarding the effect of income inequality.

Our theoretical approach is motivated by the shape of public and private intergenerational transfers depicted in Figure 1. The working age adults pay for the young through both public and private transfers, but for the retired population entirely through public transfers. Figure 2 presents further evidence for this:

Figure 2: *Public and Private Pension Spending*



Note: Pension spending is defined as all cash expenditures (including lump-sum payments) on old-age and survivors pensions.
Source: Pension spending, OECD (2019).

for almost all countries the vast majority of pensions spending is publicly provided. Therefore we choose this particular setting where there is public and private education for the young, but only a public pay-as-you go pensions system for the elderly.[1]

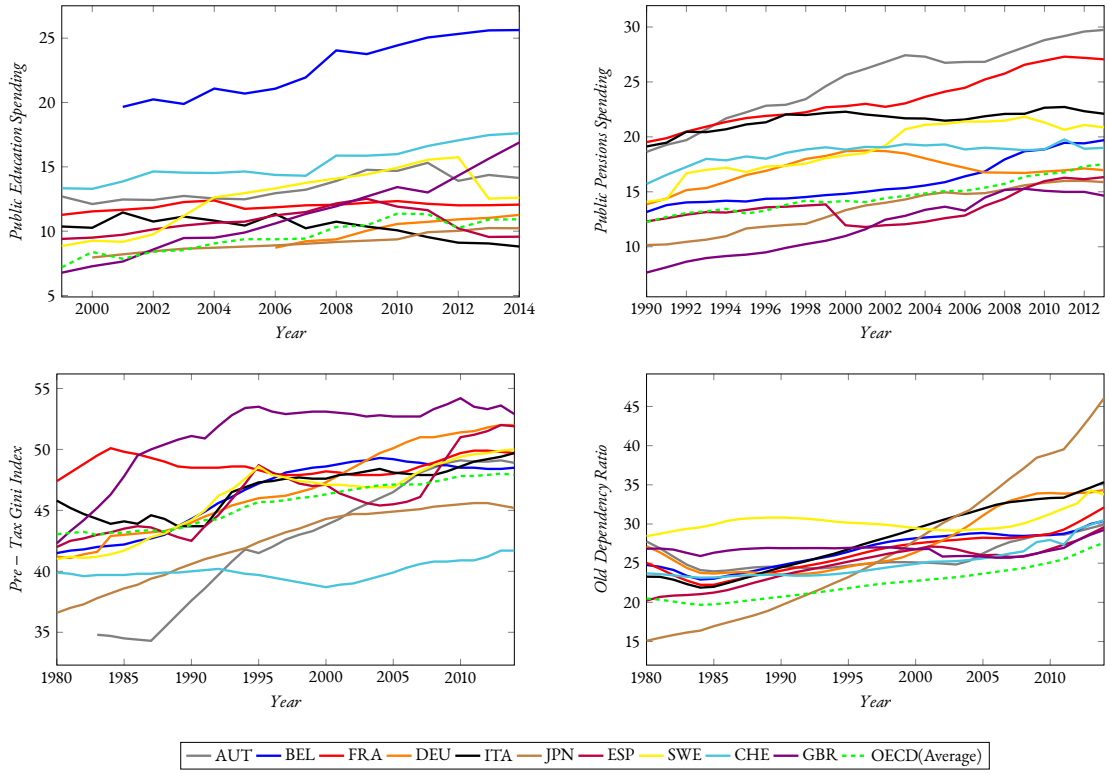
Moreover, as we can see from Figure 3 and Figure 4, the old dependency ratio (the ratio of retirees that have to be supported by working age adults, henceforth ODR) has increased substantially and it is expected to grow even stronger in the near future.[2] Parallel to the ageing of the population, there was a strong increase in income inequality, leading to an even stronger increase in resources available for education to high income households and a sharp decrease in the resources available to low income households. As can be seen in Figure 3, the Gini index as a measure of pre-tax and transfers income inequality has increased for all observed countries. As a result of these trends we expect the intensity of the two political conflicts – intergenerational and intragenerational – over the welfare state to be increasing.

The first political conflict belongs to the literature of the political economy of social security (i.e., public pensions). In this literature, the ageing process affects pensions through two opposing channels. On the one hand, there is the "fiscal leakage" hypothesis, which suggests that the increasing proportion of elderly decreases the expected profitability of pay-as-you-go pension systems for current working-age voters, thereby inducing them to favour lower current pensions. Therefore, the working-age generation repudiates the social security system (Breyer and Stolte, 2001; Razin et al., 2002; Razin and Sadka, 2007). On the other hand, according to the median voter theorem, governments implement the distribution of public funds that is preferred by the median voter (Downs, 1957) and as the median voter becomes older – due to population ageing – the political clout of the elderly seems set to grow. In turn, the increasing political power of the elderly transforms the allocation of public resources, shifting more resources towards the older cohorts (e.g. for pensions) and fewer to the younger cohorts (e.g. for education) (Browning, 1975). In the context of a limited fiscal budget, this reallocation of public funds might trigger a "struggle" for fiscal resources between the young and elderly, the so-called "intergenerational conflict" hypothesis (Poterba, 1997; Cattaneo and

[1] In our model, the consumption of the retirees is covered by pensions rather than private savings, which constitute only a fraction of the elderly income in OECD countries (see OECD, 2017).

[2] The main forces behind population ageing are, declining fertility rates after the post-war "baby boom" and increased life expectancy. Among other things, the latter is a result of better quality services due to technological progress in the healthcare system, while the former results from the increasing opportunity cost for women of having children in developed economies. According to Galor and Weil (1996), this is brought about by the higher increase in female wages with respect to household income. Other potential channels include the increase in human capital investment per child and the quantity-quality trade-off à la Becker (1960) (Becker et al., 1990; Galor and Weil, 2000).

Figure 3: *Recent Trends in Demographics, Income Inequality, and Education and Pensions*



Note: These plots show the increasing trends in education spending per student and pensions spending per pensioner measured in constant U. S. $1,000 (PPP 2011), pre-tax and transfers income inequality and old dependency ratio. Data Source: OECD, United Nations and the Standardized World Income Inequality Database. The time span of the graphs is dependent on data availability.

Wolter, 2009; Krieger and Ruhose, 2013).[3]

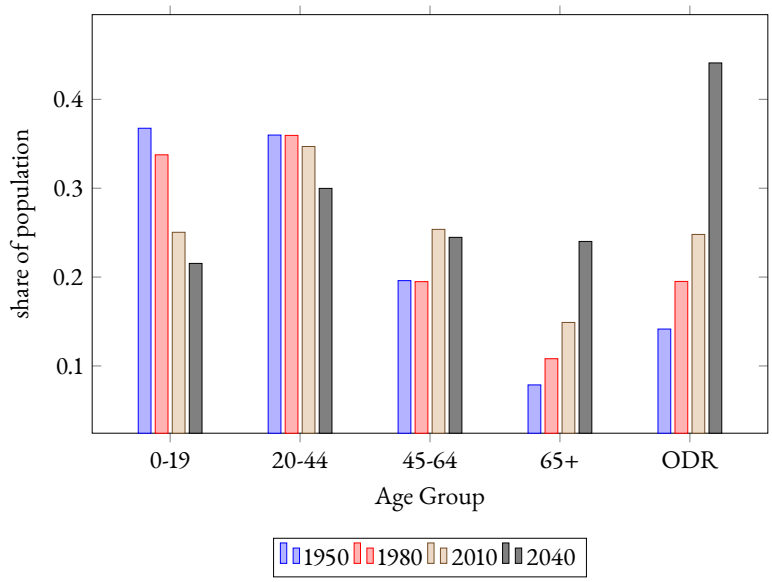
However, it has been pointed out by Casamatta and Batté (2016) that it is crucial to examine the nature of the linkage between publicly funded education and pensions before attempting to predict the effect of ageing on them. Becker and Murphy (1988) consider this connection as an exchange of transfers between young and old, where the former pay social security contributions and the latter invest in education. In the same vein Rangel (2003) and Boldrin and Montes (2005) consider a type of intergenerational contract in which generations link forward (e.g. education) to backward intergenerational transfers (e.g. pensions) in order to achieve an optimal and sustainable allocation of public economic resources. In particular, Rangel (2003) demonstrates the imperative role of backward intergenerational transfers in sustaining forward intergenerational transfers.[4]

Furthermore, the seminal paper of Pogue and Sgontz (1977) shows that the design of the PAYG pension system – pay contributions "now" and receive benefits "tomorrow" – and consecutively the connection of old age benefits to labour productivity of the future generations – the positive link between pensions and education – generates the appropriate incentives to invest in public education. More specifically, the working age generations are willing to pay for public education only if they can "reap" gains of higher (human capital) productivity in the future in terms of higher taxable income (Konrad, 1995), social security contributions (Kemnitz, 2000) and/or higher returns on savings (Gradstein and Kaganovich, 2004). Moreover, Lancia and

[3] In the literature this hypothesis is also known as the "political power of elderly" (Boadway and Wildasin, 1989; Breyer and Craig, 1997; Tabellini, 2000; Disney, 2007; Shelton, 2008; Tepe and Vanhuysee, 2009).

[4] The political economy application of this theory is empirically evaluated in Michailidis and Patxot (2018).

Figure 4: *Changing Demographic Structure of Voting Cohorts*



NOTE: *The bar plot illustrates the changing demographic structure in OECD countries on average. We divide the total population in 4 major age cohorts: A) Children: Children under 20 years old, B) Young Adults: people from 20 to 44 years old, C) Old Adults: People from 45 to 64 years old, D) Elderly: people above 65 years old. Every age cohort is expressed as share of total population. E) ODR: the share of elderly (over 65 years old) over the working population (20-64 years old). The share of each cohort is depicted over 90 years (1950 to 2040) demonstrating the demographic transition.*

Russo (2016) argue that adults support education only if they can ensure that they will be able to extract a political rent in form of future pensions. Hence, the strategic role of human capital is more important when the political power of the elderly is larger and the forward looking adults support public education policy as they are democratically entitled to claim share of the produced human capital of future generations.[5]

The second political conflict that we are interested in is the intragenerational conflict between rich and poor. Since the 1970s, there was a strong increase in income inequality in the OECD countries (see Piketty, 2013). In the U. S. this has taken the form of a polarisation of incomes (Goos et al., 2009; Acemoglu and Autor, 2011)[6] and parallel to this there was an increase in the inequality of investments into children and the achievement gap between poor and rich students (Kornrich and Furstenberg, 2013; Reardon, 2011).[7] In a similar vein, Mayer (2002) finds that in the U. S. states with higher income inequality have higher differences in educational attainment between children from poor and rich backgrounds, but higher per pupil public education expenditures.[8]

There is a vast literature on income inequality, education and voting. Stiglitz (1974) discusses the effect of different educational institutional arrangements (public v. s. private education) on educational outcomes in a setting with majority voting. He shows that the equilibrium outcome is depending on whether education is mainly understood as a private good or a public good. Bearse et al. (2005) study the effect of in-

[5] See Michailidis et al. (2019) for the empirical confirmation of this theoretical prediction.

[6] There is no evidence of a polarisation of wages in Europe yet. There is an increase of upper tail inequality, but no decrease of lower tail inequality in the U. K. and Germany (Manning et al., 2007; Antonczyk et al., 2018).

[7] Reardon (2011) shows that parallel to the increase in income inequality in the U. S. there was an increase in the education achievement gap between children from the 90th and the 10th income percentile, though rising income inequality appears not to be the dominant factor.

[8] Bailey and Dynarski (2011) show that there was a strong increase in the college completion rate between 1979 and 1997, with a much stronger increase for children from high income families. This is driven by a strong increase in the college attendance rate of women from high income families.

come inequality on public and private education in a majority voting model where public education can be both substituted and supplemented by private education expenditures. If supplementary private education spending and private schooling are prefect substitutes, there is no private school enrolment. In a mixed equilibrium, where they are not perfect substitutes, an increase in income inequality first increases per student public education spending, but then decreases it as students start to drop out of private education. Ichino et al. (2011) has a model of social mobility and public education spending. When the poor families are less politically active, there is less public education spending and less social mobility.

Another strand of the literature uses education to link income inequality to economic growth. In Galor and Zeira (1993) and Moav and Galor (2004), credit constraints hinder poor families from acquiring an optimal level of education, which leads to a negative effect of income inequality on economic growth. Other strands of the literature find a negative link between inequality, education and growth through assortive mating (Fernández and Rogerson, 2001) or technological progress (Galor and Tsiddon, 1997). The most related study to us, Glomm and Ravikumar (1992), shows in an endogenous growth model with majority voting that if income inequality is high a public education regime leads to higher growth, whereas if income inequality is low a private education regime leads to higher growth.

The rest of the paper is structured as follows: Section 2 introduces our model, Section 3 analyses the effect of income inequality and population ageing on the equilibrium levels of public education and pensions, Section 4 evaluates these effects using OECD data, and Section 5 concludes the paper.

2 The Model

Our model based on De La Croix and Doepke (2009) is populated by a continuum of agents that has a mass of one. They live for three periods: in the first period they are born and children, in the second they are adults and work, and in the third they receive a pension and live from that pension. Agents that are working adults in period t base their decisions on the following utility function:

$$\ln(c_t) + \gamma\left[\ln(n_t) + \eta \ln(h_t)\right] + \beta\mathbb{E}\left[U^o_{t+1}(p_{t+1})\right], \tag{1}$$

where $U^o_{t+1}(p_{t+1})$ is their utility when old:

$$U^o_{t+1}(p_{t+1}) = \ln(p_{t+1}). \tag{2}$$

Here, c_t is the consumption of the agent as adult, p_{t+1} is the pension which they consumes as retiree, n_t is the number of children they have, and h_t is the education of their children in terms of per child education spending. In this model we consider the pension spending per pensioner and education spending per student as the "quality" of pensions and education, respectively. The parents are altruistic towards their children with parameter γ and care about the quality of their children's education relative to the number of children with parameter η. β is the discount factor for the future consumption, and future consumption is equal to the expected pension p_{t+1} that the agent receives.

There are no savings in this economy, and the consumption after retirement is financed through a pay-

as-you-go pension system. The agent's budget constraint is equal to

$$c_t + (1 - v_t)n_t e_t = (1 - v_t)y_t(1 - \phi n_t), \tag{3}$$

where y_t is the wage, v_t is the income tax rate. ϕ is the per child time that an agent has to dedicate to child rearing, and $1 - \phi$ is the time that an agent works. e_t is the private education spending per child, which is tax exempt, therefore $(1 - v_t)n_t e_t$ is the total private spending on education. We distinguish between agents that send their children to public education, denoted by a superscript s, and agents that send their children to private education, denoted by a superscript e. If parents are sending their children to private education they have to choose the per child spending on education e_t that they have to pay themselves and $h_t = e_t$. If they send their children to public education the level of education is decided and provided for by the government and $h_t = s_t$, where s_t is a political variable. The agents cannot supplement public education by private spending, and $e_t = 0$ for agents with children in public education. The budget constraint for parents sending their children to public education is thus:

$$c_t = (1 - v_t)y_t(1 - \phi n_t).$$

There is no capital in this economy, the potential economic output Y_t (when all agents are employed full time) is equal to a Cobb-Douglas production function using privately and publicly educated agents. The relationship between potential output Y_t and education is defined in the following way:

$$\ln Y_t = \ln \mathcal{A} + (1 - \Psi_{t-1}) \ln \hat{e}_{t-1}^{\alpha} + \Psi_{t-1} \ln s_{t-1}^{(1-\alpha)}, \tag{4}$$

where $\hat{e}_{t-1}$ is the average spending per student in private education, s_{t-t} is the spending per student in public education, and $\alpha \in [0, 1]$ is the elasticity of substitution between the two. We introduce the share of public education Ψ into the Cobb-Douglas parameter in order to ensure the marginal return on an increase in the spending per student in both the public and the private education sector increases with the number of students attending public and private education respectively. This is needed to guarantee the tractability of the model. This also allows for the existence of a total private education system and a total public education system. $\mathcal{A}$ is a parameter that captures the technology and non human capital related parts of the economy. Only adults work, therefore the output depends on the human capital accumulated in the previous period. Individuals differ in the relative share of the total income x that they receive. We normalise the distribution $G(x)$ of x to have mass one, therefore the income that an individual with x could get if they worked full time is equal to

$$y_t = xY_t.$$

We assume that the distribution of x is independent of the choices of last period. Private and public choices do affect the level of potential income in the future, the relative population size, but not the income distribution. Therefore the distributional parameters stay constant over time, and the political choice in t becomes a static problem independent of the future income distribution and future political choices.

The next period potential output is a function of this period's decisions. In order to solve this model, we assume that the expected value of next periods pensions is proportional to the output of the economy:

$$\mathbb{E}_t(p_{t+1}) \propto Y_{t+1}.$$

That means that if the next periods output increases, agents expect to have an increase in their pensions of the same magnitude as well. This assumption refers to the positive intergenerational link between the working age adults and children.[9] In particular, we assume that it is of the following form:

$$\mathbb{E}_t(p_{t+1}) = \Theta_{t+1} Y_{t+1},$$

where Θ_{t+1} is the expected share of potential output that is dedicated to pensions, a variable that captures the expected future policies. We assume, as standard in the political choice literature, that current policies and decisions do not affect expected future policies, i. e. that Θ_{t+1} is independent of choices made in t.

2.1 The Private Choice

Agents optimise their utility over the number of children n_t, their consumption c_t, and the investment into their children's education h_t given their budget constraint (3). They take political variables as exogenously given. We distinguish between agents that choose public education for their children, and agents that choose private education for their children, denoted by superscript s and e respectively. If an agent chooses to send their children to public education, they will receive an education in the value of s_t, which will be paid and determined by the government (i. e. the political process). If they send their children to private education, they can choose the level of education spending e_t but have to pay for it themselves.

Incorporating (2), (3), and (4) into utility (1), we get the following indirect utilities in the cases of private and public education:

$$U_t^s(y_t, n_t | s_t, v_t, p_{t+1}) = \ln(1 - v_t) + \ln(y_t) + \ln(1 - \phi n_t) + \gamma \ln(n_t) + \gamma\eta \ln(s_t) + \beta\mathbb{E}\left[\ln(p_{t+1})\right], \tag{5}$$

$$U_t^e(y_t, n_t, e_t | v_t, p_{t+1}) = \ln(1 - v_t) + \ln\left[y_t(1 - \phi n_t) - n_t e_t\right] + \gamma \ln(n_t) + \gamma\eta \ln(e_t) + \beta\mathbb{E}\left[\ln(p_{t+1})\right]. \tag{6}$$

There is a Beveridgean redistributive pay-as-you-go pension system and agents do not choose the level of pension, which is a political variable. They optimise their utility only over consumption, number of children, and in case they are choosing private education the education spending per child. The optimal choice of variables for parents choosing private education is equal to:

$$c_t^e = (1 - v_t)\frac{y_t}{1 + \gamma},$$

$$n^e = \frac{\gamma(1 - \eta)}{\phi(1 + \gamma)}, \tag{7}$$

$$e_t^e = \frac{\eta\phi y_t}{1 - \eta}, \tag{8}$$

[9] The working age adults are willing to pay for the education of young because they expect to reap the gains of higher productivity during their retirement in the near future (Konrad, 1995; Kemnitz, 2000)

where $n_t^e = n^e$ is static and independent of other variables. The optimal choice for parents choosing public education is equal to:

$$c_t^s = (1 - v_t)\frac{y_t}{1+\gamma},$$
$$n^s = \frac{\gamma}{\phi(1+\gamma)}, \tag{9}$$

where $n_t^s = n^s$ is static and independent of other variables as well.

Agents choose private education if the value of private education in terms of utility is larger or equal to the value of public education in terms of utility, i. e.:

$$U^e(y_t, c_t^e, n^e, e_t^e | v_t, p_{t+1}) \geq U^s(y_t, c_t^s, n^s | s_t, v_t, p_{t+1}). \tag{10}$$

These indirect utilities only depend on y_t, which is directly proportional to x. Agents differ only in the share of total output x that they receive. Thus there will be a $\tilde{x}_t$ for which the utilities in both education systems will be the same. Solving (10) for $\tilde{x}_t$ we get:

$$\tilde{x}_t = \frac{1-\eta}{\hat{\eta}\phi\eta}\mathbb{E}_t(s_t), \tag{11}$$

where $\hat{\eta} = (1-\eta)^{1/\eta}$. Here, $\mathbb{E}_t(s_t)$ is the expected value of public education. Agents do not know the realisation of the quality of public education when they decide on fertility and whether they send their children to public or private education. Therefore $\tilde{x}_t$, the x of the agent that is indifferent between sending their children to public or private education depends on the school quanlity that they expect when the agents make their private choice.

We assume a uniform distribution of x over the interval $[1-\sigma, 1+\sigma]$. Therefore the fraction of children participating in the public education system is equal to

$$\Psi_t = \begin{cases} 0 & \text{if} \quad \tilde{x}_t < 1-\sigma, \\ \frac{\tilde{x}_t - (1-\sigma)}{2\sigma} & \text{if} \quad 1-\sigma \leq \tilde{x}_t \leq 1+\sigma, \\ 1 & \text{if} \quad \tilde{x}_t > 1+\sigma. \end{cases} \tag{12}$$

In the first case, the x with which an agent would be indifferent between public and private educaiton is lower than the one of the poorest agent in the economy and therefore the share of parents sending their children to public education is equal to 0. In the last case, $\tilde{x}_t$ is larger than the one of the richest agent in the economy, and therefore everyone sends their children to public schools ($\Psi_t = 1$). In the case with $1-\sigma \leq \tilde{x}_t \leq 1+\sigma$ is the case wehre some parents send their children to public and some to private schools.

We define N_t as the population size of the adult at the time t. We define the population growth rate as ϱ_t, such that the relation between population in t and $t-1$ is equal to

$$N_t = (1 + \varrho_{t-1})N_{t-1}.$$

We normalise the adult population at t to one, so in t the retired population size of generation $t-1$ is equal

to $1/(1+\varrho_{t-1})$. The population growth rate depends on the participation in public education Ψ_t in the following way:

$$1+\varrho_t = \Psi_t n^s + (1-\Psi_t)n^e. \tag{13}$$

Since agents that choose public education do not have to pay the cost of education for their children, they choose to have a higher number of children ($n^s > n^e$), and thus an increase in the participation in public education Ψ_t leads to an increase in population growth ϱ_t.

2.2 Public Choice

After making their private choices, i. e. deciding whether to participate in public or private education and how many children to have, the adult and the retired agents vote on the public choice variables s_t, p_t, and v_t. A policy $\{s_t, p_t, v_t\}$ has to fulfil the following government budget constraint:

$$\int_0^{\tilde{x}_t} s_t n^s g(x)dx + \frac{1}{1+\varrho_{t-1}} p_t = v_t \left\{ \int_0^{\tilde{x}_t} x(1-\phi n^s)g(x)dx + \int_{\tilde{x}_t}^{\infty} \left[x(1-\phi n^e) - e_t^e(x)n^e\right] g(x)dx \right\}, \tag{14}$$

where $g(x)$ is the probability density function of $G(x)$. The left hand side of this equation represents the government expenditures, i. e. the expenditures for public education (first term on the left) and the expenditures for pension of the retired (second term on the left). The right hand side represents the revenue from income taxes v_t on those with public education (first term on the right) and those with private education (second term on the right). Using (7), (8), and (9) we can show that the taxable income in period t is equal to

$$\int_0^{\tilde{x}_t} x\left(1-\phi n^s\right) g(x)dx + \int_{\tilde{x}_t}^{\infty} \left[x\left(1-\phi n^e\right) - e(x)n^e\right] g(x)dx = \frac{Y_t}{1+\gamma}\int_0^{\infty} xg(x)dx = \frac{Y_t}{1+\gamma}. \tag{15}$$

where $e(x) = e_t^e$ for agents with income $y_t = xY_t$. The tax revenue is independent of the participation rate Ψ_t and only depends on the economic output. Using this, we can rewrite the government budget constraint (14) as

$$v_t \frac{Y_t}{1+\gamma} = s_t \Psi_t n^s + p_t \frac{1}{1+\varrho_{t-1}},$$

which leads to the following expression of the tax rate v_t as a function of per pensioneer pensions p_t and per student spending on public education s_t

$$v_t = \frac{1+\gamma}{Y_t}\left(s_t \Psi_t n^s + p_t \frac{1}{1+\varrho_{t-1}}\right). \tag{16}$$

Thus we can replace v_t in the indirect utilities (5) and (6) with (16) and formulate the public decision as a decision on two variables p_t and s_t, where the tax rate v_t is a function of the two. The policy variables are chosen according to a probabilistic voting, where the adults and retirees vote on competing political platforms defined on $\{s_t, p_t\}$ (for a discussion of the probabilistic voting see Appendix A). The winning

political platform is the one that optimises the following objective function:

$$\Omega(s_t, p_t) = \int_0^{\tilde{x}_t} U_t^s \left[x, s_t, p_t, v_t(s_t, p_t)\right] g(x)dx + \int_{\tilde{x}_t}^{\infty} U_t^e \left[x, s_t, p_t, v_t(s_t, p_t)\right] g(x)dx + \frac{1}{1+\varrho_{t-1}} U_t^o(p_t).$$

One can show that Ω is strictly concave in s_t and p_t. The maximisation of Ω with respect to s_t leads to

$$0 = -\frac{\Psi_t n^s}{\frac{Y_t}{1+\gamma} - s_t \Psi_t n^s - p_t \frac{1}{1+\varrho_{t-1}}} + \Psi_t \frac{\eta\gamma}{s_t} + \frac{\beta\Psi_t(1-\alpha)}{s_t}. \tag{17}$$

The first term on the right is the costs of an increase in s_t through taxes for the adult population, the second term is the benefit of an increase in s_t for the parents sending their children to public schools, and the third term is the benefit of an increase s_t for all adults through the higher expected future production that is paying for their pensions.

Maximising Ω with respect to p_t yields

$$0 = -\frac{\frac{1}{1+\varrho_{t-1}}}{\frac{Y_t}{1+\gamma} - s_t \Psi_t n^s - p_t \frac{1}{1+\varrho_{t-1}}} + \frac{1}{1+\varrho_{t-1}} \frac{1}{p_t}. \tag{18}$$

Again, the first part of this equation represents the costs of an increase in p_t through taxes on adults income and the second part the benefit of an increase in p_t for the retirees.

We can now use (17) and (18) to solve for the political outcome of the voting process $\{s_t^*, p_t^*\}$:

$$s_t^* = \frac{(1+\varrho_{t-1})\left[\eta\gamma + \beta(1-\alpha)\right]}{(1+\varrho_{t-1})\Psi_t\left[\eta\gamma + \beta(1-\alpha) + 1\right] + 1} \frac{Y_t\gamma}{\phi}, \tag{19}$$

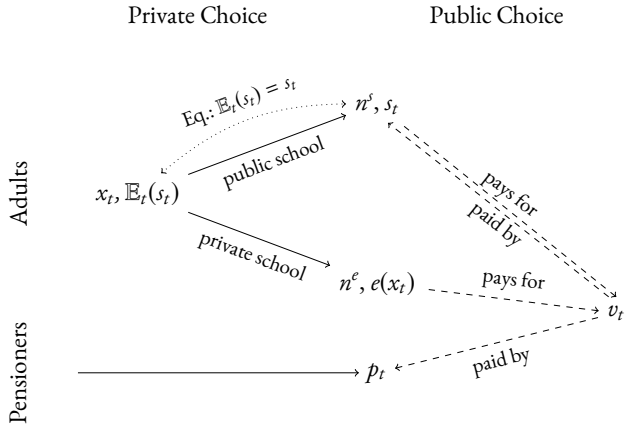
$$p_t^* = \frac{1}{(1+\varrho_{t-1})\Psi_t\left[\eta\gamma + \beta(1-\alpha) + 1\right] + 1} \frac{Y_t(1+\varrho_{t-1})}{1+\gamma}. \tag{20}$$

We can insert (19) and (20) into (16) to get the tax rate v_t^* that corresponds to this policy:

$$v_t^* = \frac{\Psi_t\gamma\eta + \frac{1}{1+\varrho} + \Psi_t\beta(1-\alpha)}{1 + \Psi_t\gamma\eta + \frac{1}{1+\varrho} + \Psi_t\beta(1-\alpha)}. \tag{21}$$

According to the probabilistic voting theory, it is optimal for competing political platforms to offer the policy $\{s_t^*, p_t^*, v_t^*\}$, which is maximising the probability of being elected. Therefore this is the equilibrium outcome of the political process. All these political variables are dependent on the participation rate in public education Ψ_t, which is an outcome of the expectations on the level of public schooling $\mathbb{E}_t(s_t)$. A representation of this sequence of the above choices is depicted in Figure 5. We are now going to define an equilibrium with perfect foresight of the agents with respect to s_t.

Figure 5: *Sequence of Choices*



Note: As we can see, first adults choose whether to send their children into public or private schools and how many children to have (n^s or n^e), as well as the level of private education $e(x_t)$ in case their children attend a private school. This private decision depends on their location in the income distribution x_t and the expected per student spending in public schools $\mathbb{E}(s_t)$. Afterwards the electoral body (adults and pensioners) vote simultaneously on the tax rate v_t, per pensioner pensions p_t and per student spending in public schools s_t. An equilibrium of this model is the point where the expectations are fulfilled, i. e. $\mathbb{E}(s_t) = s_t$.

2.3 Equilibrium

In this model, agents are deciding first whether or not to send their children to public education based on their expectations on the level of public education ($\mathbb{E}(s_t)$). This decision then influences the outcome of the political process and thus the level of public education s_t itself. We are assuming perfect foresight of the agents with respect to this periods policies, and an equilibrium is thus defined as the expected value of s_t that yields itself as the outcome of aggregated private choices and the resulting public policies:

Definition 1. *An equilibrium consist of an income threshold $\tilde{x}$ satisfying (11), a fertility rule $n = n^s$ for $x \leq \tilde{x}$ and $n = n^e$ for $x > \tilde{x}$, a private education decision $e = 0$ for $x \leq \tilde{x}$ and $e = e^e(x)$ for $x > \tilde{x}$, and aggregate variables $\{\Psi_t, s_t^*, p_t^*, v_t^*\}$ given by equations (12), (19), (20), and (21), such that the perfect foresight condition holds:*

$$\mathbb{E}_t(s_t) = s_t. \tag{22}$$

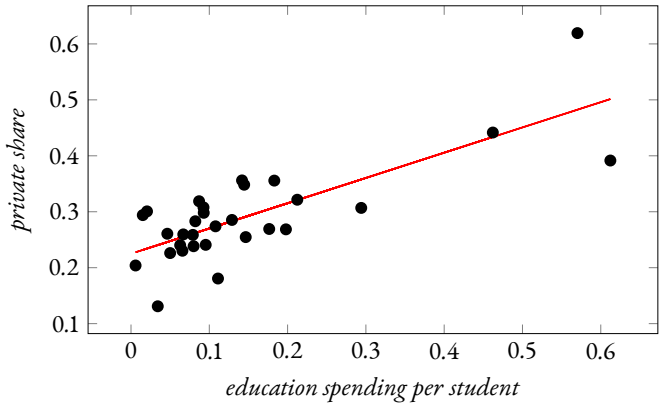
To show that an equilibrium exists and is unique, we are using Brouwer's fixed-point theorem. For this we need the following lemma:

Lemma 1. *The level of public education s_t^* and the level of public pensions p_t^* are decreasing in the participation in public education Ψ_t, whereas the tax rate v_t^* is increasing in participation in public education.*

Proof. The first derivative of s_t^* and p_t^* with respect to Ψ_t are equal to

$$\frac{\partial s_t^*}{\partial \Psi_t} = -\frac{(1+\varrho_{t-1})^2 \left[\eta\gamma + \beta(1-\alpha)\right] \left[\eta\gamma + \beta(1-\alpha) + 1\right]}{\left\{(1+\varrho_{t-1})\Psi_t \left[\eta\gamma + \beta(1-\alpha) + 1\right] + 1\right\}^2} \frac{Y_t\gamma}{\phi}, \tag{23}$$

Figure 6: *Participation in Public Education and Per Student Public Education Spending*



Note: This scatter plot depicts the relationship between the private share in primary & secondary education and public education spending per student in primary & secondary education as a share in GDP per capita, for OECD countries in our sample in 2014. This relationship is highly correlated and statistically significant 0.77 (0.000).

and

$$\frac{\partial p_t^*}{\partial \Psi_t} = -\frac{(1+\varrho_{t-1})^2\left[\eta\gamma+\beta(1-\alpha)+1\right]}{\left\{(1+\varrho_{t-1})\Psi_t\left[\eta\gamma+\beta(1-\alpha)+1\right]+1\right\}}\frac{Y_t}{1+\gamma}, \tag{24}$$

which are both always negative. The first derivative of v_t^* with respect to Ψ_t is equal to

$$\frac{\partial v_t^*}{\partial \Psi_t} = \frac{\gamma\eta+\beta(1-\alpha)}{\left[1+\Psi_t\gamma\eta+\frac{1}{1+\varrho}+\Psi_t\beta(1-\alpha)\right]^2}, \tag{25}$$

which is always positive. □

A decrease in the participation in public education Ψ_t means that there are now less parents that are voting in favour of public education, and also the weight of public educated children in the future production is decreasing. But at the same time the number of children in public education is decreasing, which is dominating the other effect here. Since with the decrease in the number of children a higher level of public education can be provided for a lower costs, there are more funds to increase the level of pensions and decrease the tax rate. This is in line with empirical evidence for OECD countries as shown in Figure 6, there is a positive correlation of 0.77 (0.000) between participation in private education and per student spending in public education.[10]

Now, we are using Lemma 1 to show that an equilibrium exists and is unique.

Proposition 1. *An equilibrium exists and is unique.*

Proof. The existence and uniqueness of an equilibrium as defined in Definition 1 follow from an application of the Brouwer's fixed-point theorem. Using (19), the actual quality s_t and the expected schooling quality

[10] De La Croix and Doepke (2009) find this as well for the U. S. regions.

$\mathbb{E}_t(s_t)$ lie in the interval

$$\mathbb{E}_t(s_t), s_t \in \left\{ \frac{(1+\varrho_{t-1})\left[\eta\gamma+\beta(1-\alpha)\right]}{(1+\varrho_{t-1})+1}\frac{Y_t\gamma}{\phi}, \frac{(1+\varrho_{t-1})\left[\eta\gamma+\beta(1-\alpha)\right]}{(1+\varrho_{t-1})\left[\eta\gamma+\beta(1-\alpha)+1\right]+1}\frac{Y_t\gamma}{\phi} \right\}. \tag{26}$$

We define a mapping Δ from $\mathbb{E}_t(s_t)$ into s_t, which maps this interval into itself. A unique fixed point of this mapping implies the existence of a unique equilibrium with $\mathbb{E}_t(s_t) = s_t$. Using (11) and (12), we can show that the participation in public education $\Psi - t$ as a function of $\mathbb{E}_t(s_t)$ is equal to:

$$\Psi_t = \Psi[\mathbb{E}_t(s_t)] = \max\left\{\min\left[\frac{1-\eta}{2\sigma\hat{\eta}\phi\eta}\mathbb{E}_t(s_t) - \frac{1-\sigma}{2\sigma}, 1\right], 0\right\}. \tag{27}$$

This function is weakly increasing in $\mathbb{E}_t(s_t)$. The higher the expected quality of public education, the more parents are going to prefer sending their children to public education.

We can use (19) to define the mapping Δ, which gives us the actual per student public education expenditure s_t that results for the voting process with the participation rate $\Psi[\mathbb{E}_t(s_t)]$ from (27). This education quality $s_t = \Delta[\mathbb{E}_t(s_t)]$ is given by

$$\Delta[\mathbb{E}_t(s_t)] = \frac{(1+\varrho_{t-1})\left[\eta\gamma+\beta(1-\alpha)\right]}{(1+\varrho_{t-1})\Psi[\mathbb{E}_t(s_t)]\left[\eta\gamma+\beta(1-\alpha)+1\right]+1}\frac{Y_t\gamma}{\phi}. \tag{28}$$

An equilibrium is a fixed point of $\Delta[\mathbb{E}_t(s_t)]$, i. e. public education spending s_t that satisfies $s_t = \Delta(s_t)$. At this fixed point the schooling quality s_t that is expected by the agents is identical to the one that results from the voting process. Given (28) and Lemma 1, Δ is a continuous, weakly decreasing function mapping the closed interval given in (26) into itself. The mapping therefore crosses the 45 degree-line exactly once, and a unique equilibrium exists. □

This proof of the existence and uniqueness of the equilibrium works in the following way: according to Lemma 1 the equilibrium per student spending on public education is decreasing with the participation rate in public education. As $\Psi_t \in [0, 1]$, the level of the per student spending on public education s_t^* is also bounded. Because the participation rate is an increasing function of the expected schooling quality, and the actual schooling quality is a decreasing function of the participation rate in public education, the actual schooling quality is a decreasing function of the expected schooling quality. As the actual schooling quality is decreasing in expected schooling quality, and both are bounded, according to Brouwer's fixed-point theorem there exists a unique fix point between the two. This is the equilibrium point where expected schooling quality and actual schooling quality coincide and the perfect foresight condition holds.

3 Comparative Statics

We can now use the equilibrium schooling and pensions to derive comparative statics in the model. In particular, we are interested in the effect of changes in income inequality on public education provision and pensions. There are three different education regimes: (i.) majority public with $\Psi_t \in [1, 1/2)$; (ii.) equally separated with $\Psi_t = 1/2$; or (iii.) majority private with $\Psi_t \in (1/2, 0]$. Unlike De La Croix and

Doepke (2009) we cannot rule out any of this regimes, but as can be seen in Figure 7 almost all countries have majority public education regimes, and therefore we concentrate our analysis on this case (for an analysis of the other regimes see Appendix B). Initially we are looking at the effect of income inequality on the participation rate in public education. We get for the relationship between the inequality σ and Ψ_t the following:

Proposition 2. *In a majority public education regime with $\Psi_t > 1/2$ participation in public education Ψ_t and the tax rate v_t^* are decreasing with income inequality σ and the quality of public education s_t^* and the pensions per pensioner p_t^* are increasing in σ.*

Proof. The first derivative of Ψ_t with respect to σ is

$$\frac{\partial \Psi_t}{\partial \sigma} = \frac{\sigma - \left[\frac{1-\eta}{\dot{\eta}\phi\eta}\mathbb{E}_t(s_t) - (1-\sigma)\right]}{2\sigma^2} = \frac{1}{\sigma}\left(\frac{1}{2} - \Psi_t\right). \tag{29}$$

This is negative for $\Psi_t > 1/2$. Following Lemma 1 this means that p_t^* and s_t^* are increasing in σ and v_t^* is decreasing in σ for $\Psi_t > 1/2$. □

The mechanism of the effect of an increase in income inequality is the following: an increase in income inequality is increasing the income of the marginal agent that is indifferent between private and public education if this agent has an above average income. This means that this agent now prefers private education. This decrease in public education perticipation decreases the share of voters with children in public education, but it also decreases the number of children in public education. Therefore the total spending on public education decreases, but the number of children in publice education decreases stronger. Overall this leads to an increase in per student public education spending. The decrease in total education spending leads to an increase in pensions and to a decrease in taxes.

Secondly, we look at the effect of an increase in the share of old people in the population $1/(1+\varrho_{t-1})$ on pensions and per student public education spending. For this we look at the comparative statics of $1/(1+\varrho_{t-1})$ on p_t^*, s_t^*, v_t^*, Ψ_t, and $(1+\varrho_t)$:

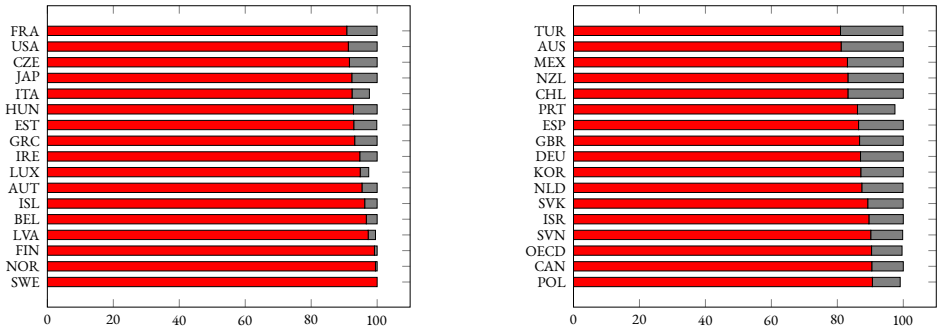
Proposition 3. *An increase in the share of retirees in the population $1/(1+\varrho_{t-1})$ decreases the pensions per pensioner p_t^*, the level of public schooling s_t^*, and the participation in public education Ψ_t, and it increases the tax rate v_t^*. It also decreases future population growth $(1+\varrho_t)$.*

Proof. Using the implicit function theorem, (11), (12), and (23), we can derive the first derivative of s_t^* with respect to $1/(1+\varrho_{t-1})$:

$$\frac{\partial s_t^*}{\partial \frac{1}{1+\varrho_{t-1}}} = -\frac{1}{\frac{1-\eta}{2\sigma\dot{\eta}\phi\eta}\left[\eta\gamma + \beta(1-\alpha) + 1\right] + \frac{\left\{(1+\varrho_{t-1})\Psi_t\left[\eta\gamma+\beta(1-\alpha)+1\right]+1\right\}^2}{(1+\varrho_{t-1})^2\left[\eta\gamma+\beta(1-\alpha)\right]}\frac{\phi}{Y_t\gamma}}, \tag{30}$$

which is always negative. Following (11) and (12) this leads to a decrease in the equilibrium value of Ψ_t and according to (13) this decreases $(1+\varrho_t)$.

Figure 7: *Distribution of Public and Private Funds*



Note: Distribution of public and private funds for primary, secondary and post-secondary non-tertiary educational institutions. Final funds after transfers between public and private sectors, excluding international funds (2015). Source: Education at a Glance, OECD, 2018.

Using this, (11), (12), and (24), we can derive first derivative of p_t^* with respect to $1/(1+\varrho_{t-1})$:

$$\frac{\partial p_t^*}{\partial \frac{1}{1+\varrho_{t-1}}} = -\frac{\frac{1}{\eta\gamma+\beta(1-\alpha)}\frac{\phi}{\gamma(1+\gamma)}}{\frac{1-\eta}{2\sigma\hat{\eta}\phi\eta}[\eta\gamma+\beta(1-\alpha)+1]+\frac{\left\{(1+\varrho_{t-1})\Psi_t\left[\eta\gamma+\beta(1-\alpha)+1\right]+1\right\}^2}{(1+\varrho_{t-1})^2\left[\eta\gamma+\beta(1-\alpha)\right]}\frac{\phi}{Y_t\gamma}},$$

which is also always negative.

Following from (30), (11), (12), and (24) the first derivative of v_t^* with respect to $1/(1+\varrho_{t-1})$ is

$$\frac{\partial v_t^*}{\partial \frac{1}{1+\varrho_{t-1}}} = \frac{1}{\left[1+\Psi_t\gamma\eta+\frac{1}{1+\varrho}+\Psi_t\beta(1-\alpha)\right]^2}\frac{\frac{1-\eta}{2\sigma\hat{\eta}\phi\eta}+\frac{\left\{(1+\varrho_{t-1})\Psi_t\left[\eta\gamma+\beta(1-\alpha)+1\right]+1\right\}^2}{(1+\varrho_{t-1})^2\left[\eta\gamma+\beta(1-\alpha)\right]}\frac{\phi}{Y_t\gamma}}{\frac{1-\eta}{2\sigma\hat{\eta}\phi\eta}[\eta\gamma+\beta(1-\alpha)+1]+\frac{\left\{(1+\varrho_{t-1})\Psi_t\left[\eta\gamma+\beta(1-\alpha)+1\right]+1\right\}^2}{(1+\varrho_{t-1})^2\left[\eta\gamma+\beta(1-\alpha)\right]}\frac{\phi}{Y_t\gamma}}.$$

This is always positive. □

The mechanism behind this is similar to the one in Proposition 2: an increase in the share of old people increases the share of voters voting for pensions, but also increases the number of pensioners. This increases the total spending on pensions, but decreases the pensions per pensioner. The increase in pensions is paid by an increase in taxes and a decrease in public education spending. The decrease in public education spending leads to a decrease in participation in public education, which leads to a decrease in population growth.

To conclude the theoretical predictions of the model, an increase in income inequality decreases taxes, but increases per student spending on public education and per pensioner pensions. It decreases the size of the welfare state but increases the quality of the provided services. On the other hand, an increase in the population weight of the retirees does decrease both the per pensioner pensions and the public education spending per student. Both mechanism operate mainly through fiscal leakage in the budget constraint. An increase in income inequality increases the income of the agent indifferent between public and private education, and thus decreases the participation in public education. This reduces the share of voters caring for public education through altruism for their children, which reduces the total public education spending (which in turn decreases taxes and increases pensions). The number of children attending public education decreases faster than the total spending, which leads to an increase in per student spending on public education. The mechanism in the case of an increase in the number of retirees works in a similar fashion: The increase in the number of pensioners increases the political weight of the retirees, increasing total pension

spending (which increases taxes and decreases per student public education spending). The number of pensioners increases faster than the total pension spending, thus the per pensioner pension is decreasing. In both cases we find a positive relationship between per student public education spending and pensions through the budget constraint.

4 Empirical Evidence

The theoretical model that we develop in this paper makes prediction on how public education spending per student is affected by income inequality and population ageing. The main predictions of our model about the intergenerational and the intragenerational conflict are the following ones: (i.) Education spending per student and pensions spending per retiree are positively related and affected by changes in inequality and ageing towards the same direction. (ii.) When the majority of children attend public education, a rise in income inequality decreases the participation in public schooling (primary & secondary) and increases the per student spending on education. (iii.) An increase in the share of elderly decreases the per student education expenditures and the per pensioner pensions. We test these theoretical predictions using data on OECD countries in order to assess the validity of our model. The main goal is to investigate how primary and secondary public education spending per student are affected by changes in population ageing and income inequality.

4.1 Data

We consider a cross-country analysis using panel data on OECD countries and yearly observations over the period 1998–2014.[11] [12] More specifically, we use aggregated data on public education spending, participation in public and private schooling, income inequality, population ageing and pensions, taken from OECD, UNESCO and World Bank datasets.[13]

As a dependent variable we set the public education spending per enrolled student in only primary public education (henceforth, ESPSPE), only secondary public education (henceforth, ESPSSE), as well as the total primary and secondary public education spending (henceforth, ESPSPSE). Education expenditure is calculated by dividing the total general government expenditure on only primary, only secondary, and total expenditure on primary and secondary education – measured in $ PPP (constant 2011) – by the number of the enrolled students in only primary public education, only secondary public education, as well as the total enrolments in public primary and secondary education, respectively. We also use as dependent variable the total government education spending as % of GDP on primary (GEPE), secondary (GESE), and the sum of primary and secondary education (GEPSE). The main results hold for this specification. For the analysis on total education spending as % of GDP, see Appendix C Table 5.

[11] OECD countries in our sample: Australia, Austria, Belgium, Chile, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Latvia, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, South Korea, Spain, Sweden, Switzerland, Turkey, the U.K. and the U.S.. We exclude from our OECD sample Canada and the newest OECD member Lithuania, due to the missing data.

[12] As it is pointed out by (De La Croix and Doepke, 2009) it is a common sense to assume that governments adjust their budget for education on a yearly base.

[13] More detailed description of variables and data sources are provided in the Appendix D Table 7.

As main explanatory variables we use the old dependency ratio (ODR) that measures the size of the elderly (population above 65 years old) relative to the size of the working age population (20–64 years old) in order to capture the effect of population ageing on education spending.[14] We use the Gini index (henceforth, Gini) as a measurement of the market income inequality before taxes and transfers to capture the impact of income inequality on education spending. Following De La Croix and Doepke (2009) the Gini coefficient is used in its lagged form in order to avoid possible reverse causality from education to income inequality. More specifically, we use levels of Gini index with a 24 year lag, i. e. the 1975 to 1991 time period of 17 years that correspond to our sample span (1998–2014).[15]

Furthermore, we control for the share of private enrolments – the indirect effect of income inequality on education spending in our model – in only primary, only secondary, and total primary and secondary schooling. Our model predicts that an increase in private schooling participation translates into less students attending public schools and hence higher per student public education spending. Moreover, since public education and pensions compete for the same fiscal resources (intergenerational conflict) we control for the level of pensions. More specifically, we control for pension "generosity" using the level of public pensions per retiree (henceforth, PubPen) as a proxy. Pensions per pensioner are calculated using the total public pensions in % of GDP divided by the number of the people that are expected to be retired (population above 65 years old). Finally, we control for the level of economic development using GDP per capita measured in $ PPP (constant 2011). Table 1 displays the descriptive statistics of all variables used in our empirical analysis.

4.2 Two-way Fixed Effects Model

The cross-country analysis over time (panel analysis) seems to be the most appropriate way to examine empirically the effects of income inequality and population ageing on public education expenditure for primary and secondary education levels. Since income inequality, population ageing, and education spending vary over time and across countries, the standard two–way fixed effects approach fits our purpose. More specifically, the fixed effects assumption is needed in order to avoid systematic biases connected to unobserved characteristics (like culture heritage or religion) that remain constant over years and might have a significant influence on public education spending.[16] The Hausman test points to the use of fixed effects and is in line with our theoretical reasoning.[17] Additional diagnostic tests reveal a need to use time fixed effects and heteroscedastically robust standard errors.[18]

[14] As robustness check we also use a broader measure of old dependency ratio, that is population over 55 years old as a percentage of working age people from 20 to 54 years old. The quantitative results do not change, see Appendix D Table 8.

[15] We use a 24 year lag following the definition of the UN of "young people" for youth unemployment to ensure that the inequality is measured before the birth of anyone who is still in education.

[16] Castles (1994) argues that cultural heritage and the tradition of Catholicism can play an important role in public expenditure on education. Countries that have Catholicism as their predominant religion might have to spend less on public education of children as the Catholic Church undertakes a large part of the children's education.

[17] More specifically, we reject the the null hypothesis that random effects provide consistent estimates or that there is no correlation between the error term and the independent variables (Hausman, 1978).

[18] We use the time fixed effects test "testparm" available in STATA 14. We reject the null hypothesis: *no time fixed effects*. Also, we conduct the modified Wald test for groupwise heteroskedasticity in the residuals of fixed effects regression introduced by Baum (2001). Again, the null hypothesis: *presence of homoskedasticity*, is rejected.

Table 1: *Descriptive Statistics*

A. Dependent Variables: Public Education Spending Total and per Student, primary, secondary & both

	N	mean	sd	min	max
GEPE: Government Expenditure in Primary Education (as % of GDP)	475	1.4045	0.4343	0.5369	2.6773
GESE: Government Expenditure in Secondary Education (as % of GDP)	487	2.0414	0.4414	0.9650	3.0541
GEPSE: Government Expenditure in Primary & Secondary Education (as % of GDP)	472	3.4664	0.6456	2.2461	5.2068
ESPSPE: Education Spending per Student in Primary Education (in $1,000 PPP, constant 2011)	444	8.5155	4.1335	1.6243	27.3467
ESPSSE: Education Spending per Student in Secondary Education (in $1,000 PPP, constant 2011)	440	10.8157	5.5995	2.1625	30.1209
ESPSPSE: Education Spending per Student in Primary & Secondary Education ($1,000 PPP, constant 2011)	420	9.6731	4.6894	1.8134	25.6298

B. Main Explanatory Variables

	N	mean	sd	min	max
Gini: Gini index pre-tax and transfers (%)	595	47.1395	4.9288	30.8	60.3
ODR: Old Dependency Ratio (Over 65/20-64) (%)	595	24.2664	5.6864	9.9357	46.0558
ODR(20-54): Old Dependency Ratio (Over 55/20-54) (%)	595	30.4627	7.0934	12.0325	52.8460

C. Control Variables: Public & Private Enrolments

	N	mean	sd	min	max
ENPUBPE: Enrolments in Public Primary Education (in millions)	532	2.3827	4.4629	0.02857	22.5571
ENPUBSE: Enrolments in Public Secondary Education (in millions)	510	2.4966	4.2807	0.0268	22.5634
ENPUBPSE: Enrolments in Public Primary and Secondary Education (in millions)	503	4.9429	8.7864	0.0561	44.8700
SHPRPE: Share of Private Primary Education	515	0.0960	0.1315	0.0008	0.6151
SHPRSE: Share of Private Secondary Education	495	0.1424	0.1390	0.0032	0.6949
SHPRPSE: Share of Private Primary and Secondary Education	486	0.1198	0.1287	0.0055	0.6122

D. Other Control Variables

	N	mean	sd	min	max
PubPen: Public Pensions per retiree (in $1,000 PPP, constant 2011)	560	15.3260	7.1656	1.5390	44.1942
GDPpc: GDP per capita (in $1,000 PPP, constant 2011)	595	34.7077	14.4755	10.1492	97.8642

Note: *Definitions and sources of the data can be found in the Appendix D Table 7*

As baseline estimations we use the following two-way fixed effects specification:

$$\ln(Y_{i,t}) = b + \beta X'_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t},$$

where $Y_{i,t}$ is public education spending per student of country i at time t, b is the constant term, β is a coefficient vector, and α_i and γ_t represent country and time fixed effects, respectively. Finally, $\varepsilon_{i,t}$ is the idiosyncratic error term. The vector X includes all the regressors used in our estimations.

Table 2 shows estimations of the above specified model when we apply the within regression estimator. In the first three regressions we use as dependent variable the log of education spending per student for total (primary and secondary), only primary and only secondary, respectively. Moreover, as main explanatory variable we employ the current (non-lagged) Gini index. In regressions 4 to 6 we use instead the lag of Gini. Regression 1 shows a weak negative effect of current income inequality on public education spending per student for primary and secondary education when they are considered together. Regression 2 reveals that this negative effect is mainly driven by public primary education spending, as the same effect is insignificant for the secondary education. However, as have mentioned above, the use of the current income inequality

Table 2: *Ageing and Inequality Effect on Education Spending per Student*

	(1)	(2)	(3)	(4)	(5)	(6)
	ESPSPSE	ESPSPE	ESPSSE	ESPSPSE	ESPSPE	ESPSSE
Gini	-0.0149†	-0.0225*	-0.0131			
	(0.008)	(0.010)	(0.009)			
L.24.Gini				0.0186†	0.0216	0.0189*
				(0.011)	(0.017)	(0.007)
ODR	0.0073	0.0000	0.0147*	0.0092	0.0021	0.0145
	(0.008)	(0.010)	(0.007)	(0.010)	(0.014)	(0.009)
PubPen	0.0201*	0.0222**	0.0188*	0.0137	0.0136	0.0188
	(0.007)	(0.007)	(0.009)	(0.011)	(0.008)	(0.012)
GDPpc	0.0588***	0.0638***	0.0510***	0.0543***	0.0500***	0.0541***
	(0.007)	(0.011)	(0.008)	(0.009)	(0.013)	(0.007)
SHPRPSE	1.0795*			0.9953*		
	(0.413)			(0.395)		
SHPRPE		1.5482†			1.5024	
		(0.880)			(0.985)	
SHPRSE			1.1061**			1.0487**
			(0.340)			(0.292)
Country & Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	371	396	391	294	315	304
Countries	32	33	34	31	32	33
F-test	79.90***	21.41***	55.99***	137.37***	65.55***	127.78***
R^2-within	0.8142	0.7829	0.7316	0.7674	0.7264	0.7378

NOTE: *Two-way fixed effects regressions with robust standard errors reported in parentheses, ***p<0.001, **p<0.01, *p<0.05, †p<0.10. The standard errors are clustered over the number of countries used in each regression. Dependent variables: education spending per student in primary (ESPSPE), secondary (ESPSSE), primary & secondary education (ESPSPSE) are in logs. Gini: current Gini index on pre tax and transfers income and L.24.Gini is a lag (24 years) of the Gini index, ODR: old dependency ratio. Public pensions spending per pensioner (PubPen) and GDPpc are measured in $1,000 PPP (constant 2011). Share of private education in total primary (SHPRPE), secondary (SHPRSE), primary & secondary (SHPRPSE) education, Constant is not reported but included in all the regressions above.*

may generate problems of reverse causality – from education to income inequality – that we avoid by using a 24 lag of the Gini. When we address this problem – in regressions 4, 5 and 6 – the coefficients of income inequality become positive, although this effect is not significant for only primary education. This result is in line with our theoretical prediction that income inequality decreases the participation in public education increasing the spending per student in public schools.

Our estimations also show that while public pensions per pensioner have the expected positive effect, they are statistically insignificant for estimations with lagged inequality. Moreover, the share of private enrolments has a positive impact on primary and secondary education, but the effect is only significant for the latter. Additionally, the GDP per capita has the expected positive effect on education spending, reflecting the fact that richer countries have higher education spending. Except of the old dependency ratio, the rest of the variables in our estimations behave in the expected way.

As we can see from Table 2 the coefficient of the old dependency ratio is positive but is not significant (regressions 4 to 6). However, the effect of old dependency ratio might dependent on the level of pensions per pensioner which could lead to a misspecification of the model.[19] The intuition for this comes directly from the literature on intergenerational conflict where elderly try to appropriate more resources in their favour when there is a competition for fiscal resources. Hence, we estimate our model including the interaction between pensions and old dependency ratio.

[19] As shown in Appendix D Table 6, the level of pensions and the old dependency ratio are positively correlated.

Additionally, further diagnostic tests reveal the presence of cross-sectional dependence and autocorrelation in error terms.[20] As mentioned in Cameron and Trivedi (2010), ignoring cross-sectional dependence and correlation of errors over time can lead to systematic bias and thus to erroneous results. To cope with autocorrelation and cross-sectional dependence in the idiosycratic errors we use an estimation method that allows us to conduct consistent estimations in the presence of AR(1) autocorrelation within panels and contemporaneous correlation. For that purpose, we use the estimator (SCC) introduced by Hoechle (2007), that produces Driscoll and Kraay (1998) standard errors for the estimated coefficients using fixed effects. In our specification of this estimator, the error structure is assumed to be heteroscedastic, autocorrelated up to one lag and correlated between the countries. As mentioned in Hoechle (2007), Driscoll-Kraay standard errors are robust to very general forms of cross-sectional and temporal dependence when the time dimension is large enough. Additionally, their particular technique to estimate standard errors does not impose any restrictions on the number of countries, which can be even bigger than the number of periods. Moreover, as Cameron and Trivedi (2010) show, the implementation of Driscoll and Kraay's covariance estimator works for both balanced and unbalanced panels. All the above properties make this estimator suitable for our panel data analysis.

In Table 3 we make the following changes compared to Table 2: First, we introduce the interaction term between old dependency ratio and public pensions per pensioner in order to capture the plausible dependence of the former on the latter in its impact on education spending per student. More specifically, we estimate the first 3 regressions using time fixed effect just as in Table 2. Second, we use the estimation technique described above in order to avoid the biased estimates to estimate the same model in regressions 4, 5 and 6. There are not many significant differences between these two groups of regressions. The lagged income inequality has a strong positive effect on education spending for both regression groups, confirming our main theoretical prediction. More specifically, a rise of 1% in lagged income inequality has a positive effect of 2.35% on education spending per student when primary and secondary levels are considered together, 3.01% and 2.15% for primary and secondary levels respectively when they are considered separately. Furthermore, both public pensions and old dependency ratio have a positive individual effect on education spending, however their interaction indicates that the effect of ODR becomes negative beyond a certain level of public pensions per pensioner.[21] More specifically, the effect of ODR on primary and secondary education turns to be negative when the level of public pensions per retiree is beyond $14,000 (reg. 5), $22,000 (reg. 6), respectively and $17,000 when considered together (reg. 4). Finally, the share of private education in primary, secondary has a positive impact on education spending just as it is expected by the theory.

The results of Table 3 empirically support the theoretical predictions that we examine in this section. Next, we want to investigate the effects of the income inequality and ageing using a dynamic panel approach

[20] More specifically, using Pesaran's cross-dependence test introduced by Pesaran (2004), we reject the null hypothesis: *residuals across entities are not correlated*. Also, using the serial correlation test or the test for autocorrelation by Wooldridge (2010), we reject the null hypothesis: *no serial correlation*.

[21] Isolating the interaction effect of the ODR and PubPen on total education spending, we obtain the expression below:

$$\text{EPSPPSE} = 0.0420 \cdot \text{ODR} + 0.0648 \cdot \text{TPS} - 0.0024 \cdot \text{ODR} \cdot \text{PubPen}$$

In order to obtain the effect of the old dependency ratio on total education spending, we take the first derivative of EPSPPSE with respect to the ODR:

$$\partial\text{EPSPPSE}/\partial\text{ODR} = 0.0419 - 0.0023 \cdot \text{PubPen}$$

Table 3: *Interaction Effect and Education Spending*

	Fixed Effects			*Fixed Effects-Driscoll-Kraay standard errors*		
	(1)	(2)	(3)	(4)	(5)	(6)
	ESPSPSE	ESPSPE	ESPSSE	ESPSPSE	ESPSPE	ESPSSE
L.24.Gini	0.0235**	0.0301*	0.0215**	0.0235***	0.0301***	0.0215***
	(0.008)	(0.012)	(0.007)	(0.005)	(0.007)	(0.004)
PubPen	0.0648***	0.0867***	0.0549*	0.0648***	0.0867***	0.0549***
	(0.017)	(0.016)	(0.020)	(0.008)	(0.011)	(0.009)
ODR	0.0420***	0.0487***	0.0380**	0.0420***	0.0487***	0.0380**
	(0.009)	(0.012)	(0.011)	(0.007)	(0.005)	(0.012)
ODR*PubPen	-0.0024**	-0.0033***	-0.0017*	-0.0024***	-0.0033***	-0.0017**
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
GDPpc	0.0422***	0.0326***	0.0460***	0.0422***	0.0326***	0.0460***
	(0.006)	(0.007)	(0.007)	(0.006)	(0.007)	(0.004)
SHPRPSE	1.2158*			1.2158***		
	(0.448)			(0.289)		
SHPRPE		2.0764†			2.0764**	
		(1.020)			(0.579)	
SHPRSE			1.2190***			1.2190***
			(0.244)			(0.117)
Country & Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	294	315	304	294	315	304
Countries	31	32	33	31	32	33
F-Test	338.74***	97.28***	402.41***	283621.49***	114652.06***	622700.15***
R^2-within	0.8079	0.7924	0.7562	0.8079	0.7924	0.7562

NOTE: *Two-way fixed effects regressions with robust standard errors (regression 1 to 3) and Driscoll-Kraay standard errors corrected for heteroscedasticity, autoregressive process of order 2 (regression 4 to 6) reported in parentheses, ***p<0.001, **p<0.01, *p<0.05, †p<0.10. The standard errors are clustered over the number of countries used in each regression. Dependent variables: education spending per student in primary (ESPSPE), secondary (ESPSSE), primary & secondary education (ESPSPSE) are in logs. L.24.Gini: is a lag (24 years) of the Gini index on pre tax and transfers income, ODR: old dependency ratio. Public pensions spending per pensioner (PubPen) and GDPpc are measured in $1,000 PPP (constant 2011). Share of private education in total primary (SHPRPE), secondary (SHPRSE), primary & secondary (SHPRPSE) education. Constant is not reported but included in the above regressions.*

in order to consider possible path dependence in the determination of education spending.

4.3 Dynamic Panel Analysis

So far, it has been implicitly assumed in our model that the past values of the dependent variable do not play any role in the formulation of its current value. However, the current level of education spending might depend on its past levels. Hence, we include as an additional regressor only the first lag of education spending per student. This particular specification of the model implies that we assume that the education spending per student depends on its value in the previous period. Here, we can not apply the previous estimation techniques to the dynamic panel model because the lag of dependent variable is correlated with fixed effects in the error term (dynamic panel bias, see Roodman, 2009).

Moreover, we are not able to exclude the possibility of having endogeneity problems in our previous and current econometric model due to the reverse causality from education spending to fertility and consequently to population ageing (ODR).[22] Also, we can not exclude the possibility of Tiebout effects in the

[22] However, one can argue that this effect is taking place in the long-run. In other words, the age structure if affected is only affected in the long-run and it is fixed and predetermine in the short-run. Also, the impact of education on fertility is far from straightforward. In the past it was thought that more educated women tend to have fewer children (Becker et al., 1990; Galor and Weil, 1996) due to the increasing opportunity cost, however in the most recent study Esping-Andersen and Billari (2015) point to a reversion of this negative relationship.

international arena that can influence the fertility rate even at a cross-country level (for a discussion see Persson and Tabellini, 2000). In our case, an example of Tiebout sorting could be the immigration among OECD countries due to better education systems or welfare states. These threats to the internal validity of our model can bring potential biases to our estimations.

In order to address the aforementioned endogeneity concerns and incorporate the lag of the dependent variable as an additional regressor, we employ the "difference GMM" or Arellano-Bond estimation method introduced by Holtz-Eakin et al. (1988) and Arellano and Bond (1991).[23] [24] For this purpose we consider an autoregressive model of 1st order in education spending. We use the following specification:

$$\ln(Y_{i,t}) = \gamma \ln(Y_{i,t-1}) + \beta X'_{i,t} + u_i + \delta_t + \varepsilon_{i,t},$$

where $Y_{i,t}$ is public education spending per student of country i at time t, and $Y_{i,t-1}$ is the first lag of public education spending per student. Just as before, the β is a coefficient vector, the u_i is the unobserved country-level effect and δ_t represents the time fixed effects, respectively. Finally, $\varepsilon_{i,t}$ is the idiosyncratic error term. The vector X includes all the regressors used in our estimations.

In Table 4 we present the estimations when applying difference GMM to the above specified model. First, in regressions 1, 3 and 5 we estimate the dynamic model without the interaction term between ODR and PubPen. Second, when we include the interaction term – in regressions 2, 4 and 6 – the effect of the lag of education spending is statistically significant and positive. In this case, the coefficients are lower than without the interaction term. More specifically, a one percent increase in education spending of the previous year increases the current spending of total primary ans secondary public education by 0.80% (0.79% and 0.60% in primary and secondary, respectively). However, when we include the interaction term the effect is significantly lower, it is 0.38% for total primary and secondary, 0.32% for only primary and 0.39% for only secondary. One possible explanation for this could be that the interaction effect is absorbed by the lag of education when the interaction of ODR with PubPen is not considered.

Regarding our main explanatory variables, the coefficients have the expected sign, although not all of them are statistically significant. ODR has a negative but non-significant effect on all levels of education spending when we do not take into account its interaction effect with public pensions per pensioner (see regressions 1, 3, and 5). However, when the interaction term is considered the old dependency ratio has a negative impact on primary and secondary education spending per student only when public pensions spending per pensioner is beyond \$14,000 (reg. 2).[25] The same effect is negative when public pensions spending per pensioner is beyond \$17,000 when we consider only primary education, a level considerably higher compared to \$14,000 in regression 4, Table 3. The effect of income inequality on education spending is statistically significant and positive (about 1.10-1.18%) for primary education spending per student (regression 3 and 4). However, the effect is not statistically significant when we consider primary and secondary

[23] The Arellano and Bond estimator forms moment conditions using lagged-levels of the dependent variable and the predetermined variables with first-differences of the disturbances. This estimation technique transforms all regressors – by differencing them and removing the fixed effects – and uses Generalized Method of Movements (Hansen, 1982).

[24] When applying Arellano-Bond estimation to the model given by equation ??, we classify our regressors with respect to their level of exogeneity. We set as exogenous variables, the lag of income inequality and the private share of enrolments. As predetermined variables we set the public pensions per retiree and ODR. Finally, GDP per capita enters as endogenous variable.

[25] The effect of the interaction is determined through the partial derivative just as in the previous section.

Table 4: *Dynamic Panel Estimation*

	(1)	(2)	(3)	(4)	(5)	(6)
	ESPSPSE	ESPSPSE	ESPSPE	ESPSPE	ESPSSE	ESPSSE
L.ESPSPSE	0.8013***	0.3808**				
	(0.087)	(0.128)				
L.ESPSPE			0.7990***	0.3252*		
			(0.086)	(0.162)		
L.ESPSSE					0.6082***	0.3959**
					(0.117)	(0.124)
L.24.Gini	0.0037	0.0108	0.0106*	0.0188*	-0.0018	0.0011
	(0.006)	(0.007)	(0.005)	(0.008)	(0.007)	(0.007)
PubPen	-0.0059	0.0748**	-0.0143	0.0846*	0.0182	0.0724*
	(0.010)	(0.028)	(0.011)	(0.038)	(0.013)	(0.033)
ODR	-0.0223	0.0389*	-0.0075	0.0573*	-0.0291	0.0264
	(0.018)	(0.018)	(0.012)	(0.023)	(0.024)	(0.029)
ODR*PubPen		-0.0028**		-0.0035**		-0.0023*
		(0.001)		(0.001)		(0.001)
GDPpc	0.0119	0.0137	0.0108	0.0055	0.0188†	0.0155*
	(0.009)	(0.009)	(0.009)	(0.016)	(0.011)	(0.007)
SHPRPSE	0.4600	0.7748				
	(0.525)	(0.685)				
SHPRPE			0.2931	0.7017		
			(0.494)	(0.881)		
SHPRSE					0.4364	0.8213
					(0.494)	(0.507)
Instruments	73	74	76	77	74	75
Sargan-Test	0.7181	0.6980	0.7626	0.8850	0.1591	0.1351
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	216	216	242	242	225	225
Countries	29	29	31	31	30	30
χ^2 test	1841.77***	2766.40***	19129.95***	2158.69***	1960.11***	9695.37***

NOTE: *One-step GMM estimation, Arellano-Bond robust VCE estimator. Robust standard errors reported in parentheses, ***p<0.001, **p<0.01, *p<0.05, †p<0.10. Time fixed effects included in all regressions. The null hypothesis of the Arellano-Bond test for zero autocorrelation: no autocorrelation, is rejected only at order 1 but not at higher orders. The null hypothesis of the Sargan test of overidentifying restrictions: overidentyfing restrictions are valid, is not rejected. In the specification of the model we use PubPen and ODR as predetermined variables and GDPpc as an endogenous variable. Dependent variables: education spending per student in primary (ESPSPE), secondary (ESPSSE), primary & secondary education (ESPSPSE) are in logs. L.24.Gini: is a lag (24 years) of the Gini index on pre tax and transfers income, ODR: old dependency ratio. Public pensions spending per pensioner (PubPen) and GDPpc are measured in $1,000 PPP (constant 2011). Share of private education in total primary (SHPRPE), secondary (SHPRSE), primary & secondary (SHPRPSE) education. Constant is not reported but included in the above regressions.*

education jointly (reg.1 and 2). Finally, the effect on secondary education is positive but insignificant.

In our empirical analysis we use two different specifications to estimate the effect of income inequality and population ageing on education spending per student. We can conclude from our baseline specification that there is a positive effect of higher pre-tax and transfers income inequality on education spending per student. When we extend the specification to its dynamic form, we find mixed results regarding the effect of income inequality on education spending per student. More specifically, the effect of income inequality on education spending is mainly driven by the primary education level. Furthermore, the results of both specifications indicate that population ageing has a negative effect on education spending when there is a competition for fiscal resources, namely, pensions spending per pensioner is above a certain level.

5 Conclusions

In the recent decades two major trends in income inequality and population ageing have generated significant concerns about the sustainability of the welfare state. The higher income inequality and the increasing elderly population have fuelled the intragenerational and intergenerational conflict, respectively, and in turn have affected the public financing of public education and pensions. The former is a conflict within generation and it is between "rich" and "poor" groups of population over taxation for public provision of pensions and education. The latter conflict is between generations, as young and old have different preferences how to allocate public resources. The aim of this paper is to investigate the effect of these trends on public education and pensions spending per student and retiree, respectively.

To this end we developed a two-dimensional political economy model with public and private education and public pay-as-you-go pension scheme. Our model takes into account both political conflicts and uses the probabilistic voting model to examine the political outcome of the voting process on pensions and education given the preferences of each voting group. Our contribution is to examine those two trends simultaneously in order to understand the mechanisms through which they affect the public finance of education and pensions.

The model predicts that income inequality has a positive impact on education spending per student and the level of pensions per pensioner. This effect goes through the participation in public schooling. An increase in income inequality will increase the share of parents that choose to send their children to private schools, reducing the participation in public schools. Hence, increasing the spending per enrolled student and releasing fiscal resources that can be allocated towards a more generous level of pensions. When the state/government is the main provider of schooling an increase in income inequality would improve both the level of education and pensions and reduce the general tax level. The second theoretical prediction of our model states that a rise in the share of elderly population has a negative effect on education spending per student and worsens the level of pensions that every retiree is entitled to. This outcome is a result of a fiscal leakage that comes along with the rise in the population of elderly and puts more pressure on the welfare state.

Our empirical strategy concentrates on the effect of income inequality on education spending in a majority public education regime. We find support of the theoretical claims using OECD data on pensions and education, inequality and ageing. More specifically, we show evidence of the negative effect of old dependency ratio on education when we take into account that the impact could depend on the level of pensions. However, we obtain mixed results regarding the effect of income inequality on education spending.

An interesting direction for future research could follow an alternative approach by relaxing the assumption of a balanced government budget that we make in this model. The possibility to finance pensions and education by increasing the government's primary deficit could alter the incentives of the voting groups that we consider in this study. Moreover, it would be interesting to develop a model that considers a political process with a dynamic interaction between private savings and a PAYG pension system. Another possible trajectory concerns the weight of political power of different voting groups in policy-making.

References

Acemoglu, Daron and David Autor, "Skills, Tasks and Technologies: Implications for Employment and Earnings," in "Handbook of Labor Economics," Vol. 4b, Elsevier Inc., 2011, pp. 1043–1171.

Antonczyk, Dirk, Thomas DeLeire, and Bernd Fitzenberger, "Polarization and Rising Wage Inequality: Comparing the US and Germany," *Econometrics, MDPI, Open Access Journal*, 2018, *6*(2), 1–33.

Arellano, Manuel and Stephen Bond, "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations," *The Review of Economic Studies*, 1991, *58*(2), 277.

Bailey, Martha J and Susan M Dynarski, "Inequality in Postsecondary Education," in Greg Duncan and Richard J. Murnane, eds., *Whither Opportunity? Rising Inequality, Schools and Children's Life Chances*, 2011, chapter 6, pp. 118–131.

Baum, Christopher F, "Residual diagnostics for cross-section time series regression models," *The Stata Journal*, 2001, *1*(1), 101–104.

Bearse, Peter, Gerhard Glomm, and Debra Moore Patterson, "Endogenous Public Expenditures on Education," *Journal of Public Economic Theory*, 2005, *7*(4), 561–577.

Becker, Gary S., "An Economic Analysis of Fertility," in Ansley J. Coale, ed., *Demographic and Economic Change in Developed Countries*, Princton, NJ: Princeton University Press, 1960, pp. 209 – 240.

_ and Kevin M. Murphy, "The Family and the State," *The Journal of Law & Economics*, 1988, *31*(1), 1–18.

_ , _ , and Robert Tamura, "Human Capital, Fertility, and Economic Growth," *Journal of Political Economy*, 1990, *98*(5), 12–37.

Boadway, Robin W. and David E. Wildasin, "A Median Voter Model of Social Security," *International Economic Review*, 1989, *30*(2), 307–328.

Boldrin, Michele and Ana Montes, "The Intergenerational State Education and Pensions," *Review of Economic Studies*, 2005, *72*(3), 651–664.

Breyer, Friedrich and Ben Craig, "Voting on social security: Evidence from OECD countries," *European Journal of Political Economy*, 1997, *13*(4), 705–724.

_ and Klaus Stolte, "Demographic change, endogenous labor supply and the political feasibility of pension reform," *Journal of Population Economics*, 2001, *14*(3), 409–424.

Browning, Edgar K, "Why the Social Insurance Budget Is Too Large in a Democracy," *Economic Inquiry*, 1975, *13*(3), 373–388.

Cameron, A Colin and Pravin K Trivedi, *Microeconometrics Using Stata: Revised Edition*, A Stata College Station, Texas : Stata Press, 2010.

Casamatta, G. and L. Batté, "The Political Economy of Population Aging," in John Piggott and Alan Woodland, eds., *Handbook of the Economics of Population Aging, vol 1*, Elsevier, 2016, chapter 7, pp. 381–444.

Castles, Francis G, "On religion and public policy: Does Catholicism make a difference?," *European Journal of Political Research*, 1994, *25* (1), 19–40.

Cattaneo, Alejandra M. and Stefan C. Wolter, "Are the elderly a threat to educational expenditures?," *European Journal of Political Economy*, 2009, *25* (2), 225–236.

Croix, David De La and Matthias Doepke, "To segregate or to integrate: Education politics and democracy," *Review of Economic Studies*, 2009, *76* (2), 597–628.

Disney, Richard, "Population ageing and the size of the welfare state: Is there a puzzle to explain?," *European Journal of Political Economy*, 2007, *23* (2), 542–553.

Downs, Anthony, "An Economic Theory of Political Action in a Democracy," *Journal of Political Economy*, 1957, *65* (2), 135–150.

Driscoll, John C and Aart C Kraay, "Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data," *Review of Economics and Statistics*, 1998, *80* (4), 549–560.

Esping-Andersen, Gøsta and Francesco C. Billari, "Re-theorizing Family Demographics," *Population and Development Review*, 2015, *41* (1), 1–31.

Fernández, Raquel and Richard Rogerson, "Sorting and Long-Run Inequality," *The Quarterly Journal of Economics*, 2001, *116* (4), 1305–1341.

Galor, Oded and Daniel Tsiddon, "Technological Progress and Economic Growth," *The American Economic Review*, 1997, *87* (3), 363–382.

_ and David N. Weil, "The Gender Gap, Fertility, and Growth," *American Economic Review*, 1996, *86* (3), 374–387.

_ and _ , "Population, Technology, and Growth: From Malthusian Stagnation to the Demographic Transition and beyond," *The American Economic Review*, 2000, *90* (4), 806–828.

_ and Joseph Zeira, "Income Distribution and Macroeconomics," *The Review of Economics Studies*, 1993, *60* (1), 35–52.

Glomm, Gerhard and B. Ravikumar, "Public versus Private Investment in Human Capital: Endogenous Growth and Income Inequality," *The Journal of Political Economy*, 1992, *100* (4), 818–834.

Goos, Maarten, Alan Manning, and Anna Salomons, "Job polarization in Europe," *The American Economic Review: Papers and Proceedings*, 2009, *99* (2), 58–63.

Gradstein, Mark and Michael Kaganovich, "Aging population and education finance," *Journal of Public Economics*, 2004, *88* (12), 2469–2485.

Hansen, Lars Peter, "Large Sample Properties of Generalized Method of Moments Estimators," *Econometrica*, 1982, *50*(4), 1029.

Hausman, Jerry A., "Specification Tests in Econometrics," *Econometrica*, 1978, *46*(6), 1251–1271.

Hoechle, Daniel, "Robust standard errors for panel regressions with cross-sectional dependence," *The Stata Journal*, 2007, *7*(3), 281–312.

Holtz-Eakin, Douglas, Whitney Newey, and Harvey S. Rosen, "Estimating Vector Autoregressions with Panel Data," *Econometrica*, 1988, *56*(6), 1371.

Ichino, Andrea, Loukas Karabarbounis, and Enrico Moretti, "The Political Economy of Intergenerational Income Mobility," *Economic Inquiry*, 2011, *49*(1), 47–69.

Kaganovich, Michael and Itzhak Zilcha, "Pay-as-you-go or funded social security? A general equilibrium comparison," *Journal of Economic Dynamics and Control*, 2012, *36*(4), 455–467.

Kemnitz, Alexander, "Social security, public education, and growth in a representative democracy," *Journal of Population Economics*, 2000, *13*(3), 443–462.

Konrad, Kai A, "Social security and strategic inter-vivos transfers of social capital," *Journal of Population Economics*, 1995, *8*(3), 315–326.

Kornrich, Sabino and Frank Furstenberg, "Investing in Children: Changes in Parental Spending on Children, 1972-2007," *Demography*, 2013, *50*(1), 1–23.

Krieger, Tim and Jens Ruhose, "Honey, I shrunk the kids'benefits—revisiting intergenerational conflict in OECD countries," *Public Choice*, 2013, *157*(1-2), 115–143.

Lancia, Francesco and Alessia Russo, "Public Education and Pensions in Democracy: a Political Economy Theory," *Journal of the European Economic Association*, 2016, *14*(5), 1038–1073.

Lee, Ronald and Andrew Mason, *Population Aging and the Generational Economy: A Global Perspective*, Cheltenham: Edward Elgar, 2011.

Levy, Gilat, "The Politics of Public Provision of Education," *The Quarterly Journal of Economics*, 2005, *120*(4), 1507–1534.

Lindbeck, Assar and Jörgen W. Weibull, "Balanced-budget redistribution as the outcome of political competition," *Public Choice*, 1987, *52*(3), 273–297.

Manning, Alan, Marten Maarten Goos, and Alan Manning, "Lousy and Lovely Jobs: The Rising Polarization of Work in Britain," *The Review of Economics and Statistics*, 2007, *89*(1), 118–133.

Mayer, Susan E., "How Did the Increase in Economic Inequality between 1970 and 1990 Affect Children's Educational Attainment?," *American Journal of Sociology*, 2002, *107*(1), 1–32.

Michailidis, Gianko and Concepció Patxot, "Political viability of public pensions and education. An empirical application," *Applied Economics Letters*, 2018, *26* (03), 245–249.

_ , _ , and Meritxell Solé, "Do pensions foster education? An empirical perspective," *Applied Economics*, mar 2019, pp. 1–24.

Moav, Omer and Oded Galor, "From Physical to Human Capital Accumulation," *The Review of Economic Studies*, 2004, *71* (4), 1001–1026.

Naito, Katsuyuki, "Two-sided intergenerational transfer policy and economic development: A politico-economic approach," *Journal of Economic Dynamics and Control*, 2012, *36* (9), 1340–1348.

OECD, "Pensions at a Glance 2017: OECD and G20 Indicators," Technical Report 2017.

Ono, Tetsuo and Yuki Uchida, "Pensions, education, and growth: A positive analysis," *Journal of Macroeconomics*, 2016, *48*, 127–143.

Persson, Torsten. and Guido Enrico Tabellini, *Political economics : explaining economic policy*, MIT Press, 2000.

Pesaran, M. H., "General Diagnostic Tests for Cross Section Dependence in Panels," *Cambridge Working Papers in Economics*, 2004.

Piketty, Thomas, *Le capital au XXIe siècle*, Seuil, 2013.

Pogue, Thomas F. and L. G. Sgontz, "Social security and investment in human capital," *National Tax Journal*, 1977, *30*, 157–169.

Poterba, James M, "Demographic Structure and the Political Economy of Public Education," *Journal of Policy Analysis and Management*, 1997, *16* (1), 48–66.

Rangel, Antonio, "Forward and Backward Intergenerational Goods: Why Is Social Security Good for the Environment?," *American Economic Review*, 2003, *93* (3), 813–834.

Razin, Assaf and Efraim Sadka, "Aging population: The complex effect of fiscal leakages on the politico-economic equilibrium," *European Journal of Political Economy*, 2007, *23* (2), 564–575.

_ , _ , and Phillip Swagel, "The Aging Population and the Size of the Welfare State," *Journal of Political Economy*, 2002, *110* (4), 900–918.

Reardon, Sean F., "The Widening Academic Achievement Gap Between the Rich and the Poor: New Evidence and Possible Explanations," in Greg J. Duncan and Richard J. Murnane, eds., *Whither opportunity? Rising inequality, schools, and childrens life chances*, 2011, chapter 5, pp. 91–116.

Roodman, David, "How to do xtabond2: An introduction to difference and system GMM in Stata," *Stata Journal*, 2009, *9* (1), 86–136.

Shelton, Cameron A., "The aging population and the size of the welfare state: Is there a puzzle?," *Journal of Public Economics*, 2008, *92* (3-4), 647–651.

Soares, Jorge, "A dynamic general equilibrium analysis of the political economy of public education," *Journal of Population Economics*, jun 2006, *19* (2), 367–389.

Stiglitz, J. E., "The demand for education in public and private school systems," *Journal of Public Economics*, 1974, *3* (4), 349–385.

Tabellini, Guido, "A Positive Theory of Social Security," *Scandinavian Journal of Economics*, 2000, *102* (3), 523–545.

Tepe, Markus and Pieter Vanhuysee, "Are Aging OECD Welfare States on the Path to Gerontocracy? Evidence from 18 Democracies, 1980-2002," *Journal of Public Policy*, 2009, *29* (1), 1–28.

Wooldridge, Jeffrey M., *Econometric analysis of cross section and panel data*, MIT Press, 2010.

A The Voting Mechanism

We extend the probabilistic voting model used in De La Croix and Doepke (2009) by introducing the dimension of pensions in the voting process. Hence, voters decide about the tax rate v_t the per student spending on public education s_t, and the per pensioner pension p_t according to a probabilistic voting mechanism based on Lindbeck and Weibull (1987) and Persson and Tabellini (2000). This voting works in the following way: There are two political platforms a and b competing for the votes of the agents. They are competing by offering a policy consisting of a tax rate v_t, a per pensioner pension p_t and a per student education spending s_t that are fulfilling the government budget constraint

$$\int_0^{\tilde{x}_t} s_t n^s g(x)dx + \frac{1}{1+\varrho_{t-1}} p_t = v_t \left\{ \int_0^{\tilde{x}_t} x(1-\phi n^s) g(x)dx + \int_{\tilde{x}_t}^{\infty} \left[x(1-\phi n^e) - e_t^e(x) n^e \right] g(x)dx \right\}.$$

Voters are more likely to vote for the platform that yield them a higher utility. In contrast to the median voter theory, voters do not vote with probability one for the platform that maximises their utility but the probability of voting for platform a instead of platform b is an increasing and differentiable cumulative distribution function on the utility difference between policy a and policy b:

$$F\left\{ U_t\left[x, s_t^a, p_t^a, v_t(s_t^a, p_t^a)\right] - U_t\left[x, s_t^b, p_t^b, v_t(s_t^b, p_t^b)\right] \right\}.$$

This means that the voting decision is not discrete but rather a continuous function of the policy offered by both parties. The uncertainty of the voting is the result of the presence of ideological bias which is independent of the proposed policies. From this follows that the political platforms do not only appeal to the median voter, but consider the preferences of all voters instead. This allows us to aggregate the preferences of different demographical groups (rich, poor, young and old) in the policy function, which leads to the following objective function:

$$\Omega(s_t, p_t) = \int_0^{\tilde{x}_t} U_t^s(x, s_t, p_t, v_t(s_t, p_t)) g(x)dx + \int_{\tilde{x}_t}^{\infty} U_t^e(x, s_t, p_t, v_t(s_t, p_t)) g(x)dx + \frac{1}{1+\varrho_{t-1}} U_t^o(p_t).$$

Both parties maximise their expected vote share in a symmetrical way, leading to an equilibrium where both political platforms converge to the same policy $\{v_t^*, s_t^*, p_t^*\}$. The equilibrium policy is the policy that maximises the objective function above.

B Education Regimes

In a majority private education regime with $\Psi_t < 1/2$, participation in public education Ψ_t and the tax rate v_t^* are increasing with income inequality σ and the quality of public education s_t^* and the pensions per pensioner p_t^* are decreasing with σ. In an equally separated education regime, participation in public education, tax rate, quality of public education, and pensions are not affected by changes in inequality. This follows from the

proof of Proposition 2, where the first derivative of Ψ_t with respect to σ

$$\frac{\partial \Psi_t}{\partial \sigma} = \frac{\sigma - \left[\frac{1-\eta}{\hat{\eta}\phi\eta}\mathbb{E}_t(s_t) - (1-\sigma)\right]}{2\sigma^2} = \frac{1}{\sigma}\left(\frac{1}{2} - \Psi_t\right)$$

is positive for $\Psi_t < 1/2$, and equal to 0 for $\Psi_t = 1/2$. Following Lemma 1 this means that p_t^* and s_t^* are decreasing in σ and v_t^* is increasing in σ for $\Psi_t < 1/2$ and they are not affected by a change in σ is $\Psi_t = 1/2$.

The mechanism of the effect of an increase in income inequality is the following: an increase in income inequality is decreasing the income of the marginal agent that is indifferent between private and public education if this agent has a below average income. This means that this agent now prefers public education. This increase in public education increases the share of voters with children in public education, but it also increases the number of children in public education. Therefore the total spending on public education increases, but the spending per child decreases. Overall this leads to a decrease in public education quality. The increase in total education spending leads to a decrease in pensions and to an increase in taxes.

C Analysis on the Total Education Spending

In Table 5 we consider the effect of income inequality and population ageing on total education spending as percentage of GDP. In this specification of the empirical model we use as control variables the level of public pensions, GDP per capita, the share of students in private education and number of students in public primary, secondary and total education. As we can observe, income inequality has a positive effect on primary and secondary education in both specifications of the model. Regarding the non-dynamic panel model in regressions 1,2 and 3, we observe that a percentage rise in past income inequality increases primary total education spending by 0.0325%, secondary by 0.0295%, and the aggregate spending on primary and secondary education by 0.0675%. Old dependency ratio and public pensions per pensioner have positive effect on most levels of education spending considered in the Table 5.

In regressions 4, 5 and 6 with dynamic panel specification, one percentage increase in income inequality in the past has an impact of about 0.0588% on total education spending (primary and secondary considered jointly), 0.0276% on primary and 0.0284% on secondary total spending. Moreover, our proxy for population ageing (ODR) has a negative but insignificant impact on education spending.

Table 5: Total Spending in Primary and secondary Education as % of GDP

	Fixed effects SCC			*Arellano-Bond*		
	(1)	(2)	(3)	(4)	(5)	(6)
	GEPSE	GEPE	GESE	GEPSE	GEPE	GESE
L.GEPSE				0.6107**		
				(0.191)		
L.GEPE					0.6813***	
					(0.125)	
L.GESE						0.3186*
						(0.139)
L.24.Gini	0.0675**	0.0325***	0.0295*	0.0588***	0.0276*	0.0284*
	(0.021)	(0.005)	(0.012)	(0.016)	(0.011)	(0.014)
ODR	0.0392*	-0.0151	0.0312**	-0.0018	-0.0464	0.0246
	(0.015)	(0.009)	(0.008)	(0.067)	(0.032)	(0.039)
PubPen	0.0681***	0.0294**	0.0351**	-0.0191	-0.0503*	0.0375
	(0.016)	(0.008)	(0.010)	(0.042)	(0.020)	(0.024)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Instruments				77	78	77
Sargan-Test				0.0978	0.0972	0.0564
F-test	396921.96***	71246.01***	522487.65***			
Country FE	Yes	Yes	Yes			
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	294	315	304	230	252	238
Countries	31	32	33	29	31	30
R^2	0.3493	0.3732	0.3213			
χ^2				403.79***	659.11***	453.21***

Note: *Regressions 1,2 and 3: Fixed effects with robust Driscoll-Kraay standard errors corrected for heteroscedasticity, autoregressive process of order 2. Regressions 4, 5 and 6: One-step GMM estimation, Arellano-Bond robust VCE estimator. Robust standard errors for both groups of regressions are reported in parentheses, ***p<0.001, **p<0.01, *p<0.05, †p<0.10. Time fixed effects included in all regressions. The null hypothesis of the Arellano-Bond test for zero autocorrelation: no autocorrelation, is rejected only at order 1 but not at higher orders. The null hypothesis of the Sargan test of overidentifying restrictions: overidentyfing restrictions are valid, is not rejected. In the specification of the model we use PubPen and ODR as predetermined variables and GDPpc as an endogenous variable. Dependent variable: total education spending in primary (GEPE), secondary (GESE), primary & secondary education (GEPSE). L.24.Gini: is a lag (24 years) of the Gini index on pre tax and transfers income, ODR: old dependency ratio. Public pensions spending per pensioner (PubPen) and GDPpc are measured in $1,000 PPP (constant 2011). As control variables (not reported) we use the GDPpc, the share of private education in total primary (SHPRPE), secondary (SHPRSE), primary & secondary(SHPRPSE) education, and the number of student in public primary (ENPUBPE), secondary (ENPUBSE) and total primary and secondary (ENPUBPSE) education. Constant is not reported but included in the above regressions.*

D Appendix Tables

Table 6: Partial Correlations Between Education, Pension Spending and Old Dependency Ratio

Variables	ESPSPSE	PubPen	ODR
ESPSPSE	1.0000		
Obs	420		
PubPen	0.7334* (0.0000)	1.0000	
Obs	389	803	
ODR	0.4525* (0.000)	0.4606* (0.0000)	1.0000
Obs	420	803	1225

Table 7: Data: Definitions and Sources

Variable	Definition & Source
ESPSPE, ESPSSE, ESPSPSE	Education spending per enrolled student in primary, secondary, total primary and secondary educational level. It is calculated using the total public education spending and enrollments, Expenditure on Education, UNESCO.
ENPUBPE, ENPUBSE, ENPUBPSE	Enrollments (number of students) in primary, secondary, total primary and secondary educational level (as a % of total (private and public) primary & secondary), Enrollment by type of institution, UNESCO.
SHPRPE, SHPRSE, SHPRPSE	Share of enrollments in private primary & secondary education, World Bank Data: World Development Indicators.
GINI	Gini index of market income inequality before taxes and transfers, The Standardized World Income Inequality Database.
ODR (ODR(20-54))	Old dependency ratio, population over 65(55) years old as % of working age population 20-64(54) years old, World Population Prospects, United Nations
PubPen	Public pensions spending per retiree, calculated using Total Public Pensions as % of GDP and population over 65 years old , Social Expenditure, OECD.
GDPpc	GDP per capita based on purchasing power parity (PPP), World Bank Data: World Development Indicators.

Table 8: Alternative Old Dependency Ratio 20-54

	Fixed Effects (SCC)			*Arellano-Bond*		
	(1)	(2)	(3)	(4)	(5)	(6)
	ESPSPSE	ESPSPE	ESPSSE	ESPSPSE	ESPSPE	ESPSSE
L.ESPSPSE				0.4382***		
				(0.126)		
L.ESPSPE					0.4101**	
					(0.158)	
L.ESPSSE						0.4169***
						(0.097)
L.24.GINI	0.0214***	0.0270***	0.0194***	0.0089	0.0163**	0.0009
	(0.005)	(0.006)	(0.004)	(0.006)	(0.006)	(0.006)
ODR(20-54)	0.0255***	0.0283***	0.0235*	0.0211*	0.0303*	0.0117
	(0.005)	(0.005)	(0.009)	(0.010)	(0.012)	(0.014)
PubPen	0.0585***	0.0741***	0.0539***	0.0538**	0.0550*	0.0541*
	(0.008)	(0.010)	(0.009)	(0.021)	(0.024)	(0.025)
ODR(20-54)*PubPen	-0.0016***	-0.0020***	-0.0013**	-0.0014**	-0.0017**	-0.0012+
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
Instruments				74	77	75
Sargan-Test				0.5828	0.8022	0.0812
F-test	322930.89***	149133.05***	635177.87***			
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	294	315	304	216	242	225
Countries	31	32	33	29	31	30
R^2	0.8173	0.8011	0.7620			
χ^2				1678.31***	3297.80***	4231.70***

Note: *Regressions 1,2 and 3: Fixed effects with robust Driscoll-Kraay standard errors corrected for heteroscedasticity, autoregressive process of order 2. Regressions 4, 5 and 6: One-step GMM estimation, Arellano-Bond robust VCE estimator. Robust standard errors for both groups of regressions are reported in parentheses, ***p<0.001, **p<0.01, *p<0.05, †p<0.10. Time fixed effects included in all regressions. The null hypothesis of the Arellano-Bond test for zero autocorrelation: no autocorrelation, is rejected only at order 1 but not at higher orders. The null hypothesis of the Sargan test of overidentifying restrictions: overidentyfing restrictions are valid, is not rejected. In the specification of the model we use PubPen and ODR as predetermined variables and GDPpc as an endogenous variable. Dependent variable: education spending per student in primary (ESPSPE), secondary (ESPSSE), primary & secondary education (ESPSPSE) is in logs. L.24.Gini: is a lag (24 years) of the Gini index on pre tax and transfers income, ODR(20-54): old dependency ratio, people over 55 years old as a percentage of people 20 to 54 years old. Public pensions spending per pensioner (PubPen) and GDPpc are measured in $1,000 PPP (constant 2011). As controls variables (not reported) we use the GDPpc, the share of private education in total primary (SHPRPE), secondary (SHPRSE), primary & secondary (SHPRPSE) education. Constant is not reported but included in the above regressions.*