ASSESSING THE EFFICIENCY OF PUBLIC EDUCATION AND PENSIONS.[1]

by

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Abstract

Theory says that in an OLG context intergenerational transfer agreements, either private or carried out via government intervention, are efficient if the induce equality between certain implicit rates of return. We apply this theory to the case of public education and pensions, where public education is a loan from middle age to young and, a period later, pensions are the repayment of this loan, plus interest, from middle age to old. We use micro and macro data from Spain to estimate how far actual arrangements are from the normative goal. When demographic stationarity is assumed, the results are surprisingly good. We also quantify the impact of undergoing demographic change on the implicit rates of return. The results are unsurprisingly bad. Our estimates point to dramatic changes in future generational rate of returns. Nevertheless, and contrary to earlier predictions in the generational accounting literature, our findings suggest that future generations are not necessarily going to be worse off than current ones.

1. Introduction

Moral hazard problems have long prevented and still prevent the development of credit markets to finance individual investment in human capital. It is often alleged that this is the main reason for the existence of public education financing. The argument is intuitively convincing: to the extent that human capital accumulation is both necessary for growth and a gateway to a more efficient allocation of resources, government intervention should be advocated to ameliorate such a far-reaching and widespread market failure. In Boldrin and Montes (1999, 2004a) we cast this argument in the context of a life-cycle model of saving and human capital accumulation and reach the following conclusion: public education per-se, even if provided in the "efficient" amount, is not enough to restore efficiency when credit markets to finance human capital accumulation are missing. This is because, when a general equilibrium perspective is adopted, one is lead to recognize that financing the accumulation of human capital is just a part of the general life-cycle saving and consumption problem. During their working years, individuals invest in various assets to provide for retirement consumption; if financial markets were complete the human capital of future generations would be a component of the optimal retirement portfolio. The optimal retirement portfolio allows you to invest in the human capital of the future generations and, later on, also to draw a return from such investment. Public education achieves the first objective, i.e. it allows the working generation to invest in the human capital of the future generations, but not the second, i.e. it does not allow the former investors to collect the market return from their beneficiaries. This, we have shown, will generally lead to an inefficiency: investment in physical capital is too high and there is less intergenerational consumption smoothing than under the first best.

Our proposed solution is to link public financing of education and public pensions. This leads to a completely different design of PAYGO pension systems from the one advocated in Diamond (1965). In a life-cycle model, through the public financing of education, the young borrow from the middle age to invest in human capital. When middle age and employed, they pay back their debt via a social security tax, the proceedings of which finance pension payments to the now elderly lenders. In this setting public financing of education and public pensions are parts of a "social contrivance" between generations: if pension payments are appropriately linked to earlier investment in human capital, the complete market allocation can be implemented and, should the latter be implemented, a certain equality among (risk adjusted) rates of return should be observed.

In section 2 we illustrate this point by means of an example, which is a special case of the general model developed in Boldrin and Montes (2004a). In the rest of the paper we take the normative prescriptions of our model to the data. By doing so, we are not pretending to test the model, as the latter has only normative implications; we are instead pretending to test the efficiency of a real world public education and public pension system, the Spanish one. We use data from Spain to get a quantitative assessment of how far current arrangements may be from the theoretical optimum.

The results are surprising, in the sense that, under the assumption of demographic stationarity, current arrangements come extremely close to satisfy the predicted equality. According to our criterion, this means both that the efficient allocation is being approximated and that a negligible amount of intergenerational redistribution is taking place. To test the robustness of this finding, we also simulate a number of reasonable future demographic and policy scenarios. Things change dramatically. We find that, should current rules be maintained, the combined Spanish education and pension system will grossly violate the desired rate of return equality and, therefore, become both inefficient and highly redistributive across generations. The computed rates of return are far enough from the model's prescriptions to suggest that reforming the two systems by making the linkage between education and pension explicit would improve economic efficiency and social welfare. We believe that similar, or even stronger, conclusions hold for other European countries. In this sense, this paper provides a contribution to the ongoing policy debate on reforming the welfare state. Further, in the applied literature on contribution-based Social Security systems the issue of actuarial fairness between contributions paid and pensions received is an actively debated topic. Our model suggests that one should look for actuarial fairness somewhere else, that is between contributions paid and amount of public funding for education received on the one hand, and between taxes devoted to human capital accumulation and pension payments on the other. This observation is not irrelevant for the ongoing debate about the "sustainability" of public pension systems in USA and Europe alike.

The spirit of the empirical exercise is affine, but not identical, to that of the literature on Generational Accounting (see, for example, Auerbach, Kotlikoff, and Leibfritz (1999) and references to earlier work therein), which asks how far away from intergenerational balance current fiscal policies are. Instead, we ask how far away from the normative optimum current public education and pension systems are. We also show, in front of demographic change, which policy choices would keep the overall system close to the normative optimum and which would lead it far astray, which would redistribute in favor of some generations and which would sustain intergenerational neutrality. Traditionally, works in the GA tradition have treated education as government consumption, leaving aside its role as an investment/transfer favoring the young generations. More recent works have modified this assumption and started treating public education as a transfer toward the young. This modification is, in our view, quite appropriate and has lead to empirical findings that go in a direction similar to ours, i.e. a lower burden of taxation on the young and future generations.

In this sense our theoretical approach is complementary and not alternative to Generational Accounting, and it may lead to a clearer theoretical understanding of the empirical estimations obtained with that methodology. When looking at the whole collection of public policies and associated taxes, though, it remains a daunting task to model appropriately the "missing markets" these policies are supposed to take care of. The case for education and pensions is, in our view, much clearer and well defined than that for most other welfare policies.

2. The Basic Model

To illustrate our argument, consider an economy of overlapping generations where three generations are present in any period. In each period $t = 0, 1, 2, \cdots$ the physical capital, k_t, and the human capital, h_t, are owned, respectively, by the old and the middle age individuals. Aggregate output of the homogenous commodity is $y_t = Ak_t^{\alpha} h_t^{1-\alpha}$, with $A \geq 1$ and $\alpha \in (0, 1)$. At the beginning of each period a new generation of young agents is born. They are endowed with a stock h_t^y of basic knowledge which can be used to produce human capital. If they spend time and money at school their human capital becomes $h_{t+1} = Bd_t^{\beta} \left(h_t^y\right)^{1-\beta}$, with $B \geq 1$, $\beta \in (0, 1)$, when middle age. Here, d_t is the amount of homogenous good invested in the educational process. During the second period of their live, individuals work and carry out consumption-saving decision. When old, they consume the total return on their saving before dying.

We assume agents draw utility from consumption when middle age and old (c_t^m and c_{t+1}^o) according to the utility function $log(c_t^m) + \delta log(c_{t+1}^o)$. Neither leisure nor the welfare of their descendants affect utility.

Let the homogenous commodity be the numeraire, in each period $t = 0, 1, 2, \cdots$ output y_t is allocated to three purposes: aggregate consumption ($c_t = c_t^m + c_t^0$), accumulation of next period's physical capital (k_{t+1}) and investment in education

(d_t). Human and physical capital are hired by firms at competitive prices equal, respectively, to $w_t = A(1-\alpha)k_t^{\alpha}\ h_t^{-\alpha}$ and $1 + r_t = A\ \alpha k_t^{\alpha-1} h_t^{1-\alpha}$. Aggregate saving is allocated, through competitive credit markets, to finance physical and human capital accumulation ($s_t = k_{t+1} + d_t$), accruing a total return equal to $(1 + r_{t+1})s_t = R_{t+1}s_t$.

Assume financial markets for both kinds of capital are available. In these circumstances, the life-cycle optimization problem for the agent born in period $t-1$ is

$$U_{t-1} = \max_{d_{t-1}, s_t} \left\{ \log(c_t^m) + \delta \log(c_{t+1}^o) \right\} \tag{2.1}$$

subject to:

$$\begin{aligned} & 0 \leq d_{t-1} \leq \frac{w_t h_t}{R_t} \\ & c_t^m + s_t + R_t d_{t-1} \leq w_t h_t \\ & c_{t+1}^o \leq R_{t+1} s_t \\ & h_t = h(d_{t-1}, h_{t-1}^y). \end{aligned}$$

The first order conditions of households and firms give

$$s_t = \frac{\delta}{1+\delta} \left[w_t h_t - (1 + r_t) d_{t-1} \right],$$

$$d_{t-1} = \frac{\beta(1-\alpha)}{\alpha} k_t.$$

Setting $\beta(1-\alpha)/\alpha = \gamma$ and using the market-clearing condition for saving and investment, gives

$$d_{t-1} = \frac{\gamma s_{t-1}}{1+\gamma}.$$

Aggregate saving is therefore equal to

$$s_t = \left[A \frac{\delta(1-\alpha)(1-\beta)}{1+\delta} \right] \left[k_t^{\alpha} h_t^{1-\alpha} \right]$$

which implies

$$k_{t+1} = A\eta \left[k_t^{\alpha} h_t^{1-\alpha}\right] \tag{2.2a}$$

$$h_{t+1} = B(h_t^y)^{1-\beta}(A\gamma\eta)^{\beta} \left[k_t^{\alpha} h_t^{1-\alpha}\right]^{\beta} \tag{2.2b}$$

where $0 < \eta = \frac{\delta}{(1+\delta)} \frac{(1-\alpha)(1-\beta)}{(1+\gamma)} < 1$.

For simplicity set $h_t^y = h_t$ so that an autonomous system can be derived. The only rest point of (2.2) is the origin. The ray

$$x^* = \frac{k_t}{h_t} = \left[\frac{A\eta}{B\left(A\gamma\eta\right)^{\beta}}\right]^{\frac{1}{1-\alpha(1-\beta)}}$$

in the (h_t, k_t) plane defines a balanced growth path. Straightforward algebra shows that for all initial conditions $(h_0, k_0) \in \Re_+^2$, iteration of (2.2) leads (h_t, k_t) to the ray x^*. Along the balanced growth path, the two stocks of capital expand (or contract) at the factor

$$1 + g^* = A\eta \left[\frac{B(A\gamma\eta)^{\beta}}{A\eta}\right]^{\frac{1-\alpha}{1-\alpha(1-\beta)}}$$

which is larger than one (i.e. there is unbounded growth) when

$$\eta > \frac{1}{A} \cdot \left[\frac{1}{B^{1/\beta}\gamma}\right]^{(1-\alpha)}.$$

A sufficient condition for the equilibrium path to be dynamically efficient is that the gross rate of return on capital be larger than or equal to one plus the growth rate of output. With linearly homogeneous production functions, the rate of return on capital is determined by the factor intensity ratio. Hence we need $(1 + g^*) < \alpha A\left(x^*\right)^{-(1-\alpha)}$. The latter reduces to $\alpha > \eta$, which is equivalent to $\frac{(1-\alpha)(1-\beta)}{\alpha+\beta(1-\alpha)} < \frac{1+\delta}{\delta}$. For reasonable values of α and β, the latter is satisfied, as long as $\delta > 0$.

Next, consider a situation in which markets for financing education are altogether absent. Then $d_t = 0$ and $s_t = k_{t+1}$ for all t, the competitive equilibrium is not efficient. Introduce the intergenerational welfare state. In each period t two taxes are levied upon the middle age generation, to provide resources for two simultaneous transfers. The proceeding from the first tax (T_t^p) are used to pay out a pension (P_t) to the elderly. The proceeding from the second tax (T_t^e) are used to finance investment in the education of the young generation. We assume balanced budget period by period.

The budget constraints for the representative member of a generation born in period $t-1$ become

$$0 \leq d_{t-1} \leq E_{t-1} \tag{2.3a}$$

$$c_t^m + s_t \leq w_t h_t - T_t^p - T_t^e \tag{2.3b}$$

$$c_{t+1}^o \leq R_{t+1} s_t + P_{t+1}. \tag{2.3c}$$

Comparison of equations (2.3) with the budget restrictions of problem (2.1) shows that, if the lump-sum amounts satisfy

$$E_t = d_t^* \qquad \text{and} \qquad P_t = d_{t-1}^* R_t^*, \tag{2.4}$$

the competitive equilibrium under the new policy achieves the Complete Market Allocation (starred symbols, from now onward, always refer to the CMA). In other words, a benevolent planner can restore efficiency, improve long-run growth rates, and preserve intergenerational fairness by establishing publicly financed education *and* PAYGO pensions simultaneously, and by linking the two flows of payments via the market interest rate.

Only this arrangement can implement the efficient complete market allocation. Note first that neither retirement pensions financed by the investment in physical capital nor a PAYGO system with a rate of return equal to the growth rate of the population can achieve the CMA. Second, a system of pure public school financing cannot lead to the CMA either. Only a *combined* public education and pension system satisfying (2.4) can restore the CMA. This scheme is also intergenerationally "fair", in the sense that it provides each generation with a market driven return from its investment in human capital. In particular, we have

$$E_t R_{t+1}^* = T_{t+1}^p \qquad \text{and} \qquad T_t^e R_{t+1}^* = P_{t+1}. \tag{2.5}$$

Note that, contrary to what seems to have become the norm in many European reforms (e.g. Italy and Sweden) the internal rate of return of an efficient PAYGO pension system should not be determined by the growth rate of GDP but, instead, by the rate of return on human capital investment.

2.1. Connecting the Model to the Real World

Boldrin and Montes (2004a) prove that

Proposition 1. *If the set of intergenerational transfers induced by the public education and the public pension systems support the complete market allocation, the following should be observed. For a given generation, the implicit rate of return* i_t *which, along the life cycle, equalizes the discounted values of education services received and social security contributions paid, is equal to the market rate of interest* r_t*. Similarly, the implicit rate of return* π_t *that, along the life cycle, equalizes the discounted values of education taxes paid and pension payments received, is also equal to the market rate of interest* r_t*.*

As reality is seldom, if ever, fully efficient, it becomes relevant to ask how much "off the mark" current intergenerational arrangements are. The pair $|\pi_t - r_t|$ and $|i_t - r_t|$ gives a reasonable way of measuring such distance. Should reality turn out to be not far from what we have shown to be the efficient allocation, it would become an interesting topic of research to ask how existing political mechanisms implement allocations that satisfy the Pareto criterion. Should reality turn out to be far from the efficient allocation, then it becomes relevant to ask how one should proceed to bring it closer.

These considerations lead us to entertain, albeit briefly, a positive reading of our model. In the real world benevolent planners are probably harder to come across than credit instruments for financing education. A priori, there are very few reasons to expect that existing public education and pension systems should strive to replicate the complete market allocation and achieve the efficiency gains we have outlined here. As a matter of fact, in none of the countries we are aware of is the welfare state legislation explicitly organized around the principles advocated in this paper. In general, social security contributions are levied as a percentage of labour income and bear no clear relation to the previous use of public education. Pension benefits received are related, in one form or another, to past social security contributions but never to some measure of lifetime contributions to aggregate human capital accumulation. Still, there are intuitive reasons to believe that intergenerational transfers that are either grossly inefficient or openly unfair (in the sense that some generations collect rates of return systematically higher than those of other generations) would be subject to strong public pressure to be either dismantled or improved upon. Further, in a recursive environment in which the middle-age generation decides whether and how to implement an intergenerational welfare system, an equilibrium satisfying (2.5) may arise. In Boldrin and

Montes (1999) we present a dynamic game of generational voting, along the lines of Boldrin and Rustichini (2000), which possesses a subgame perfect equilibrium implementing the CMA. We refer the interested reader to Boldrin and Montes (2004b) for this result, a discussion of the circumstances under which the political equilibrium implementing the CMA is the unique subgame perfect and, finally, for extensions to other notions of recursive equilibrium, and to more general OLG environments. Results along the same lines have been derived independently by Rangel (2003) and, to a smaller degree, by Bellettini and Berti-Cerroni (1999), while Cigno (2004) contains a fairly complete survey of theoretical results on efficient intergenerational transfers, especially in their connection to fertility choice.

All of this conjures to make an examination of the data worthy of our time. This we do, using Spanish data, in the next section.

3. The Spanish Case

In this section, we use Spanish data to compute the values of i and π implied by the rules in place and the taxes and transfers implemented in 1990-1991. To carry out our computations, the stationarity assumptions made in the model are first taken verbatim and then relaxed as we move along. We proceed in three stages. In the first, we abstract from demographic change and economic growth. It will be shown that, as long as growth takes place at a constant rate, it cannot affect the efficiency result. In the second stage, we incorporate the forecasted demographic evolution for the period 1990-2089 and consider a number of reasonable policy scenarios. In the third, we use the same demographic predictions to evaluate the quantitative impact that economic growth at a constant rate would have on the implicit rates of return faced by different generations. At the end of the section we replicate the same exercise with more recent data for the years 1998-1999.

More specifically, in our empirical exercise we assume that the rules of the Spanish public education and public pension systems will not be changed for the very long future and that all individuals currently alive have also lived under those same rules in the past. This is obviously false, because both education and pension systems underwent large and frequent changes in the period 1960-85. In 1985 the pension system was reformed once more, and since then, it has kept its basic rules almost unchanged. The same goes for the public education system, which achieved its current structure in the early 1980s and has not changed much since. Hence, while our assumption of stationarity is only an approximation to reality, it is a good approximation for the last 20 years, and it appears to be a reasonable one for the foreseeable future.

In the first stage, we assume that the aggregate burden of taxation and its age distribution have not varied and will not vary over the lifetime of the individuals alive in 1990-1991. In the second and third stages we let aggregate public expenditure change according to specific scenarios. As for income, in the first and second stages we assume it remains constant, for each age group, over the simulation horizon. In the third, we let age-specific per capita income grow at a constant rate and adjust aggregate taxation accordingly, under the assumption of a constant age distribution of taxes and transfers. Notice that, if it were not for the changing demographic structure, this would imply constant tax and transfer rates for each age group and function. Finally, in all of our simulations we make the assumption that the education and pension yearly budgets are balanced.

We abstract from deficit financing and the generational burden of public debt for a variety of reasons. First, the Spanish public sector deficit has varied a lot during the last 15 years and has decreased to values very near zero since 1998. The same is true for the social security administration budget, which was repeatedly manipulated by changes in accounting criteria and has generated a surplus since 1997. Secondly, there is no reliable method to allocate the debt burden over different cohorts, either for the past or for the future. Third, no ear-marking of debt is available, hence any attribution of part of the current or future debt to either education or pensions would be completely arbitrary. The intergenerational distribution of the debt burden remains, nevertheless, an important issue to be addressed. It requires an explicit model of optimal fiscal policy in a life cycle model with changing demographic structure. A first step in this direction is taken in Boldrin and Montes (2004c).

Ours are, indeed, relatively strong assumptions. Stationarity and balanced growth assumptions are often made in most empirical applications of dynamic models, and our case makes no exception. Given the available micro data, we find our approach to be a reasonable starting point.

Data[4]

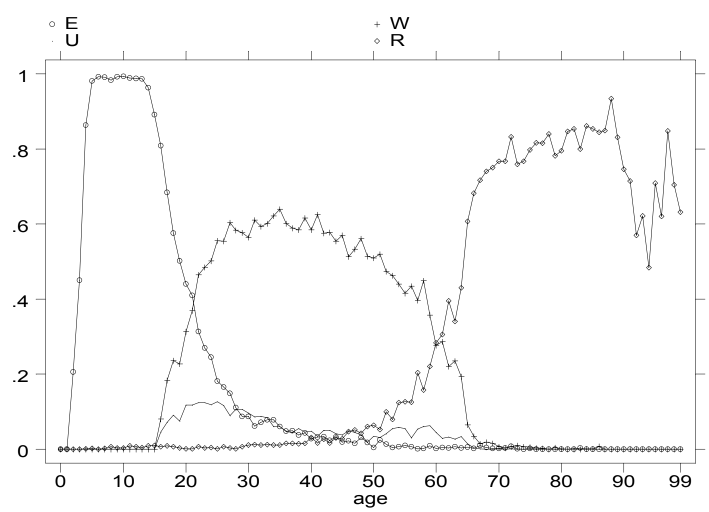
To compute the stationary values of i and π, we use several kinds of micro and macro data. The choice of the reference year for the baseline case is dictated by the availability of data, especially for what is concerned with the allocation of time along the life cycle. Currently, there is only one reliable data source, the *Encuesta de Presupuestos Familiares*, Household Budget Survey or EPF from now

[4]Further details about the data sets we use are in the Appendix and in Montes (2000).

on, which is furthermore available only for 1980-1981 and 1990-1991. We have used the 1990-1991 EPF because the Spanish public pension system underwent a major reform in 1985 and because the 1980-1981 EPF contains only a severely limited subset of the information we need.

For each individual in the sample, conditional upon age and occupational status, the information in the EPF allows for the estimation of (1) the value of the school services received and which were directly or indirectly financed by the state, (2) the value of direct and indirect taxes paid, (3) the amount of pension contributions paid, and (4) the amount of public contributive pensions received. The information in the EPF also affords the computation of the share of the population which, at each age, is studying, working, unemployed, or retired. Such lifetime distribution of activities is reported, in percentages of each age group, in Figure 1. Together with quantities (1)-(4), it allows the computation of the implicit rates of return.

Figure 1: Life-time distribution among activities.



E=Student, W=Worker, U=Unemployed, R=Retired,
Inactive, not reported.

3.1. The base case under stationarity

Consider an individual living for a maximum of A periods, and let p_a denote the (conditional) probability of survival between age a and $a+1$. Denote with i the interest rate at which young people "borrow" through public education and with π the rate of return the elderly receive from their "investment" in public education. For a given sequence of taxes and transfers, the rates i and π (time invariant, because of the stationarity assumptions) are defined implicitly by

$$\sum_{a=1}^{A} \left(\Pi_{j=1}^{a} p_j \cdot (1+i)^{A-a} \right) [E_a - T_a^p] = 0 \qquad (3.1a)$$

$$\sum_{a=1}^{A} \Pi_{j=1}^{a} p_j \cdot (1+\pi)^{A-a} [T_a^e - P_a] = 0. \qquad (3.1b)$$

The representative agent for our base case is defined by the following assumptions:

(a) At age $a = 1, \ldots, 98$, the probability p_a of being alive at age $a+1$ is the one reported by the *Instituto Nacional de Estadistica* for that age group in 1990. The EPF does not contain individuals older than 99.

(b) At each age $a = 1, \ldots, 99$, the representative individual is working, studying, unemployed, or retired with a probability equal to the frequency of that activity in the EPF sample of people of age a.

(c) At each age $a = 1, \ldots, 99$, an individual receives or pays tranfers and taxes equal to the average, in the EPF, for those individuals that at age a were in the same occupational status.

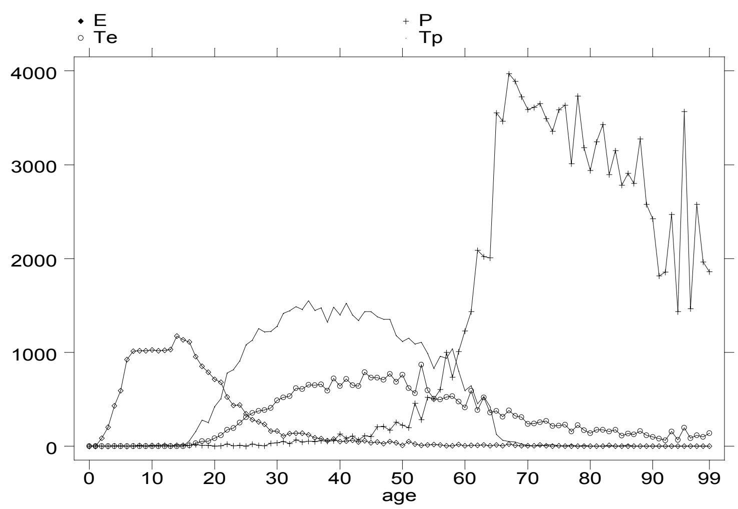
Assumptions (a)-(c) can be used to extract from the EPF the amounts E_a, P_a, T_a^e, and T_a^p that an individual of age a would pay or receive. Such estimation uses the age- and status-specific information contained in the EPF, according to assumptions (b) and (c). Let X be a stand-in for any of the four quantities. For each $a = 1, 2, \ldots, 99$, we use population data to compute the amounts X_a attributable to the representative agent of that age. Let L_a be the number of individuals of age a in the Spanish population in 1990 (INE (1991)). A four-tuple of weights x_a can be computed by setting

$$x_a = \frac{X_a}{\sum_{a=1}^{A} X_a L_a}.$$

Write this four-tuple of x_a as $[\alpha_a, \beta_a, \gamma_a, \delta_a]$. The terms denote, respectively, the share of total T^e and T^p paid and of total P and E received (according to the EPF) by the representative individual of age a.

Next, from the government and social security administration budgets for 1990, we compute the quantities X^{90} corresponding to the effective total tax or transfer relative to each function. We allocate these amounts over the lifecycle of the representative agent by means of the weights x_a. The lifetime distribution of these four flows, in Euros of 1990, is reported in Figure 2.

Figure 2: Life-time distribution of tax and transfer flows.



Equations (3.1) become

$$\sum_{a=1}^{99} \left(\Pi_{j=1}^{a} p_j\right) (1+i)^{99-a} \left[\delta_a \cdot E^{90} - \beta_a \cdot T^{90,p}\right] = 0 \tag{3.2a}$$

$$\sum_{a=1}^{99} \left(\Pi_{j=1}^{a} p_j\right) (1+\pi)^{99-a} \left[\alpha_a \cdot T^{90,e} - \gamma_a \cdot P^{90}\right] = 0. \tag{3.2b}$$

Notice in passing that, had we assumed a constant annual growth rate of $g > 0$ for both taxes and transfers, equations (3.2) would be modified by multiplying each annual entry by a factor of $(1+g)^a$. Dividing through by $(1+g)^{99}$ and replacing $(1+i)$ and $(1+\pi)$ by $(1+i)/(1+g)$ and $(1+\pi)/(1+g)$, respectively, leads back to (3.2). This implies that adding a constant growth rate changes the quantitative but not the qualitative conclusions of our exercise. We come back to this point at the end of the section, when we quantify the joint impact of economic growth and demographic change.

We solve expressions (3.2) numerically. Our point estimate of the implicit rate of return on education investment is

$$\pi = 4.238\%.$$

Our point estimate of the implicit rate of interest at which young people borrow is more ambiguous. It depends upon the convention with which one handles the yearly surpluses and deficits of the various Spanish social security administrations. In 1990, the social security administration for workers of the private sector (INSS) realized a surplus of pension contributions over pension outlays[5], while the social security administration for public employees (RCP) realized a deficit. The latter was covered by a transfer of funds from the general government budget. Our model assumes a year-by-year balanced budget. One possibility is to get rid of both the INSS surplus and the RCP deficit by assuming that the total amount of social security contributions was, in fact, equal to the public contributive pension payments made in that year (P^{90}). In this case, our point estimate is

$$i_1 = 3.6307\%.$$

A second possibility is to use the actual social security contributions paid to INSS and RCP in 1990 ($T^{90,p}$). In this case,we have

$$i_2 = 3.772\%.$$

Finally, a third alternative is to add to the total contributions paid in 1990 ($T^{90,p}$) the amount transferred from the general government budget to cover the RCP deficit. Adopting this wider definition, the implicit rate of interest is computed to be

$$i_3 = 4.2601\%.$$

[5]The INSS is divided further into six different funds, some of which exhibited a deficit and others a surplus during the same year. Our micro data do not allow us to consider this finer partition.

We believe that i_3 is a better estimate of the true implicit rate because the RCP "deficit" is a misnomer attributable to accounting practices. The government portion of the social security contributions for its employees is highly forecastable and, de facto, is always recorded as a transfer from the general budget to cover the RCP deficit. In other words, the transfers included in the computation of i_3 are functionally equivalent to the employers' contributions paid by private sector firms to the INSS. To us, this means they are part of the gross labor income of public employees and, for this reason, should be treated as part of the total social security contributions they pay.

The difference between the estimated value for π and i_3 is very small suggesting that, around the year 1990, the Spanish public education and pension systems carried out a set of intergenerational transfers that were remarkably close to what a benevolent planner would want to achieve. This positive result, though, is heavvily dependent upon both the stationarity assumptions made so far and the use of an average or representative agent. Things turn out to be quite different, and very far from efficient, once we take either heterogeneity or non-stationarity into consideration. We look at the impact of heterogeneity along educational levels next, and consider a number of non-stationary factors in the next section.

3.2. Educational Heterogeneity

Under a relatively mild set of assumptions, our data set allows us to consider separately the life cycle taxes and transfers of individuals with different levels of education. To do this we need to assume that

- (i) An individual studying in 1990-1991 will complete the educational cycle in which he/she is enrolled.
- (ii) Moreover, he/she will also achieve at least the level education of his/her head of household.
- (iii) Individuals who are above the minimum working age (16) and who are not attending school, will not go back to school in the future.

These are conservative assumptions, as they certainly underestimate the extent to which college-level attendance rates have increased in Spain since the early 1980s. We classify people in four groups: without studies (w) (include all individuals that leave school before completing primary education), primary education

(p), secondary education (s) and higher education (h). To each of these four representative individuals we apply assumptions (a)-(c) above and extract from the EPF the amounts E_a^j, P_a^j, T_a^{je}, and T_a^{jp} that an individual of age a and educational level j pays or receives. For each representative individual j a four-tuple of weights x_a^j can be computed by setting

$$x_a^j = \frac{X_a^j}{\sum_{a=1}^{A} \sum_j X_a^j L_a^j}.$$

We allocate the aggregate quantities X^{90} over the life cycle of each representative agent j by means of the weights x_a^j. The available probabilities of survival do not distinguish between educational levels, hence we assume that

- (iv) The (conditional) probability of survival at each age is the same for all $j = w, p, s, h$.

The results are the following. The implicit "borrowing" rates are

$$i^w = 4.2171\%,\ i^p = 4.4731\%,\ i^s = 4.7142\% \text{ and } i^h = 4.4197\%.$$

The borrowing rates are increasing in the educational level, but not for higher education. Nevertheless, these interest rates are still very similar. The implicit "lending" rates are

$$\pi^w = 5.3078\%,\ \pi^p = 4.0718\%,\ \pi^s = 3.6934\% \text{ and } \pi^h = 2.4769\%.$$

The lending rates are strongly descreasing in the educational level. The distance between π^w and π^h may be somewhat exagerated by the fact that we apply the same survival probabilities to all individuals, whereas it is known that better educated people tend to leave longer, hence collect longer streams of pension payments. Still, we doubt that adjusting for different mortality rates would make a substantial difference. Hence, we conclude, the Spanish education and pension systems are highly redistributive.

4. Extensions

4.1. Changes in Mortality Rates

In our definition of the Spanish representative agent, we have used the mortality rates reported by the INE for 1990 (assumption (a) above). This is a debatable choice because those rates were computed using observations prior to 1990; survival probabilities have changed greatly since then, and are still changing. To correct for this, we run the base case simulation using the updated survival probabilities implicit in the Fernández Cordón (2000) demographic forecasts. The new estimates are $i = 4.4565\%$ (from now on, only i_3 will be reported) and $\pi = 4.7853\%$, reversing the order of our previous findings. As should be expected, public pensions become a better deal as survival rates improve.

The population forecasts of Fernández Cordón (2000) are obtained by simultaneously using new mortality rates and expected immigration flows. Unfortunately, the two sources of change cannot be disentangled, so that for certain age groups the estimated probability of survival is slightly higher than one. Immigrants are concentrated in the 20 to 40 age groups so, if we force all probabilities of survival to be bounded above by one, we get $\pi = 4.859\%$ and $i = 4.388\%$, making pensions an even better deal.

Clearly, the continuously increasing life expectancy at retirement is rapidly moving the system away from the equality of rates of return which appeared to be realized in the early 1990s.

4.2. Sources of Non stationarity

To provide a fuller account of the impact that demographic change and economic growth may have on i and π, we consider a number of alternative scenarios.We begin with the impact of expected demographic change. To do this, we replace the assumption of demographic stationarity with the projections of Fernández Cordón (2000), which take into account variations in both mortality and fertility rates. Removing demographic stationarity makes i and π dependent upon the date of birth. Each cohort faces different rates (i_a, π_a), depending upon its age $a = 1, 2, \ldots, A$ in the initial period. Here we report results for three selected cohorts: that born in 1990, that born in 1974 (16 is the minimum working age in Spain), and that born in 1950. Results for other cohorts are available upon request.

4.2.1. Demographic Change

Changing the demographic structure while keeping the balanced budget requirement satisfied in each period requires making assumptions on the policies for distributing the additional taxes and transfers across individuals belonging to different generations. In particular, one needs to make an assumption as to which features of the system that were observable in 1990 will be maintained in future periods. Many scenarios are conceivable. We selected four, which we consider most likely or, at least, most informative; in all four we abstract from growth in per-capita real income, which will be examined next. In all scenarios, for the generations born in 1974 and 1950, we use 1990 age-specific values to impute the taxes/transfers paid/received in the years previous to 1990.

- Scenario A, we assume that age-specific, per capita expenditure in education and pensions will remain at their 1990 level, in real terms.
- Scenario B, we assume that age-specific, per capita education taxes and social security contributions will remain at their 1990 real values.
- Scenario C, we take as fixed the borrowing rate realized in 1990, and apply it to the generation born in that year.
- Scenario D we consider the case in which the lending rate is kept at its base case level for the generation born in 1990.

The careful reader will notice that, for each scenario, the specific policy adopted and the year-by-year balanced budgets are not enough, for given demographics, to uniquely pin down all remaining variables. Consider, for example, Scenario A. Using per capita expenditure in education and demographic data, we can compute total education expenditure E_t in each future year. The balanced budget constraint implies that $E_t = T_t^e$, for all t. This determines the total education tax to be levied in each year, but leaves its distribution, across generations, still open. The same is true for the distribution of T_t^p across generations, etcetera. To address this problem, we proceed as follows. For each of the four flows, let X_a be the amount paid or received by the representative individual of age a according to the 1990 data. For each $x = E, T^e, P, T^p$ and age $a, a' = 1, 2, \ldots, A$, define the constants

$$k^x(a, a') = \frac{X_a}{X_{a'}}.$$

Then, for all future years and in all four scenarios we assume that, for each function x whose distribution over cohorts is to be determined endogenously, the payments from or transfers to the average individuals of age a and a' will yield the same $k^x(a, a')$ as in 1990. In other words, we assume that, while a certain policy may either favor or hurt a given cohort over its entire lifetime, it will not do so by charging different taxes to people of different ages in any given year. The same is true for transfers.

Scenario A We set real per capita expenditure E_a and P_a at the 1990 level, for all a. The demographic projections allow the computation of aggregate expenditures, E_t and P_t, for each year $t = 1990, \ldots, 2089$. We use a balanced budget in each year to compute T_t^e and T_t^p. We use the assumption of constant $k^{T^e}(a, a')$ and $k^{T^p}(a, a')$, together with demographic data, to compute the distribution of taxes across individuals in each year. Given this, we compute the rates of return. For the generation born in 1990, we obtain $i_{90}^A = 6.0643\%$ and $\pi_{90}^A = 6.8918\%$, while we have $i_{74}^A = 4.7620\%$ and $\pi_{74}^A = 6.3121\%$ for the generation born in 1974, and $i_{50}^A = 4.2888\%$ and $\pi_{50}^A = 4.9525\%$ for the generation born in 1950.

Scenario B Here we fix real per capita taxation T_a^e and T_a^p at the 1990 level, for all a. Then we proceed as in Scenario A, using the assumption of constant $k^E(a, a')$ and $k^P(a, a')$ to compute the yearly distribution of E_t and P_t across individuals of different ages. For the generation born in 1990, this policy gives $i_{90}^B = 3.0018\%$ and $\pi_{90}^B = 2.2021\%$, while we have $i_{74}^B = 4.2322\%$ and $\pi_{74}^B = 2.1912\%$ for the generation aged 16 in 1990, and $i_{50}^B = 4.3763\%$ and $\pi_{50}^B = 3.9421\%$ for the generation aged 40 in 1990.

Scenario C In this case, we take the borrowing rate $i_{90}^C = 4.4565\%$ for the generation born in 1990 as given. On the basis of the 1990 data, we fix the per capita expenditure in E for each age group. We use this per capita expenditure to project total lifetime transfers to each generation alive in 1990. This gives us the total education expenditure, E_t, in each fiscal year between 1990 and 2089. Next, we use 1990 per capita social security contributions (for each age group) to compute how much will be available to pay pensions, T_t^p, during each fiscal year between 1990 and 2089. Notice that, by doing this, we guarantee that the generation born in 1990 will pay $i_{90}^C = 4.4565\%$, as the representative agent in the base case. Finally, we use the yearly balanced budget restrictions together with the assumption of time-invariant $k^{T^e}(a,a')$ and $k^P(a,a')$ to determine endogenously the amount of taxes $T_t^{e,a}$ paid and pensions P_t^a received by an individual of age a in year t. For the generation born in 1990, this yields a lending rate of $\pi_{90}^C = 4.2295\%$, while the cohort aged 16 in 1990 faces implicit rates equal to $i_{74}^C = 4.3843\%$ and $\pi_{74}^C = 3.9804\%$, respectively, and the cohort aged 40 has $i_{50}^C = 4.3735\%$ and $\pi_{50}^C = 4.2956\%$.

Scenario D This case takes as given the lending rate $\pi_{90}^D = 4.7853\%$ for the generation born in 1990. Again, we start from the 1990 data for real per capita T^e and P and use demographic projections to compute future E_t and T_t^p. The yearly balanced budget restrictions together with the constants $k^E(a,a')$ and $k^{T^p}(a,a')$ determine the other two flows. For the generation born in 1990, this yields a borrowing rate of $i_{90}^D = 4.7497\%$, while the people born in 1974 face implicit rates of $i_{74}^D = 4.6312\%$ and $\pi_{74}^D = 4.7323\%$, and those born in 1950 have $i_{50}^D = 4.2922\%$ and $\pi_{50}^D = 4.6613\%$.

A changing demographic structure makes a very big difference, and this effect is amplified by adopting one or another among a set of feasible and apparently reasonable policies. Until recently the policies adopted in Spain have induced an allocation which is fairly close, in fact: surprisingly close, to the efficient and intergenerational fair allocation. Future policies will need to implement substantial adjustments to maintain efficiency and intergenerational fairness in the face of forthcoming demographic changes.

4.2.2. Impact of Economic Growth

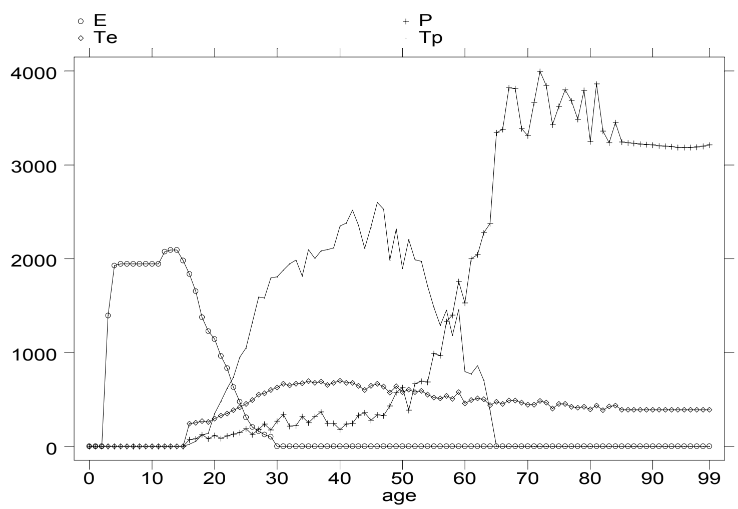
After equations (3.2), we pointed out that the inclusion of a constant growth rate would not change the qualitative conclusions. In each of the four scenarios considered, introducing a constant growth rate g implies that $(1+g)(1+i)$ and $(1+g)(1+\pi)$ would be the new rates, where i and π are the numbers we just reported for each scenarios. Hence, for example, in the base case and accounting for recent mortality rates, a balanced growth rate of about 3% (which is pretty close to the historical experience of the last 20 years) would yield a borrowing rate of $i^* = 7.51\%$ and a lending rate of $\pi^* = 8.00\%$. Adjusting for growth does not change the qualitative conclusions, while making the comparison to historical rates of return on capital more meaningful.[6]

[6] We thank Tim Kehoe for pointing this out to us.

4.2.3. Recalibrating to 1998-99 Data

In order to check the robustness of our results we have also used more recent data for the years 1998-1999 to perform our simulations. This data set, provided by Collado *et al.* (2004), is less complete than the 1990-1991 EPF as it reports substantially less micro information at the household level. Nevertheless, they provide enough information about the age-distribution of social security contributions, total taxation, education transfers and pensions payments during 1998-1999 to make our approach implementable. Making use of updated population estimates, reported in INE(1999), we compute the new four-tuple of x_a (*i.e.* $[\alpha_a, \beta_a, \gamma_a, \delta_a]$.) Then, we go to the government and social security administration budgets for 1998 to compute the aggregate quantities X^{98} corresponding to the effective total tax or transfer relative to each function. Next, we allocate these amounts over the lifecycle of the representative agent by means of the weights x_a. The new lifetime distributions of the four flows, in 1990 Euros, are reported in Figure 3.

Figure 3: Life-time distribution of tax and transfer flows.



A comparison with Figure 2 shows the substantial increase in the amount of public education transfers, which have literally doubled in real value at almost all age groups between 6 and 25. This is due to both strong enrollment growth and an increase in per capita expenditure. Pension expenditure has remained roughly unchanged while the increase in employment rate has brought along a visible increase in social security contributions.

Using the mortality rates reported by INE for 1998, and assuming demographich and institutional stationarity at these new levels, our point estimates are $\pi = 4.8069\%$ and $i = 2.5316\%$. With the updated survival probabilities implicit in Fernandez Cordón (2000) demographic forecasts, the point estimates are $\pi = 5.1837\%$. and $i = 2.6958\%$ instead. The distance from efficiency seems to have become substantial. This is even more apparent when the four hypothetical policy scenarios are simulated on the basis of the more recent data set.

Scenario A For the generation born in 1990 this policy gives $\pi_{90}^{A} = 6.4625\%$ and $i_{90}^{A} = 3.7551\%$, while we have $\pi_{74}^{A} = 5.7851\%$ and $i_{74}^{A} = 2.7263\%$ for the generation aged 16 in 1990 and $\pi_{50}^{A} = 5.1801\%$ and $i_{50}^{A} = 2.5257\%$ for the generation aged 40 in 1990.

Scenario B For the generation born in 1990 we obtain $\pi_{90}^{B} = 3.0353\%$ and $i_{90}^{B} = 2.3970\%$, while for those born in 1974 and 1950 we have $\pi_{74}^{B} = 3.4125\%$ and $i_{74}^{B} = 2.6252\%$, and $\pi_{50}^{B} = 4.9078\%$ and $i_{50}^{B} = 2.6133\%$, respectively.

Scenario C This policy yields $\pi_{90}^{C} = 4.32412\%$ and $i_{90}^{C} = 2.6958\%$ for the generation born in 1990; $\pi_{74}^{C} = 4.2704\%$ and $i_{74}^{C} = 2.6248\%$ for the generation born in 1974; and $\pi_{50}^{C} = 5.0357\%$ and $i_{50}^{C} = 2.6133\%$ for the generation born in 1950.

Scenario D We have $\pi_{90}^{D} = 5.1837\%$ and $i_{90}^{D} = 3.4859\%$ for people born in 1990, $\pi_{74}^{D} = 5.1257\%$ and $i_{74}^{D} = 2.7267\%$ for people born in 1974, and $\pi_{50}^{D} = 5.0638\%$ and $i_{50}^{D} = 2.5257\%$ for those born in 1950.

In all scenarios, the imbalance between the two implicit rates is dramatic and growing. Further, the underlying growth rate of the Spanish economy and the average real rate of return do not seem to have moved much away from 3% and 4%, respectively, during the last decade. The source of the imbalance is straightforward: given current demographic trends either education expenditure and pension payments are too high or social security contributions and taxes are too low. The social security tax in Spain is already very close to 30%, and average income taxes are around 20% with the top marginal at 46%, hence an increase in either income taxes or social security contribution seems hardly the appropriate policy. This should lead policy makers to seriously re-evaluate the social gains from the large increase in education expenditure that has taken place during the last decade. Similarly, the abnormally high rate of return on pensions under every policy scenario suggests that the main path to bringing intergenerational transfers into balance is drastically reducing the generosity of the pension system.

5. Conclusion

We use the model of efficient intergenerational transfers via public education and pensions of Boldrin and Montes (2004a) to evaluate the efficiency of the current Spanish welfare system. The theoretical model says that a necessary condition for efficiency is that two rates of return implicit in the flows of educational services, social security contributions, educational tax payments, and pension receipts, should be equalized. We use both microeconomic and aggregate data for Spain in 1990-1991, and 1998-1999, to compute the two implicit "borrowing" and "lending" rates. For the baseline case in which strong stationarity assumptions are imposed, and using only the 1990-91 data, our point estimates of the borrowing and lending rates are both quite close to 4.0%. This suggests that, at the end of the 1980s, the Spanish welfare system would not have been very far away from efficiency, had the existing demographic situation persisted over time. Nevertheless, once the assumption of demographic stationarity is replaced by realistic projections of the future evolution of the Spanish population and the 1998-1999 data are used, results change dramatically. We carry out four simulations based on such projections, each scenario characterized by different assumptions about the form in which public policy may react to the demographic change. While the policies we consider are hypothetical, common sense suggests that they are a reasonable starting point for this kind of analysis. In each of the four cases considered, the implicit rates we estimate move apart from each other. In particular, unless they are held fixed by the assumptions underlying the policy scenario being considered, pensions tend to yield a rate of return (on the previous education investment) higher than the rate of interest the working cohorts are expected to pay (via social security contributions) on the education services they received. This is especially true when the 1998-1999 flows are used to calibrate the life-cycle behavior of the average Spanish citizen.

A second finding is that the rates of interest paid by or accrued to generations born in different years move quite apart from each other when the demographic evolution is taken into account. Nevertheless, and contrary to a widespread presumption, such movements are not monotone; in particular, they do not seem to necessarily favor the older relative to the younger generations. In other words, *rebus sic stantibus*, the expected demographic evolution should not necessarily lead to a huge redistribution of resources away from the younger or not-yet-born generations and toward the older ones. Most previous findings, based on the generational accounting methodology pioneered by Auerbach and Kotlikoff (see, for example, Auerbach, Kotlikoff, and Leibfritz (1999)), have instead shown that the interaction between demographic change and current fiscal policies (in particular, current welfare policies) is likely to engender a large intergenerational redistribution in favor of the older cohorts. While our findings cannot rule out this conclusion and, in fact, support it under certain policy scenarios, we believe our estimates have independent value and should shed some additional light on the intricacies of intergenerational public policy.

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Appendix: Data Sources and Treatment

A.1 Data sources

Our sources of data are the following.

We obtain the aggregate expenditure on public education from the *Estadística del Gasto Público en Educación* (EGPE 1995, in Ministerio de Educación y Ciencia (1995)) and the *Encuesta sobre Financiación y Gasto de la Enseñanza Privada* (EFGEP 1990-91, in INE (1992b)). The first data base contains public expenditure for each schooling level; the second reports the amount of public funding going to private schools (*centros concertados*). Aggregate tax revenues are obtained from the *Cuentas de las Administraciones Públicas* (IGAE (1991b)). From this we extract the share of total tax revenues allocated to financing public expenditure on education, excluding the fraction covered with public debt. We assume that the fraction of public expenditure covered by debt financing is equal to the average share of public expenditure financed by debt during 1990-91.

Aggregate flows of public pension payments are obtained from the *Cuentas de las Administraciones Públicas* (IGAE (1991b)) and *Actuación Económica y Financiera de las Administraciones Públicas* (IGAE (1991a)).

The conditional survival probabilities at each age are equal to those obtained by the latest mortality tables published by the National Statistical Institute (INE (19910) with reference to the year 1990.

The aggregate data do not allow the study of individual lifecycle behavior. To do this, we use a Spanish household budget survey (*Encuesta de Presupuestos Familiares*, or EPF) carried out by INE (1992a), in 1990-91. This survey contains data on individual income, expenditure, personal characteristics, and demographic composition for 21,155 households and 72,123 Spanish citizens. This survey is representative of the entire Spanish population and is calibrated on the Spanish Census data.

A.2 Treatment of the data

A.2.1 Lifetime distributions

We now detail how, using the data in the EPF, we calculated the lifetime distribution of the four flows associated to the two public systems.

The information in the EPF allows the estimation of the contributions and payments associated to the two public systems for each individual in the sample.

These contributions and payments depend upon the labor market condition of the individual. Thus, we have considered five states in which each individual can be. For each state we compute contributions and payments the individual receives or makes. These five states are the following:

($\mathcal{E}$) *Student.* The individual is enrolled in a school or university receiving public funds. The individual is then receiving a transfer (E_a^i) of an amount equal to the average cost of a pupil of his/her age attending a school of the kind he/she specifies, during the fiscal year 1990-91. The same individual contributes toward financing of public education through a portion of his/her direct and indirect taxes, (T_a^i).

($\mathcal{W}$) *Worker.* This class includes all employed individuals. Such individuals pay direct or indirect taxes to support public education, (T_a^i), and also pay social security contributions, (T_a^{pi}).

($\mathcal{R}$) *Retired.* We consider as retired only those individuals receiving a contributive pension (P_a^i). Retired individuals are also financing the public education system with a portion of their taxes (T_a^i).

($\mathcal{U}$) *Unemployed.* If an individual receives unemployment benefits, he/she is financing the public pension system through the social security contributions paid, (T_a^{pi}). Again, the unemployed are also financing the public education system with a portion of their taxes (T_a^i).

($\mathcal{I}$) *Inactive.* Here we include all the individuals that are not in any of the previous four states. If these individuals pay some income taxes, this is recorded in the EPF. Otherwise, we attribute to them a share of the indirect taxes based on their reported expenditure. The total gives (T_a^i).

These five states are mutually exclusive. For the very rare cases in which the same individual in the EPF reports to be in two or more of them, we create two or more "artificial" individuals and increase the sample size correspondingly . We define the universe of states to be $\mathcal{S} = \{\mathcal{E}, \mathcal{W}, \mathcal{P}, \mathcal{U}, \mathcal{I}\}$. The total population at each age $a = 1, \ldots, A$ is $\sum_{s \in \mathcal{S}} L_a(s)$, with $L_a(s)$ equal to the number of individuals of age a that are in state s. Denote the share of the population of age a in state s as $\mu_a(s) = L_a(s) / \sum_{s \in \mathcal{S}} L_a(s)$, with $\sum_{s \in \mathcal{S}} \mu_a(s) = 1$. For each a and $s \in \mathcal{S}$, $\mu_a(s)$ is the probability that an individual is in state s at age a.

A.2.2 Public education system

In Spain, public financing of education is allocated in part to public schools and in part to a special kind of private schools, *centros concertados*, by means of school vouchers to students. At the compulsory school level (up to age 14 in 1990, 16 in the current legislation) schooling is completely free. After that, students attending public institutions pay only a small fraction of the total cost, the rest being born by general tax revenues. Students attending private institutions bear the full cost.

Cost of public schooling

For each educational level (primary, secondary, higher, and other), we have computed the real per-pupil public expenditure on education for various types of schools (public and *concertados*) and for the public universities. The EPF reports if an individual is enrolled in school, the type of school (public or private), and the level he/she is attending. This information is enough to compute the total number of students in each level, type of school, and age group. The criterion we followed to compute the cost of schooling for each "kind" of student (age a, level j, type k of school) is the following. From the EGPE and the EFGEP we obtain the actual total amount of public expenditures for each kind (kj) of school. We divide these amounts by the total number of pupils attending each. This gives us the effective per-student cost for each kind kj of school, E^{jk}. From the EPF we compute how many students of age a are attending a school of kind kj. Using this, we estimate public school expenditure on the representative individual at each age a as

$$E_a = \mu_a(\mathcal{E}) \sum_{k \in TC} \sum_{j \in NE} \mu_a\left(\mathcal{E}^{jk}\right) E_a^{jk} = \mu_a(\mathcal{E})\, \overline{E}_a$$

where $\mu_a(\mathcal{E})$ denotes the fraction of the population of age a attending school, NE is the universe of educational levels, and TC is the universe of types of schools. Finally, $\mu_a\left(\mathcal{E}^{jk}\right)$ is the portion of students of age a enrolled in the educational level j in a school of type k.

The age distribution of public education "borrowing" is

$$\delta_a = \frac{E_a}{\sum_{a=1}^{A} E_a L_a}.$$

Hence, δ_a is the share of (lifetime total) education-related transfers the representative individual receives at age a.

Financing of the public education system

On the financing side, we need to compute the amount of education-related taxes paid by the representative individual at age a. The taxes we consider are the following: personal income tax (*Impuesto sobre la Renta de las Personas Físicas*, or IRPF), Value Added Tax (VAT), special, and other local taxes.

The EPF provides detailed information about the income flow of each individual and the wealth and consumption baskets of each household. This allows a detailed reconstruction of the various taxes paid by an individual, which we then aggregate in a total burden of taxation (T_a^i) for individual i of age a. We calculate the average tax paid by a person of age a as

$$T_a = \sum_{s \in \mathcal{S}} \mu_a(s) \frac{\sum_{i \in s} T_a^i}{L_a(s)} = \sum_{s \in \mathcal{S}} \mu_a(s) \overline{T}_a^s$$

where $\overline{T}_a^s$ is the average tax paid by an individual in state s at age a.

Given the values T_a for $a = 1, \cdots, A$, the computation of the lifetime distribution of the total investment in public education is straightforward:

$$\alpha_a = \frac{T_a}{\sum_{a=1}^{A} T_a L_a}.$$

Hence, α_a represents the relative burden of taxation charged to the representative individual at age a, for $a = 1, \cdots, A$, Call this the age distribution of the total tax burden.

To impute the flow of real expenditures in education to the various years of one's life, we need to scale the coefficients α_a by the actual public expenditure on education. We retrieve this from IGAE (1991b); call it T_{90}^e. Then we compute $T_a^{e*} = \alpha_a \cdot T_{90}^e$ for $a = 1, \cdots, A$, the investment in public education for the representative agent.

A.2.3 Public pensions

Public contributory pensions are provided by the following programs. The General Social Security Regime (*Régimen General de la Seguridad Social*, or RGSS) is the main one and covers most private sector employees plus a (small but growing) number of public employees. The five plans included in the Special Social Security Regimes (*Regímenes Especiales de la Seguridad Social*, or RESS) are for the self-employed (*Régimen Especial de Trabajadores Autónomos*, or RETA), the agricultural workers and small farmers (*Régimen Especial Agrario*, or REA), the domestic employees (*Régimen Especial de Empleados de Hogar*, or REEH), the sailors (*Régimen Especial de Trabajadores de Mar*, or RETM) and the coal miners (*Régimen Especial de la Minería del Carbón*, or REMC). Finally, there exists a seventh, special pension system for the public employees (*Régimen de Clases Pasivas*, or RCP).

Financing the public contributive pension system

All seven pension regimes are of the pay-as-you-go-type and, presumably, are self-financing[7]. To estimate the lifetime distribution of social security payments, we identified all individuals in the EPF paying social security contributions and split them among the seven plans. For each individual we have enough information, either from the EPF or from current legislation (for example, for public employees) to compute the fictitious income (*bases de cotización* and *haberes reguladores*) upon which pension contributions are being charged. To each of the fictitious incomes we apply the social security contribution rate, as specified by the 1990-91 legislation, for the pension regime in which the individual was enrolled. Aggregating these amounts over all the individuals of age a, we obtain, for each $a = 1, \ldots, A$, the amount of social security contributions paid by individuals in state $\mathcal{W}$ ($T_a^{\mathcal{W}}$) and state $\mathcal{U}$ ($T_a^{\mathcal{U}}$). The social security contribution paid by the representative agent at age a is then

$$T_a^p = \mu_a(\mathcal{W}) \cdot T_a^{\mathcal{W}} + \mu_a(\mathcal{U}) \cdot T_a^{\mathcal{U}}.$$

Also in this case, we compute weights by setting

$$\beta_a = \frac{T_a^p}{\sum_{a=1}^{A} T_s^p L_a}$$

Finally, from IGAE (1991a, b) we obtain the total amount of social security contributions paid to the seven plans during the year 1990, T_{90}^p. In our simulation, we use

$$T_a^{p*} = \beta_a \cdot T_{90}^p.$$

Benefits of the public pension system

The Spanish social security system provides five types of contributive pensions: old-age, disability, widowers, orphans, and other relatives. We have not considered payments of noncontributive pensions as part of our scheme, as they are not financed by means of social security contributions.

[7]The RGSS shows a surplus. The five special regimes show small deficits.

In the EPF, we are told if an individual is a pension recipient, what kind of pension he or she receives, and in what amount. The average contributive pension received at each age a is therefore easily computed as

$$P_a = \mu_a(\mathcal{P}) \cdot \sum_{k \in TP} \mu_a(\mathcal{P}^k) \cdot \frac{\sum_{i \in k} P_a^i}{L_a(\mathcal{P}^k)} = \mu_a(\mathcal{P})\, \overline{P}_a$$

where $\mu_a(\mathcal{P})$ is the fraction of the population of age a receiving a contributive pension, TP is the universe of kinds of contributive public pensions, $\mu_a(\mathcal{P}^k)$ is the portion of pensioners at age a receiving a pension of type k, P_a^i is the actual pension received by individual i of age a, and $L_a(\mathcal{P}^k)$ is the number of individuals of age a receiving a pension of type k.

As in the previous cases, the lifetime weights are computed as

$$\gamma_a = \frac{P_a}{\sum_{a=1}^{A} P_a L_a}.$$

Finally, from IGAE (1991a, b) we obtain the total contributive pension payments effectively made, by the seven regimes, during the year 1990, P_{90}. The amounts used in our calculations are, therefore, $P_a^* = \gamma_a \cdot P_{90}$.