The Austrian Backpack as alternative to the Spanish PAYG pension system*

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March 2021

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Abstract

With ageing population and historical trends of low employment rates, pay-as-you-go (PAYG) public pension systems, currently in place in several European countries, imply very large economic and welfare costs in the coming decades, threatening the sustainability of these systems. In an overlapping generations economy with incomplete insurance markets and frictional labour markets, an employment fund, which can be used while unemployed or retired can enhance production efficiency and social welfare[1]. With an appropriate design, and accounting for general equilibrium effects, the sustainable Backpack employment fund (BP) can greatly outperform – measured by average social welfare in the economy – existing pay-as-you go systems and also Pareto dominate a full privatisation of the pension system, as well as a standard fully funded defined contribution pension system. We show this in a calibrated model of the Spanish economy, by first comparing steady-sate economies after the ongoing demographic transition under these different pension systems and, second, showing how a front-loaded transition from the PAYG to the BP, ahead of the demographic transition, can be Pareto improving (i.e. without losers), while minimizing the cost of the transition, which is financed with public debt.

Keywords: Social security reform, Ageing, Taxation, General Equilibrium.
JEL classification: C68, H55, J26

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*Provisional draft, do not quote without authors permission. We would like to thank Javier Díaz-Giménez who has made this project possible. This paper builds on our previous "Introducing the Austrian Backpack in Spain" (May, 2019), where the fund, without annuity insurance, complements the existing PAYG before the demographic transition.

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[1]The name comes from a similar fund introduced in Austria in 2003, without the annuity insurance component.

1 Introduction

Advanced economies in the 21st Century are characterized by their ageing population and relatively low employment rates, threatened by automation and in some cases prevailing rigidities in labour markets. Furthermore, the financial and euro debt crisis first and now the COVID pandemic crisis, have put under extreme financial stress unfunded 'social insurance systems', such as pay-as-you-go (PAYG) retirement pensions. For these economies, 'unfunded' can only mean 'bankrupt' that is, partially default in promised pension payments, or 'disruptive'; that is, high, and highly distorting, payroll taxes to finance these promises. Governments in these countries can either face this latter choice or change their PAYG system. Other, so-called, social security reforms that do not face these choices, are bound to face a major social security crisis.

Since the pioneer work of Auerbach and Kotlikoff (1987a) (and Auerbach and Kotlikoff (1987b)) there has been an extensive, theoretical, quantitative and empirical, literature comparing social security systems, as well as possible transitions from PAYG system to a fully funded (FF) system. This paper contributes to this literature in five dimensions. First, and in contrast to most of this research, in making a quantitative exploration with an overlapping general equilibrium model that incorporates a detailed labour market structure with frictions. This allows us to study the interaction between unemployment insurance and pension systems, as well as to capture general equilibrium effects often missed. Second, and it is its main novelty, by focusing on an employment fund that incorporates unemployment and retirement insurance, in part akin to the one introduced in Austria in 2003, also known as the Austrian backpack. Third, in calibrating our detailed model to the Spanish economy which is in urgent need of a social security reform and has a chronic high unemployment problem. In fact, both the Europea Commission and the International Monetary Fund have proposed the Austrian backpack as a possible alternative to the existing PAYG system. Fourth, in showing quantitatively the long-run large welfare gains of replacing the PAYG by a Backpack system, which allow for a Pareto improving transition (i.e. without losers) financed with public debt, in an environment of low interest rates. Fifth, in showing that en effective transition must be fast to minimize its overlap with the incoming demographic transition.

The basic features of a 'backpack' (BP) employment fund are: it is a fund contract with the employee which accumulates the individual savings of a basic payroll tax (BP tax), while working; it is transferable across jobs and can be finally used as a pension fund; usually it earns a market interest rate (i.e. it can be privately managed), but there may be restrictions in its use (e.g. additional individual contributions may be restricted and the worker may only be able to use it if he or she is unemployed, inactive or retired). While different forms of private employment funds are not a novelty in some countries – Austria being the leading example – such funds are not common as part of the public insurance policy. One example of a private funding scheme is the TIAA-CREF (Teachers Insurance and Annuity Association-College Retirement Equities Fund), which is a nonprofit employment fund founded by Andrew Carnegie in 1918 and nowadays serving over 5 million active and retired employees; it has played, and plays, an important role in enhancing mobility among university professors across US universities. However, it is a retirement fund not designed to provide unemployment insurance, while the BP provides both forms of insurance. Obviously, privately saved assets can also play this double role. However, there are two features that distinguish the BP: first, and foremost, its character of 'forced savings', and, second, a favourable tax treatment (both are common features of fully-funded pension systems). Our benchmark 'backpack' does not allow additional private contributions, the worker can only draw from it during an involuntary unemployment spell (and after retirement), and its returns are taxed as any capital gains but the assets accumulated in the fund are not taxed as part of the employee's income, while private savings are.

The Austrian backpack was introduced in 2003 as part of a broader labour reform. In particular, it was the socially agreed exchange for the elimination of the existing system of severance payments and, in fact, the BP tax of 1.5% was set according to this tradeoff. Kettemann et al. (2017) shows that this reform spiked job-creation and lowered unemployment. Nevertheless, the main effect of the reform came from the elimination of severance payments. We are interested in analysing the effect of introducing the 'backpack' as a complement or a substitute to pay-as-you-go pensions and unemployment insurance. Therefore, we add an important feature to the Austrian backpack: upon retirement the backpack fund (BP) can be transformed into an actuarially fair annuity.

Our work builds directly on two models: the model of Díaz-Giménez and Díaz-Saavedra (2009) and Díaz-Giménez and Díaz-Saavedra (2017), developed to study pension system reforms in Spain using overlapping generations general equilibrium models, and the model with job creation and destruction with search frictions and three employment states (employed, unemployed and inactive) of Krusell et al. (2011), further developed in Ábrahám et al. (2019) to study unemployment insurance reforms in Europe. The latter shows that there is ample room to improve existing European UI systems even within the limits of their current design in which unemployment benefits (UB) are determined by their duration and the replacement rate. In sum, in our model economy agents – which we refer to as households – can differ by their age, education, and productivity, and they decide how much to save and consume, as well as their employment status, which also depends on the rates of job creation and destruction – i.e. agents can also differ by their assets and employment status and are subject to idiosyncratic risks.

Our benchmark model economy allows for a detailed description of the Social Security system: there are minimum income transfers for low-income households, and households can save against their idiosyncratic risks privately, they also have access to a public unemployment insurance and a pay-as-you go pension system, both financed with payroll taxes. Agents find jobs in a stochastic search environment and, while working, face idiosyncratic productivity shocks, as well as layoff shocks. After a certain age, a worker can choose to retire. These exogenous factors and their optimal work and search decisions generate a labour market distribution of households, into employed, unemployed, inactive and retired. In addition to payroll taxes, there are income, consumption and capital taxes. An aggregate production function and a government that must balance the budget to close the model. The model is calibrated to the Spanish economy with its public policies in 2018, as an initial steady state. We simulate the economy in the following decades, accounting for the projected demographic changes in the age and education distributions[2].

Spain is a particularly interesting economy to study. Unemployment is high, and highly volatile, population is ageing – specially when immigration decays in recessions – and the PAYG, which had a separate budget and fund, has seen its social security fund being depleted in the aftermath of the euro-debt crisis and has introduced some reforms – such as the inflation indexation of pensions – which place an additional burden on the existing PAYG budget. In fact, if one assumes that the current system prevails in the next decades, given the expected fall of the employees/retired ratio, fulfilling the unemployment insurance and pensions promises will be extremely costly and distorting, as Figure 1 obtained with our calibrated model shows: doubling the dependency ratio implies that to fulfil unemployment benefits and pension promises the distorting payroll tax needs to be doubled too[3]

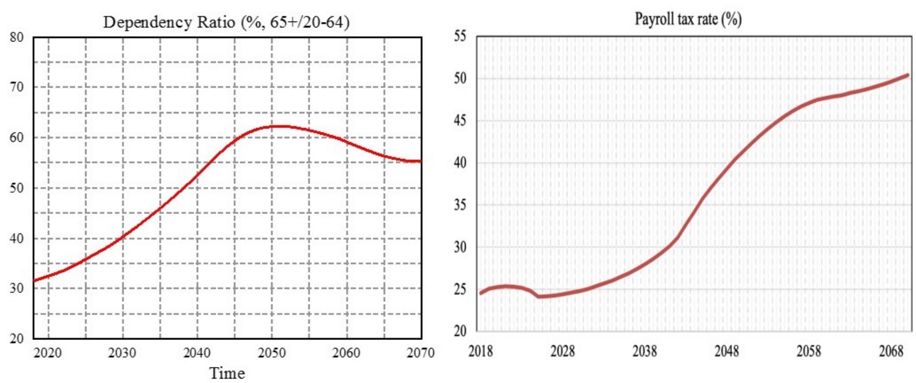

Figure 1: The expected evolution of the dependency ratio and payroll tax rate in Spain.

Figure 1 is also behind the results of other studies of the Spanish pension system namely that, with the ongoing ageing process of the population, its sustainability is under immense pressure[4]. Nevertheless, many advanced economies are, or will be, going through similar demographic tran-

[2]Unfortunately, the most recent and reliable long-term demographic forecasts do not incorporate the effect of the COVID-19 crisis. Nevertheless, this may not substantially change our results since there has been a reduction in the number of retired, but also of employed and, looking further ahead, births

[3]Some reforms have had a positive, but almost negligible, effect in reducing social security liabilities. The small reduction of the payroll tax in the 2020's captures the effect of two reforms in 2011: increasing the number of years of labor income used to compute the pension, from the last 15 to the last 25, and increasing the legal retirement ages in one more year (see Appendix D for a description of the Spanish PAYG).

[4]The already mentioned Díaz-Giménez and Díaz-Saavedra (2009) and Díaz-Giménez and Díaz-Saavedra (2017), as well as Rojas (2005), De la Fuente et al. (2019), de Cos et al. (2017) and García-Gómez et al. (2020).

sitions and the concern about the sustainability of the unfunded PAYG system with ageing populations and the difficulties to replace it with a funded system is neither unique nor new [5]. Spain just happens to be a particularly dramatic case, in particular after the recent crises. However, in a 21st Century perspective, the main problem is not the sustainability of the PAYG system, but the perverse effect of the system with an ageing population: it deters late retirements when life expectancy is high and its financing, with distortionary taxes, may further depresses labour supply (see Erosa et al. (2012) and Cooley et al. (2020)).

We assume that after the demographic transition the economy reaches a new steady-state, which is our benchmark economy for the "next generation". We then compare the PAYG steady-state with three alternative steady-states for the same stochastic economy with the same policies and institutions, except for the PAYG system which is replaced by a: *i*) private savings (PS), an economy without public pensions in which households' retirement is fully financed by the proceeds of their private savings at the risk-less interest rate; *ii*) a fully funded pension fund (FF), financed with the payroll tax as (forced) 'defined contribution', and, upon retirement, an actuarially fair annuity, and *iii*) the Backpack (BP) fund, as already described. In the latter two economies, households can complement the retirement (forced) savings with private savings, and to determine the retirement fund savings rate we search for the welfare maximizing contribution rate, which is 11% for the FF fund and 21% for the BP fund[6].

The general equilibrium effects of eliminating (PS) or replacing (FF & BP) the PAYG system are very large. There are differences among the three alternatives but, in relation to the benchmark PAYG economy, they are very similar: GDP is higher (at least 60%), productivity and capital-to-output ratios are also higher and, therefore, real interest rates are substantially lower (between 2% and 3% vs. 7.7%) and wages are higher (Table 12). Overall these alternative economies are more productive (working hours per worker are lower but aggregate labour supply is higher) and agents benefit from higher consumption; as a result, the average welfare – measured as consumption equivalent variation – of eliminating PAYG by PS is 48.2% and replacing it by FF 56.6% and by BP 60,9%; furthermore, all different groups of households gain from these radical reforms of the PAYG system. Behind these huge welfare gains there is a factor that partially explains them: while the steady-state *effective labour tax*[7] is 64.7% in the benchmark PAYG economy, in the alternative economies is: 38.3% PS, 43.6% FF and 47.5 BP (Table 15); i.e. even in the alternative system with the largest social insurance coverage – i.e. the Backpack – the effective labour tax is substantially lower. In fact, the reduction of labour supply distortions is a feature of optimal reform designs (see Conesa and Garriga (2008)).

[5]Early warnings, stressing the general dynamic equilibrium effects, are Conesa and Krueger (1999) and Nardi et al. (1999); see Aubuchon et al. (2011) for an introduction to the replacement problem.

[6]Ten times higher than the tax financing the 2003 Austrian backpack.

[7]The effective labour tax, τ_e, is given by $(1-\tau_e) = (1-\tau_y)(1-(\tau_p+\tau_x))/(1+\tau_c)$, where τ_y is the income tax, τ_p the payroll tax, τ_c the consumption tax, and τ_x is the fund tax; i.e. $x = f, b$ in FF and BP, respectively, and $\tau_x = 0$ in PAYG and PS.

Our work also helps to elucidate the non-obvious welfare differences among the three alternatives to PAYG (Table 17). The economies with an employees' fund Pareto dominate the 'more flexible' private savings economy (PS) mainly for two reasons. First, as it is common practice with social security funds, (forced) savings into the fund are not part of taxable income, only if there are capital gains these are taxed as other capital gains. Second, when a worker decides to retire, the accumulated assets in the fund account can be used as private savings or, as we have seen, converted into an actuarially fair annuity. As existing employees' funds, FF and BP funds can be managed privately (with proper regulations), therefore one can argue that the possibility to transform assets into actuarially fair annuities could also exists in the PS economy, which would increase its estimated welfare gains. However, while these contracts exists in advanced economies, these markets are thin and having them as part of a large public pension programme can change their relevance and fairness; in particular, guarantees that the reform preserves a valued feature of a sustainable PAYG system: a worker upon retirement can have a stable source of income[8].

The Backpack is the winner of the race among the four social insurance systems because, in contrast with the other three systems, it provides additional unemployment insurance. As we show, with the BP households can better manage the loss of income due to the loss of employment, as well as their life insurance profile. This individual gain translates into better employment choices, which in turn aggregate into the general equilibrium effects that make the BP economy the most (constrained) efficient among the four we analyse.

More importantly, we provide a first analysis of a possible Pareto improving transition from the PAYG to the Backpack social insurance system. However, in an economy which will go through an ageing demographic transition in the incoming decades, the well known problem of how to design a transition without losers (e.g. Aubuchon et al. (2011)) is aggravated. Our transition relies in two main elements, the long-term large welfare gains of having the BP instead of the PAYG and the current environment of low interest rates. Uncovered PAYG liabilities, due to workers moving from the PAYG to the Backpack, are funded with public debt. We take as a benchmark public debt with zero interest rate, which allows for arbitrary large levels of sustainable debt. Nevertheless, with a view that it may not be the case and part of the long-run gains will need to cover the cost of debt financing, we aim at a Pareto improving transition that minimizes the amount of debt needed to finance it. The general equilibrium gains of having a BP vs a PAYG already suggest that the transition should not be too slow, but it is the demographic transition that dictates the need to go through the core part of the social security transition before the demographic transition takes place. We show that this is possible, in the case of Spain, with a front-loaded transition, in which backpack asset transfers make the Backpack system (weakly) preferred to the PAYG by the working age population, already in the first year of the reform, limiting PAYG claims to those of

[8] In well designed credible funds, such as in the Swedish social security system, the retirement promises are conditional on the fund's returns, which are managed to be as riskless as possible; in our simulated economies there is no aggregate uncertainty at the steady-state and, therefore annuities are constant.

the retirees that year. Public debt finances the backpack asset transfers and these PAYG liabilities. In our calibrated Spanish economy this level of debt is relatively high: 100% of GDP in the first year, 2019, increasing to 200% at the end of the transition (late 2050s) when there are no more PAYG liabilities. Alternatively, one could also front-load these debt liabilities, transforming PAYG pensions into (Pareto improving) BP life annuities, front-loading therefore the full amount of the debt needed.

Regarding the existing literature, as we have said our framework expands the analysis of social security systems by incorporating a labour market with frictions and employment transitions, which allows to capture additional general equilibrium effects from system reforms. On this our work follows the tradition of OLG equilibrium models where the emphasis in on the aggregate and welfare consequences of these reforms. Also, on line with most of this literature we assume that agents have rational expectations and time-consistent preferences, therefore, in the PS economy households do not procrastinate on saving for retirement. However, since the seminal work of Feldstein (1985) this documented behaviour[9] has been an ongoing concern for the design of social security systems alternative to PAYG (e.g. İmrohoroğlu et al. (2003)). A fully funded fund (FF) with its 'forced savings' until retirement addresses this problem and, if properly designed, as we do, avoids the problem of over-accumulation of capital. In this respect, the Backpack (BP) only differs from the FF, in that the worker could myopically run-down the BP assets while unemployed, however these are the times where savings are more valuable. In fact, our rational agents are very careful on not running down their backpack assets while unemployed.

The more finance oriented literature focuses on the portfolio choice over the life cycle within a partial equilibrium framework (Cocco et al. (2005)) and how, accounting for this, can help the design of social security systems. Our agents make a limited portfolio choice in deciding how much more private assets should accumulate beyond the ones of the fund and we introduce retirement annuities as some of this work does (Larsen and Munk (2020)), but we keep the assumption of time-separable preferences. Similarly, recent work emphasises the possible gains of having age-dependent taxes or flexible defined contributions plans (Schlafmann et al. (2020)). These are improvements that could be added to our BP design, but on this we also have followed a parsimonious approach.

Regarding the transition, our work is closely related to the recent work of McGrattan and Prescott (2017), who engineer a Pareto improving transition for the U.S. economy, where the dependency ratio increases from 25% to 41% (i.e. from 4 workers per retiree to 2.4) without debt financing. Aside from the fact that the U.S. is a milder demographic transition from a better initial position than the Spanish one, there are important differences in their work with the transition we analyse. Their main transition is not from a PAYG to a Fund (in our case, the Backpack), but from transfers to the retirees paid by current payroll taxes to a system where the transfers are paid from

[9] Gomes et al. (2020) estimate that 75% of sampled individuals participating in U.S. 'defined contribution', plans undersaved for their retirement.

the general federal budget, which is subject to a timely overhaul of the tax system. We compare different social security systems, without resourcing to a major overhaul of the tax system and, in contrast with them, the transition of the PAYG to the Backpack system is financed with public debt, taking advantage of the long-term gains of the reform and the existing low interest rates.

The next section presents our model economy, Section 3 describes our calibration, Sections 4 and 5 the steady-state results, Section 6 the transition from the PAYG to the Backpack security system and Section 7 concludes.

2 The Model Economy

This section presents the model economy. We study an overlapping generations economy with heterogeneous households, a representative firm, and a government. The framework is based on Díaz-Giménez and Díaz-Saavedra (2009), with job creation and destruction and dynamic work and search decisions as in Ábrahám et al. (2019).

Time is discrete and runs forever, and each time period represents one calendar year. We begin with a description of household heterogeneity.

2.1 The Households

Households in our economy are heterogeneous and differ in their age, $j \in J$; in their education, $h \in H$; in their productivity level $z \in \mathcal{Z}$; in their labor market status $s \in S$; in their private assets, $a \in A$; and in their backpack savings, $b \in B$. Sets J, H, $\mathcal{Z}$, S, A, and B are all finite sets and we use $\mu_{j,h,z,s,a,b}$ to denote the measure of households of type (j, h, z, s, a, b). They also differ in their claims to different social insurance systems: unemployment benefits UB, retirement pensions P, and government transfers TR. We think of a household in our model as a single individual, even though we use the two terms interchangeably. To calibrate the model, we use individual data of persons older than 20 in the Spanish economy.

Age. Individuals enter the economy at age 20, the duration of their lifetimes is random, and they exit the economy at age 100 at the latest. Therefore $J = \{20, 21, ..., 100\}$. The parameter ψ_j denotes the conditional probability of surviving from age j to age $j + 1$. The notation makes explicit that the exogenous probabilities depend on age j, but not on education or other factors.

Education. Households can either be high school dropouts with $h = 1$, high school graduates who have not completed college $h = 2$, or college graduates denoted $h = 3$. Therefore $H = \{1, 2, 3\}$. A household's education level is exogenous and determined forever at the age of 20.

Labor market productivity. Individuals receive an endowment of efficiency labor units every period.

This endowment has two components: a deterministic component, denoted $\epsilon_{h,j}$ and a stochastic component, denoted by z. The deterministic component depends on the household's age and education, and we use it to characterize the life-cycle profiles of earnings. The stochastic component is independently and identically distributed across the households, and we use it to generate earnings and wealth dispersion in the economy. This component does not depend on the age or the education of the households, and we assume that it follows a first order, finite state, Markov chain with conditional transition probabilities given by Γ:

$$\Gamma\left[z'|z\right] = \Pr\left\{z_{j+1} = z'|z_j = z\right\}, \text{ with } z, z' \in Z. \tag{1}$$

Every period agents receive a new realization of z. Total labor productivity is then given by $\epsilon_{h,j}z$. A worker who supplies l hours of labor has gross labor earnings y given by:

$$y = \omega\epsilon_{h,j}zl, \tag{2}$$

where the economy-wide wage rate ω.[10]

Labor market status. In the model, an agent is either employed, unemployed, non-active or retired. Among the unemployed, there are individuals who are eligible to receive unemployment benefits and access their backpack savings (workers who have recently been laid off), and others who are not eligible (either because eligibility expired, or because they quit work). Worker decide when to retire, leaving the labor force permanently once they do. Upon entering the economy, individuals randomly draw a job opportunity and then decide to work or not during the first period. Similarly, in subsequent years the labor market status evolves according to both optimal work and job search decisions (described below), and exogenous job separation and job finding probabilities.

Employed. An individual with a job at hand in the beginning of the period, and who decides to work, is employed in that period and his labor market status is denoted by $s = e$. An employed worker provides labor services and receives a salary that depends on his efficiency labor units and hours worked. Workers face a probability of loosing their job at the end of the period, denoted σ_j. This probability is age dependent, and we use it to generate the observed labor market flows between employment and non-employment states within age cohorts.

Unemployed. An agent may not have a job opportunity at the beginning of a period, because he lost his job last period, because he quit his job, or because he was unemployed last period and did not find (or did not accept) a new job offer. Without a job, agents may actively search for a job offer next period. If they do actively search we label them as unemployed. Unemployed agents who have lost a job are eligible for unemployment benefits (we refer to them as *unemployed eligible*, with $s = ue$). A formal description of eligibility criteria is given below. Agents who have quit work are not eligible for unemployment compensation (we often refer to this group as *unemployed non-eligible*, $s = un$). Active job searchers receive a job offer at the end of the period with probability

[10] Given that we only care about steady state equilibria, we omit the time subscript t.

$\lambda_j^{\mathbf{u}}$. The probabilities are again age dependent, and we use it to generate the observed labor market flows between unemployment and employment.

Non-Active. Agents without a job and who do not actively search for a new one are labeled non-active, with $s = n$. Those agents are not eligible for unemployment benefits, and receive a job offer for next period with a lower probability than an unemployed agent, $\lambda_j^{\mathbf{n}} < \lambda_j^{\mathbf{u}}$. This probability is also age dependent, and we use it to generate the observed labor market flows between non-activity and employment.

Retirees. In our model, workers optimally decide whether to retire and leave the labor force. They take this decision after observing their current labor productivity. If they decide to retire, $s = r$, they loose the endowment of labor efficiency units for ever and exit the labor market. Depending on the pension system in place, they may receive retirement pension payments after retirement.

Private Assets. Households in our model economy endogenously differ in their asset holdings, which are constrained to being non-negative. The absence of insurance markets give the households a precautionary motive to save. They do so by accumulating real assets which take the form of productive capital, denoted $a \in A$. Different retirement pension systems affect, among others, the agents' private savings decisions.

Backpack Assets. Workers accumulate backpack savings while they work. These savings result from a mandatory contribution out of workers' salaries, and are invested in productive capital and earn the economy real rate of return. When workers loose a job, they can access their accumulated savings and decide how much to keep in their individual accounts or how much to use, while out of work, to finance consumption. A formal description of the decision problem is given below. At retirement, backpack assets are converted into retirement pension payments (an actuarily fair life annuity).

Households derive utility from consumption, and disutility from labor and the search effort. Labor is decided both at the extensive and intensive margins, while search is a discrete choice. The period utility is described by a utility flow from consumption and the utility cost of time allocated to market work and to job search. Non-active and retired agents dedicate all the time endowment to leisure consumption. Accordingly, lifetime utility is given by

$$\mathbb{E} \sum_{j=20}^{100} \beta^{j-20} \psi_j \Big[u(c, l) - \gamma e \Big], \tag{3}$$

where β is a time discount factor, u satisfies standard assumptions, c is consumption and l is labor supply, and γ representes a job search utility cost. l can take values between 0 and 1, while e equals 1 in periods of active job search and is zero otherwise. Survival probabilities ψ_j determine the age distribution in the economy, a central object in our analysis.[11]

[11] Fertility and immigration flows are exogenous.

At this point it is useful to clarify the timing of events within a period. At the begining of each period, z, households' stochastic productivity component, is realized. When entering the economy (at age 20) agents additionaly learn their education level and draw a job oportunity, that they can either accept of reject. For older households, if they start a period with a job oportunity, they decide whether to work and if so, by how much. If they lost job or decided not to work in the previous period, they choose whether to search for a new job or not. Depending on these decisions, individuals then spend the period working, unemplyoed or inactive. Wages and unemployment benefits are received, and decisions on consumption and savings are taken. At the end of the period, workers observe the job separation shock, and unemployed or inactive learn if the found a job for next period. Households can choose to retire at the beginning of the period, and once they do they leave the labor market permanently.

2.2 The Firm

In our model economy there is a representative firm. Aggregate output depends on aggregate capital, K, and on the aggregate labor input, L, through a constant returns to scale, Cobb-Douglas, aggregate production function of the form

$$Y = K^{\theta}(AL)^{1-\theta} \tag{4}$$

where A denotes labor-augmenting productivity factor. Factor and product markets are perfectly competitive and the capital stock depreciates geometrically at a constant rate, δ.

2.3 Backpack System

The BP economy features a fully funded pension system, funded by individual worker contributions. Workers may choose to use all or a fraction of the BP savings duing periods of involuntary unemployment. Every individual enters the economy without backpack claims. For every period of employment, a worker sees a fraction τ_b of his gross labor earnings deducted and invested into a personal employment-linked savings account, which is remunerated at the market rate of return, r. If b_t is the level of backpack assets at the beginning of an employment period, then next period's backpack evolves according to:

$$b_{t+1} = \tau_b y + (1 + r(1 - \tau_k))b_t, \tag{5}$$

When a worker looses his job, his backpack assets can be allocated to finance consumption (present or future, as he can choose to save the backpack assets). Next period's backpack assets become a choice variable for the involuntary unemployed. In contrast, if a worker chooses to quit his job while still in the labor force, he keeps the backpack but cannot withdraw. In that period, the backpack evolves according to

$$b_{t+1} = (1 + r(1 - \tau_k))b_t. \tag{6}$$

Upon retirement, backpack assets can be used to buy a lifetime annuity or added to private savings. If the worker decides retire at age R and allocate b amount of BP savings to the purchase of the annuity contract, he receives in return:

$$p^B(b) = \frac{(1+r)^{R-T}}{\sum_{j=R}^{T} \psi_j} b. \tag{7}$$

The aggregate amount of backpack assets is invested in the capital market and adds to the stock of productive capital available in the economy. Since this is an individual, fully funded system, the aggregate amount of BP assets used to purchase annuity contracts equals the total amount of annuity payments received by retirees. Hence we do not include it in the Social Security budget equation, shown below.

2.4 The Government

Before we specify the government budget constraint, we describe the government programs other than retirement pensions discuss above.

Unemployment Benefits. The governmet taxes workers and provides unemployment benefits to the unemployed. Eligibility for unemployment benefits – denoted $\mathbb{1}_{UB} = 1$, below – is conditional on: i) having lost a job (i.e. a job separation) and not having started a new job yet, ii) on actively searching for a job, and iii) having been unemployed for less than a given number of periods, $\bar{d}$. Eligibility expires when one of the conditions is not met, and non-eligibility is an absorbing state. Eligible agents receive unemployment benefits given by $u_b = b_0 \bar{y}_h$, where $b_0 \in (0, 1)$ is a replacement rate and $\bar{y}_h$ is the average labor earnings of workers with education h. Unemployment benefits are financed with payroll taxes, described below.

Other transfers. Households below an income level $y < \overline{t_r}$ receive a transfer from the government, denoted TR. Eligibility for transfers is conditional on income only and denoted by $\mathbb{1}_{TR} = 1$. Eligible households receive an amount t_r.

We model the government budget restriction with two separate identities. Unemployment benefits and unfunded pension systems, in the case of the *Baseline* and *PAYG* economy, are financed with payroll taxes and form the social security budget. Other government expenditures and revenues form the overall government budget. In the *BP* economy presented here, retirement pensions are fully funded and therefore are not a government liability.

The government taxes capital income, household income and consumption, and it confiscates unintentional bequests. It uses its revenues to finance an exogenous flow of public consumption and to service debt, and to make transfers to poor households. In addition, the government provides unemployment benefits and, in the economy with PAYG pension system, runs a pension system.

The government budget constraint is then:[12]

$$G_t + T_{r,t} + D_{t+1} = T_{k,t} + T_{y,t} + T_{c,t} + E_t + (1+r)D_t, \tag{8}$$
$$U_{b,t} = T_{p,t}, \tag{9}$$

where G_t denotes government consumption, $T_{r,t}$ denotes government transfers, $T_{k,t}$, $T_{y,t}$, and $T_{c,t}$, denote the revenues collected with the capital income tax, the household income tax, and the consumption tax, and E_t denotes unintentional bequests. $U_{b,t}$ denotes unemployment benefits, and $T_{p,t}$ denotes revenues collected with the payroll tax. In the remaining of the paper we assume that the level of public debt is fixed at the baseline calibration year level, $D_{t+1} = D_t$.

Capital income taxes. Capital income taxes are given by $\tau_k y_k$, where τ_k is the tax rate on gross capital income $y_k = ra$. a denotes capital holdings, and r the economy rate of return on capital.

Payroll taxes. Payroll taxes are proportional to before-tax labor earnings: $\tau_p y$.

Backpack taxes. Similarly, taxes to accumulate assets in the individual Backpack Fund account are given by: $\tau_b y$.

Consumption taxes. Similarly, consumption taxes are simply $\tau_c c$, where τ_c is the consumption tax rate and c is consumption.

Income taxes. We assume a simplified income tax formula according to which the income tax is proportional to the income level: $\tau_y \hat{y}$, where τ_y is a tax rate parameter and $\hat{y}$ is the tax base. The income tax base depends on the employment status. If a household is employed

$$\hat{y} = (1 - (\tau_p + \tau_b))y + r(1 - \tau_k)a. \tag{10}$$

For the unemployed and non-active agents,

$$\hat{y} = r(1 - \tau_k)a, \tag{11}$$

and for a retired household:

$$\hat{y} = r(1 - \tau_k)a + p^B. \tag{12}$$

In the last expression, p^B is the retirement pension.[13]

Insurance Markets. An important feature of the model is that there are no insurance markets for the stochastic component of the endowment shock, for unemployment risk, or survival risk. We model different public insurance systems that help agents in the economy smooth consumption in face of these shocks.

[12] In the *Baseline* and *PAYG* economies, the second equation is replaced with: $P_t + U_{b,t} = T_{p,t}$, where P_t denotes pension payments in period t.

[13] With the PAYG system, pension payments are given by p_h^S. In the Private Savings economy, there are no pension payments.

2.5 Individual Decision Problem

As noted before, here we describe only the problem in the *BP* economy.[14] The households' problem is described recursively. To simplify the notation, we omit in the main text the dependence of the value functions on the state variables age, education, private savings, backpack savings, and unemployment duration.

We first state the decision problem of a worker at the beginning of the period after the job acceptance was taken. Only after all the value functions are introduced we define the job acceptance and retirement decisions. An individual who is currently employed decides how much to consume c, save a', and work $l \in [0, 1]$, according to the following optimization problem:

$$W = \max_{c,l,a'} \left\{ u(c,l) + \beta \mathbb{E} \Big[(1 - \sigma_j) J + \sigma_j U \Big] \right\} \tag{13}$$

subject to:

$$(1 + \tau_c)c + a' + \tau_y \hat{y} + (\tau_p + \tau_b)y \leq (1 + r(1 - \tau_k))a + y + TR(y), \tag{14}$$

the backpack law of motion,

$$b' = \tau_b y + (1 + r(1 - \tau_k))b, \tag{15}$$

and a no-borrowing constraint:

$$a' \geq 0. \tag{16}$$

Gross labor income is $y = \omega \epsilon z l$, income tax base $\hat{y} = (1 - \tau_p - \tau_b)y + r(1 - \tau_k)a$ and government transfers for low income households are denoted by $TR(y) = t_r \mathbb{1}_{TR}(y)$, where $\mathbb{1}_{TR}(y) = 1$ if $y < \bar{t_r}$ and zero otherwise, as explained above.

Equation (13) above reads in the following way: the first term inside the curly brackets represents the utility flow from consumption and labor. The expected continuation value, discounted by β, takes into account the survival probability, all possible continuation histories of the realization of the stochastic component $z' \in \mathcal{Z}$, and two distinct labor market outcomes that are explicitly in the notation. With probability $1 - \sigma_j$, the worker keeps the job in the next period (and therefore is not eligible to claim unemployment benefits), with value denoted J that depends on next period's private and backpack assets, respectively a' and b', and the new realization of idiosyncratic productivity z'. Alternatively, with probability σ_j, the job is destroyed and the worker starts next period without a job, with value U. This value depends on the number of periods after an involuntary job separation (relevant to determine eligibility for unemployment benefits), d. In the first period after a layoff, $d = 0$. z' follows the Markov chain described in (1).

[14] The problem in the other economies can be found in the Appendix.

Workers can start the period without a job. In the BP economy, a job searcher who faced a job separation shock and has yet to start a new job has access to his backpack savings and, depending on low long he has been without working, may be eligible to receive unemployment benefits from the government. He therefore solves a consumption-savings problem, a job-search problem, and a portfolio problem for the allocation of his private and backpack savings. At the beginning of the period, the state vector for the agent is given by private asset holdings a, backpack savings b, stochastic productivity z, and layoff duration d. Given the current state, the agent chooses consumption, future asset holdings and the search effort $e \in \{0, 1\}$ according to:

$$U = \max_{c,a',b',e} \left\{ u(c) - \gamma e + \beta \mathbb{E}\Big[e\Big(\lambda_j^{\mathbf{u}} J + (1-\lambda_j^{\mathbf{u}})U \Big) + (1-e)\Big(\lambda_j^{\mathbf{n}} J + (1-\lambda_j^{\mathbf{n}})N \Big) \Big] \right\} \tag{17}$$

subject to

$$(1+\tau_c)c + a' + b' + \tau_y \hat{y} \leq (1 + r(1-\tau_k))(a+b) + UB(d,e) + TR(y), \tag{18}$$

and

$$a' \geq 0, \tag{19}$$

$$b' \leq (1 + r(1-\tau_k))b. \tag{20}$$

Equation (17) can be read as follows. The first term inside the curly brackets is the flow utility from consumption and the utility cost of search, given by γe. The expected continuation value takes into account the survival probability and the evolution of the stochastic productivity component, z. Higher search effort ($e = 1$) translates into higher probability of finding a job: $\lambda_j^{\mathbf{u}} > \lambda_j^{\mathbf{n}}$. The tradeoff in the job-search problem is made explicit inside the expectation operator. With high search effort during the current period, with utility cost γ, the agent finds a job next period with probability $\lambda_j^{\mathbf{u}}$. With low search effort ($e = 0$), a job arrives with lower probability, $\lambda_j^{\mathbf{n}}$. In the event the worker finds a job, he decides in the beginning of next period whether to work or not, with associated option value J which depends on beginning of period assets and labor productivity. If search is not sucessful the worker continues unemployed next period with probability $(1 - \lambda_j^{\mathbf{u}})$, with value U which again depends on assets, productivity and unemployment duration d' which increases deterministically by one. If the unemployed worker decides not to search, $e = 0$, and does not find a job, he becomes non-eligible for unemployment insurance benefits and may again search for a job next period, with associated value N.

Equation (18) represents the budget constraint. Total income is used to finance the left had side of (18) composed of consumption expenditures, next period assets and income taxes, with the income tax base given by $\hat{y} = r(1-\tau_k)a$. The right hand side is the sum of beginning of period private and backpack assets, plus after-tax return, unemployment benefits $UB(d,e)$ and government transfers for low-income households, $TR(y)$. The laid off worker may be entitled to unemployment benefits: $UB(d,e) = u_b \mathbb{1}_{UB}(d,e)$, with $\mathbb{1}_{UB}(d,e) = 1$ indicating eligibility for unemployment benefits. Formally:

$$\mathbb{1}_{UB}(d,e) = \begin{cases} 1 & \text{if } e = 1 \text{ and } d \leq \bar{d}, \\ 0 & \text{otherwise.} \end{cases} \tag{21}$$

The state variable d evolves deterministically according to $d' = d + 1$ if the worker continues unemployed in the following period, and $d = 0$ in the period immediately after a separation shock. We make two important simplifying assumptions here. The search effort is a dichotumous control: the agent can either actively search for a job ($e = 1$), or he doesn't search ($e = 0$). Additionaly, in the portfolio problem, represented by the constraint (20): the laid-off worker can use his backpack savings to finance present (or future) consumption, but cannot increase backpack holdings other than through wage contributions (i.e. while working). As before, there is a no-borrowing constraint given by (19).

Finally, an agent may start the period without a job because he has decided not to work or not to search in previous periods, not having found a new job yet. In this scenario, he solves the following problem:

$$N = \max_{c,a',e} \left\{ u(c) - \gamma e + \beta \mathbb{E}\Big[e\Big(\lambda_j^{\mathbf{u}} J + (1 - \lambda_j^{\mathbf{u}})N\Big) + (1-e)\Big(\lambda_j^{\mathbf{n}} J + (1 - \lambda_j^{\mathbf{n}})N\Big)\Big] \right\}, \tag{22}$$

subject to

$$(1 + \tau_c)c + a' + \tau_y \hat{y} \leq (1 + r(1 - \tau_k))a + TR(y), \tag{23}$$

and

$$a' \geq 0, \tag{24}$$

$$b' = (1 + r(1 - \tau_k))b. \tag{25}$$

As above, $\hat{y} = r(1 - \tau_k)a$. The decision problem is similar to (17), with key differences related to eligibility to unemployment benefits and access to BP savings. Specifically, in this case the unemployed worker is not eligible for unemployment benefits, and he also cannot use backpack assets. Accordingly, the evolution of BP assets is given by (25).

We consider now the the problem of the retiree after the retirement decision. Retired individuals are not in the labor market and have no endowment of efficiency units of labor. They finance consumption with past private savings, and pension payments. The problem is a standard consumption-savings decision, with survival risk and a certain maximum attainable age, assumed to be $j = 100$. At age $j = 99$, the continuation value is zero because the agent exist the economy next period with probability one. During retirement, the retired household solves a standard consumption-savings problem taking into account survival probabilities and pension payments:

$$V(a) = \max_{c,a'} \left\{ u(c) + \beta \mathbb{E}\Big[V(a') \Big] \right\}, \tag{26}$$

subject to

$$(1+\tau_c)c + a' + \tau_y \hat{y} \leq (1 + r(1-\tau_k))a + p^B(b) + TR(y). \tag{27}$$

Pension payments are part of the income side of the budget constraint. In this case, $\hat{y} = r(1-\tau_k)a + p^B(b)$. After retirement, labor market productivity is always zero and hence expectations take into account only the survival risk.

To close the description of the household's problem, we define the job acceptance and retirement decisions. These jointly pin down the value of having a job offer at the beginning of a period:

$$J = \max \Big\{ V, \max\{W, N\} \Big\}. \tag{28}$$

The outermost max operator represents the retirement decision, while the inner operator is the job acceptance decision.

2.6 Definition of Stationary Equilibrium

The definition of a stationary equilibrium can be found in Appendix B.

2.7 Steady-state dynamics

The steady-state dynamics of the economies under study have the following characterisation. Given a distribution of households entering the economy ($j = 20$ and $a = 0$; say, at T) they all receive a job opportunity and make their consumption, asset and employment decisions. These households' decisions together with their survival probabilities define the distribution of this cohort the following year ($T+1$) at $j = 21$, but it also the distribution of households of $j = 21$ at T. Similarly, for $j = 22, ..., 100$; that is, the different cohorts coexisting at T mirror the evolution of the distribution of households entering the economy at T up to the end of their potential survival $j = 100$. In other words, the decisions that agents of generation T make through their live are already made in the year they enter the labour market by older agents if they have the same state. By construction, this is a steady-state distribution, which is our benchmark distribution. Different economies simply expose the T cohort distribution to different public insurance systems and, therefore, all the cohorts coexisting at T behave as if the given system was in place when they entered the economy.

3 Calibration

In order to calibrate the model parameters using Spanish data, we need to modify the environment described in Section 2 to take into account the pay-as-you-go pension system currently in place in Spain. These modifications are however restricted to the pension system itself, and therefore the decision problem facing households, described above, is unchanged. In this baseline economy there is no Backpack fund, backpack assets (and contributions) are zero and claims on future consumption take only two forms: private savings and government retirement pension. Henceforth we use the following designation:

Baseline economy. The status quo economy, calibrated to the Spanish economy in 2018, which includes a public pay-as-you-go retirement pension system (see Appendix D). There is no Backpack system: $\tau_b = 0$.

The full description of the Baseline economy is included in the Appendix, but the description of the pay-as-you-go system is given below.

3.1 Pay-as-you-go System

The PAYG system is an unfunded defined contribution pension system, where pension payments mostly depend on individual workers history of salaries, among other factors. In the system considered here, pension payments depend on average earnings during the N_b years prior to retirement. In Spain, as in many other countries were a PAYG system exists, there is a minimum retirement age after which worker can decide to retire. We denote it by R_0. In order to capture the heterogeneity in pension payments that arises from different lifetime earnings histories, but at the same time reduce the dimensionality of the problem, we model pension payments that differ for each educational group (instead of each individual). Specifically, pension payments for retirees of educational group h are:

$$p_h^S = p_r \bar{y}_h, \tag{29}$$

where $\bar{y}_h$ is the average earnings of households in educational group h during the last N_b years before the retirement age, R_0, and p_r is a replacement rate. $\bar{y}_h$ is computed as:

$$\bar{y}_h = \frac{1}{N_b} \sum_{j=R_0-N_b}^{R_0-1} \bar{y}_{j,h} \tag{30}$$

where $\bar{y}_{j,h}$ is the average gross labor earnings of workers aged j and with education h. We assume that there are no early retirement penalties, nor minimum or maximum pensions. As mentioned before, this system is an unfunded system, financed through payroll taxes. Hence we model it as part of the Social Security budget:

$$U_{b,t} + P_t = T_{p,t}, \tag{31}$$

where, as above, $U_{b,t}$ are aggregate unemployment benefit expenditures and $T_{p,t}$ are payroll tax collections, and now P_t are aggregate retirement pension expenditures. These are a liability of the Social Security system (and a claim on pension payments for households) and therefore are in the expenditure side of equation (31). As above, the consumption tax rate is used to balance the government budget (8), and the payroll tax rate τ_p to balance (31).

To calibrate our model economy we do the following: First, we choose a calibration target country – Spain in this article – and a calibration target year – 2018. We then choose the initial conditions and the parameter values that allow our model economy to replicate as closely as possible selected macroeconomic aggregates and ratios, distributional statistics, and the institutional details of our chosen country in the target year. More specifically, to characterize our model economy fully, we must choose the values of 4 initial conditions and 38 parameters. To choose the values of these 38 parameters, we need 38 equations or calibration targets. We describe these steps, including the data sources, in Appendix C.

The next section presents the most relevant calibration targets and model statistics. We also present the government expenditure and tax revenue ratios, which are an important ingredient in the comparison of the simulations for the Spanish economy in 2068 under different retirement pension regimes.

3.2 Baseline Economy

The tables presented below summarize the calibration exercise. The values shown in bold are data targets.

Table 1: Macroeconomic Aggregates and Ratios in Spain and in the model, in 2018.

	K/Y^*	h^a	C/Y^*	G/Y^*	I/Y^*
Spain	**2.94**	34.59	**54.35**	**17.40**	25.35
Model	2.94	32.72	50.99	17.40	28.83

*In this table, variable Y is output at market prices.
^{a}Variable h denotes the average share of disposable time allocated to the market.
Data source: Fundación BBVA and Spanish National Institute of Statistics (INE).

As shown in Table 2, we target government expeditures and revenue ratios in order to determine the simplified tax system in the model. The payroll tax rate finances pension and unemployment benefit expenditures. Capital income and household income tax rates are chosen to collect 2.24% and 7.05% of GDP (at market prices), as it is the case in Spain in 2018. Finally, the consumption tax rate clears the government budget. Some Spanish regions feature a proportional tax on bequests. We use the aggregate revenue of this tax in 2018 as the data point for E (0.20% of output). In the model aggregate accidental bequests as a fraction of output is significantly higher (2.63). In the results shown below we assume that the portion of the accidental bequests that is not taxed by the government is wasted (thrown to the sea).

Table 2: Government Budget in Spain and in the model, in 2018 (% of output, Y, at market prices).

	Public Expenditure				Public Revenues				
	G	T_r	P	U	T_c	T_k	T_y	T_p	E
Spain	**17.40**	**0.83**	**10.47**	**1.32**	9.07	**2.24**	**7.05**	9.47	**0.20**
Model	17.40	0.83	10.49	1.18	8.72	2.24	7.05	11.68	0.20

G: government consumption, T_r: welfare transfers, P: pension payments, U: unemployment benefits expenditures; T_c: consumption tax collections, T_k: capital income taxes, T_y: household income tax revenue, T_p: payroll tax revenue, E: accidental bequests revenue.
Data source: Spanish Social Security (Resumen de Ejecución del Prespuesto) and Spanish National Institute of Statistics (Cuentas Nacionales).

The tax rates implied by the calibration are shown in Table 3.

Table 3: Policy Parameters in the model economy, in 2018.

	Tax rates (%)			
	τ_c	τ_y	τ_k	τ_p
Model	20.6	11.3	11.9	25.9

τ_c: consumption tax rate, τ_y: household income tax rate, τ_k: capital income tax rate, τ_p: payroll tax.

Table 4: Labor Market Shares in 2018 (% of population).

	W	U	I	R
Spain	**59.59**	10.72	**5.16**	24.51
Model	58.31	11.68	5.30	24.70

W: workers, U: unemployed, I: inactive, R: retirees.
Data source: Encuesta de Población Activa.

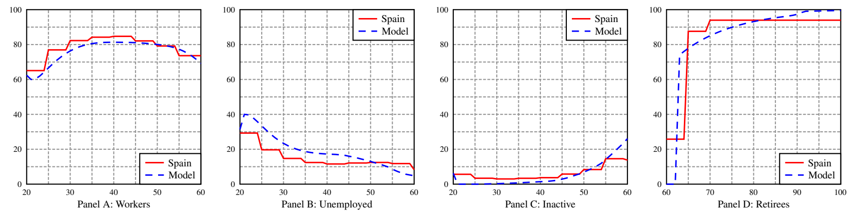

Figure 2: Labor market stocks by age in the data and in the model. Data source is the survey is Encuesta de Población Activa.

4 Pay-as-you-go pension system in the long run

The first quantitative results from the calibrated model are the predictions of the effects of population ageing in Spain, in an invariante policy scenario. They are constructed in the following way. We solve for the long-run steady state economy with the age distribution of the Spanish population which is forecasted for the year 2068.[15] In order to do so, we update the age-dependent survival probabilities, ψ_j, so that the model generates an age distribution as the 2068 forecast. The age profile of survival probabilities and the corresponding age distribution in 2018 and in the 2068 forecast can be seen in Figure 3. The share of households older than 65 increases from 24% in 2018 to 36% in 2068. Additionally, we assume that the 2018 pay-as-you-go system remains in place. In the 2068 economy, we increase the number of years used to compute the pension, N_b, from the 21 to the last 25 years before retirement. Also, the minimum retirement age becomes 63.[16] These changes follow from the 2011 and 2013 pension reforms in Spain. We also assume that an increase in aggregate pension payments is compensated by an increase in the payroll tax, τ_p. Furthermore, we adjust the consumption tax rate, τ_c, to offest any primary deficit or surplus and clear the government budget constraint (hence, government consumption and debt are unchanged).[17]

We use the following notation:

PAYG. A long-run economy, with a population age distribution as predicted for Spain in 2068, assuming the 2018 pay-as-you-go (PAYG) pension system is in place (with small parametric changes to minimum retirement age and pension payments formula).

[15]Instituto Nacional de Estadística, 2018-2068 series: https://ine.es/dynt3/inebase/es/index.htm?padre=4749

[16]We do not account for the Sustainability Factor, because its implementation has been suspended. Additionally, we assume that the probabilities to find/lose a job do not change.

[17]To update the distribution of education levels, we assume that from 2018 onwards, 7.33 percent of the 20 year-old entrants have not completed their secondary education, that 62.62 percent have completed their secondary education, and that 30.05 percent have completed college. This was the educational distribution of Spanish households born between 1980 and 1984, which was the most educated cohort in 2018 data.

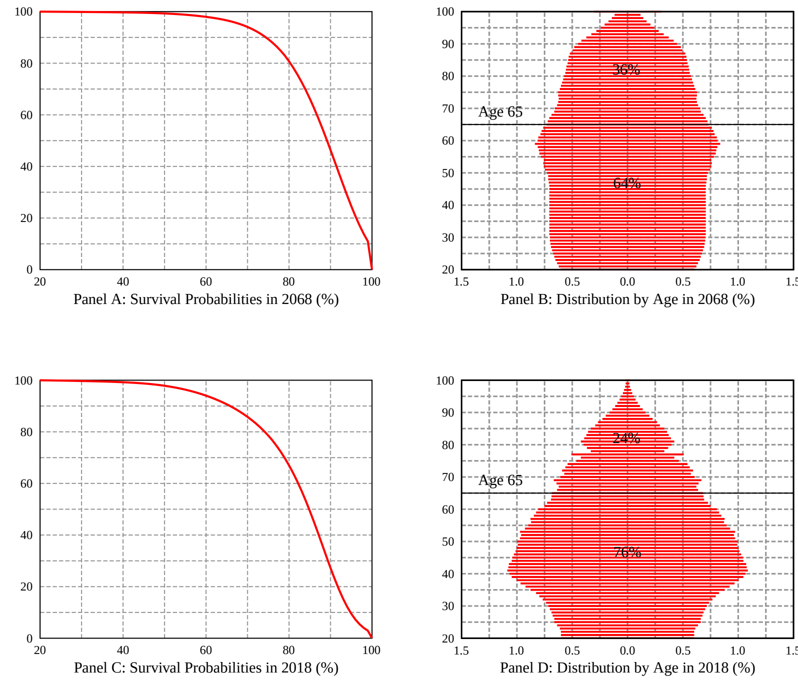

Figure 3: Survival Probabilities and Age distribution in Spain in 2018 and the 2068 forecast. Source: Instituto Nacional de Estadística, 2018-2068 series.

We now present the model results. We start with the distribution of households along the different labor market groups. The increase in the share of population aged 65 years old and older leads to a significant increase in the share of retirees in the economy. As Table 5 shows, this group represents almost 35% of the population in 2068. All the other labor market groups decrease their share, with the largest fall in the stock of employed, 8 percentage points. Worker decide to retire later, with the average retirement age increasing from 63.7 in 2018 to 65.1 in 2068. The increase is not enough to compensate for the demographic effect. Consequently, the increase in the share of retirees increases pension payments. Pension payments as a share of output more than double: from 11.5% in 2018 to 23% in 2068 (Table 7). The payroll tax rate necessary to finance PAYG pensions in 2068 is 51% (Table 15), and total payroll tax collection increases from 12.8% to 24.4% of output in 2068.

Table 5: Labor Market Shares in the baseline 2018 model economy, and in the PAYG 2068 simulation (% of population).

	W	U	I	R
Model (2018)	58.31	11.68	5.30	24.70
PAYG (2068)	50.46	10.46	4.26	34.80

W: workers, U: unemployed, I: inactive, R: retirees.

The decrease in the share of households who work and the decrease in savings reduces labor and capital in the economy: output is 12% lower. Among the workers, hours worked slightly increase due to a negative income effect of lower after-tax income. The fall in investment to below 25% reduces wages and increases the interest rate. Capital and income tax collections fall. These reduce aggregate consumption, which further requires an increase in the consumpion tax from 21% to 23%.

Table 6: Macroeconomic Aggregates and Ratios in the baseline 2018 economy, and in the PAYG 2068 simulation*.

	Y	K/Y	L/Y	h^a	C/Y	G/Y	I/Y	w	$r(\%)$
Model (2018)	2.04	3.23	33.15	32.72	46.31	19.06	30.97	1.55	6.40
PAYG (2068)	1.79	2.98	35.81	33.39	50.13	21.62	24.11	1.44	7.68

*In this table, variable Y is output at factor cost. The number for K/Y is in model units and not in percentage terms. All the remaining ratios are expressed in percentage terms.
[a]Variable h denotes the average share of disposable time allocated to the market.

Table 7: Government Budget in the 2018 model economy and in the PAYG simulation of 2068 (% of output, Y, at factor cost).

	Public Expenditure				Public Revenues				
	G	T_r	P	U	T_c	T_k	T_y	T_p	E
Model (2018)	19.06	0.91	11.50	1.29	9.55	2.46	7.73	12.80	0.22
PAYG (2068)	21.62	0.82	23.04	1.36	11.55	2.72	7.94	24.38	0.22

G: government consumption, T_r: minimum income, P: pension payments, U: unemployment benefits expenditures; T_c: consumption tax collections, T_k: capital income taxes, T_y: household income tax revenue, T_p: payroll tax revenue,E: accidental bequests revenue.

The results are line with results found by previous papers, as for example Díaz-Giménez and Díaz-Saavedra (2017), De la Fuente et al. (2019) and Díaz-Saavedra (2020). Specifically, Díaz-Giménez and Díaz-Saavedra (2017) and De la Fuente et al. (2019) find that pension payments may reach around 21 percent of output at market prices in 2050. Díaz-Saavedra (2020) finds that, with the Sustainability Factor (abandoned by the Spanish legislator), this number would reach 16 percent of output that same year.

We present additional results on changes along the demographic, income and wealth distributions when we compare the PAYG 2068 economy with the alternative reformed economies, below.

5 Backpack Economy

In this section we present the main results of the paper. We study the Backpack employment fund, in an economy without PAYG pensions and an age distribution as forecasted for Spain 2068.

In order to solve for the BP steady state economy we must choose the mandatory contribution rate, τ_b. In order to do so, we solve different equilibria, indexed with τ_b between 0 and some exogenously set upper bound. We then compute aggregate welfare in these different BP economies, and compare it to aggregate welfare in the PAYG economy (2068).[18] We find that welfare gains are concave in τ_b, with a maximum at $\tau_b = 21\%$.[19] Accordingly, in this section we present a BP economy with $\tau_b = 21\%$. We use the following designation:

BP. An alternative, reformed economy, with a Backpack (BP) fund as described above. In this simulation, we assume the age distribution is as in the 2068 forecast, and that the PAYG system is eliminated and replaced with a Backpack system with a contribution rate $\tau_b = 21\%$.

The following tables compare the BP economy with the PAYG economy.

Table 8: Aggregates in the PAYG and BP simulations of 2068.

	Y	K/Y^*	L/Y^*	h^a	C/Y^*	G/Y^*	I/Y^*	B/Y^*	w	$r(\%)$
PAYG	1.79	2.98	35.81	33.39	50.13	21.62	24.11	–	1.44	7.68
BP	2.84	4.41	25.67	31.88	48.90	21.62	27.53	3.24	2.08	2.39

*In this table, variable Y is GDP at factor cost.
^{a}Variable h denotes the average share of disposable time allocated to the market.

The primary effect of any mandatory retirement savings system is on the savings behaviour before and after retirement. The retirement pension system in the PAYG economy, by taxing a large fraction of workers wages that are then paid back after retirement, discourages private savings before retirement, since workers expect pension payments during retirement. Eliminating it provides a strong incentive to save during working years, in order to finance consumption after retirement. On the other hand, the BP system features a fixed 21% contribution rate out of gross labor income, which is capitalized and available for consumption during involuntary unemployment and after retirement. Additionaly, workers can convert backpack savings into a life annuity at retirement, which eliminates a precautionary motive to save for the event of an above average life horizon. While these features of the BP system reduce incentives to save, BP contributions are invested in productive capital (in contrast to the PAYG pension system, which transfers resources from workers to retirees within any given year, via the Social Security budget), increasing the

[18]We compare the BP economy with the laissez-faire equilibrium and a standard fully funded defined contribution pension system below.
[19]The details of this exercise can be found in Appendix E.

aggregate capital stock in the economy. Table 12 shows that the latter effect dominates, with the capital-output being 4.4 in the BP economy (and 2.98 in the PAYG economy). The stock of capitalized BP contributions is 3.24 of output.

The second direct effect of the reform is on the timing of the retirement decision. Since there is no minimum nor maximum retirement age in the BP economy, workers decide when to retire according to the earnings-leisure tradeoff, taking into account labor productivity and job finding prospects in the last years of life. Table 9 shows that this drives the share of retirees substantially down in the BP economy, by almost 10 percentage points, and the share of workers higher by almost the same share. In 2068, the average retirement age in the PAYG economy is 65.1 and in the BP economy is 81.5.[20] The effective labor tax is higher in the PAYG economy (reducing work incentives), and cost of delaying retirement relative to wage salaries tend to increase with age (as productivity starts to decline), after the minimum retirement age. Therefore the PAYG system provides a strong incentive to retire and leave the labor force close to the minimum retirement age. In contrast, the effective labor tax is lower in the BP economy and annuity payments increase with BP savings, which accumulate by working. This provides an incentive to work until later. Higher work incentives increase job search and hence unemployment is higher (and inactivity lower) in the BP economy.

Other important effects come indirectly through prices and taxes. The larger capital stock decreases its marginal product, and accordingly the real interest rate falls. The capital-labor ratio more than doubles, making labor more productive, hence the wage rate increases. Obviously, government expenditures with retirement pensions is zero, and the payroll tax rate is only 2.93% in the BP economy. On the expenditure side, government transfers increase as more low income households qualify. On the revenue side, capital income tax collection as a share of output falls, because despite the increase in capital stock and an additional source of capital income taxes, coming from BP assets, the return on capital falls and capital income as a share of output falls. Despite higher household consumption in the BP economy, the consumption tax rate is higher ($\tau_c = 28.57\%$ compared to 23.1% in PAYG), in order to balance the government budget.

Table 9: Labor Market Shares in the PAYG and BP simulations of 2068 (% of population).

	W	U	I	R
PAYG	50.46	10.46	4.26	34.80
BP	58.84	13.52	3.73	23.91

W: workers, U: unemployed, I: inactive, R: retirees.

[20] Recall that life expectancy, education, the age profile of labor market productivity, job destruction and job finding rates are the same in the two economies.

Table 10: Policy Parameters and tax revenues in the PAYG and in the BP economies.

	Tax Rates (%)	
	PAYG	BP
τ_c	23.05	28.45
τ_p	51.02	2.93
τ_b	-	21.00
τ_e	64.69	47.46

τ_c: consumption tax rate, τ_y: household income tax rate, τ_k: capital income tax rate, τ_p: payroll tax. τ_x fund tax rate; e.g. $x = b, f$, τ_e efficient labour tax (see Footnote 7).
* : As a share of output at factor cost.

Table 11: Government Budget in the PAYG and BP simulations of 2068 (% of output, Y, at factor cost).

	Public Expenditure				Public Revenues			
	G	T_r	P	U	T_c	T_k	T_y	T_p
PAYG	21.62	0.82	23.04	1.36	11.55	2.72	7.94	24.38
BP	21.62	1.32	0.00	1.30	13.91	1.25	7.56	1.30

G: government consumption, T_r: minimum income, P: pension payments, U: unemployment benefits expenditures; T_c: consumption tax collections, T_k: capital income taxes, T_y: household income tax revenue, T_p: payroll tax revenue.

The PAYG and BP long-run economies compared above, despite sharing many important features (technology, demographics, government tax structure), differ significantly in terms of the retirement pension system available to households – with large aggregate consequences, as discussed before. Nevertheless, there are different components of the pension reform that can be isolated and analyzed separately: eliminating the pay-as-you-go system, introducing a fully funded pension system, and adding flexibility to this system by allowing worker to use BP contributions during period of involuntary unemployment. The BP reform is the sum of these three elements.

In order to study the different components of the BP system, we consider below two alternative long-run economies: one where the PAYG pension system is eliminated and workers save for retirement only through individual savings (we label it Private Savings economy), and another where the PAYG pension system is substituted by a standard defined contribution funded pension system. Additionally, we discuss heterogeneous effects at the individual level, and compare the different economies in terms of welfare.

5.1 Fully Funded pension system and Privatization

To investigate the individual and aggregate implications of the BP system, we compare the BP economy with two important benchmarks: the full privatization of retirement savings and a classic fully funded, defined contribution pension system. In order to do so, we solve the stationary equilibrium of these alternative economies, assuming the 2068 age distribution and the elimination of PAYG pensions. For the defined contribution pension system, we perform a grid search as in the BP exercise and find a welfare maximizing mandatory pension contribution rate of $\tau_f = 11\%$.

PS. In the Private Savings economy there is no explicit retirement pension system, and households support consumption after retirement exclusively using private savings (PS).

FF. The fully-funded, defined contribution, pension scenario is labeled *FF*. In this case, agents save a mandatory contribution as a fixed fraction of their labor earnings, that accumulate in an individual notional account until retirement. At retirement, the capitalized lifetime contributions are converted in a pension payment as an actuarily fair annuity.

The PS economy is computed after eliminating the public pension system, by setting $p_r = 0$. This implies that aggregate pension payments are zero, $P = 0$. The economy with a fully funded pension system is similar to the BP economy, with the important distiction that worker contributions to the pension system are claimed at retirement, but not after job loss.

5.1.1 Fully-Funded System

The *FF* economy features a standard fully-funded, defined contribution, pension system. Retirement pensions are financed by individual own contributions accumulated while working. Specifically, each worker has a mandatory contribution rate of τ_f of gross labor earnings y. The contributions are remunerated at the rate of return of capital. We assume, as in the Backpack system presented below, that notional returns are taxed at the same rate as private savings returns, τ_k; and that they are not part of the income tax base, as in the BP case. Hence, denoting by m_t the notional account of pension claims of a given worker at the beginning of period t, the evolution is given by:

$$m_{t+1} = \tau_f y + (1 + r(1 - \tau_k))m_t, \tag{32}$$

and

$$m_{t+1} = (1 + r(1 - \tau_k))m_t, \tag{33}$$

in periods out of work. When a worker of age R retires with accumulated pension claims m, he is entitled to a pension payment per year given by:

$$p^F(m) = \frac{(1+r)^{R-T}}{\sum_{j=R}^{T} \psi_j} m. \tag{34}$$

In expectation, at retirement age R, given his capitalized career contributions m, the retiree receives an actuarily fair annuity $p^F(m)$. The aggregate amount of pension claims is invested in the capital market and adds to the stock of productive capital available in the economy. As in the BP case, the system is fully funded because pension payments due to retirees who live longer than average are transferred from pension claims of retirees who leave earlier than average, and no other (taxed) resources are necessary to finance pension payments.

As in the case of the BP economy, we need to define the contribution rate τ_f in order to solve the FF steady state equilibrium. We follow the same grid-search procedure as in the case of the BP economy above, and find the welfare maximizing rate at $\tau_f = 11\%$. We present a FF economy with $\tau_f = 11\%$ next. Appendix A.2 contains the formal description of the FF economy.

5.1.2 Results

As in the BP policy reform, changing or eliminating the pension system requires an assumption about which tax instrument is changed in order to balance the government budget. We mantain the assumption that the payroll tax rate τ_p adjusts to clear the social security budget, which in both the FF and PS economies (as in the BP economy), since there are no government liabilities with retirement pensions, consists only of unemployment benefit expenditures. We assume again that the consumption tax rate τ_c adjusts to clear the budget (government debt and government consumption are constant).

In the following tables, we include the PAYG 2068 economy results, presented in Section 4, for comparison. Table 12 shows the main aggregates in the three reformed economies. The elimination of the PAYG pension system drives most of the differences in macroeconomic aggregates across the three economies (i.e. the main aggregate in the three reformed economies are closer to each other than any of them is to the PAYG economy). It has a large direct effect on disposable income through the reduction in payroll taxes, and a large direct effect on savings behaviour due to the elimination of pension payments. Unsurprisingly, all the reformed economies have higher capital-output ratios than the PAYG economy. The retirement pension system in the PAYG economy discourages private savings before retirement. In contrast, the PS economy where retirees finance consumption exclusively through private savings, displays the highest stock of private savings, 4.18, that make up all of the productive capital stock in the economy. Differently, in the BP and the FF economies, the two fully funded systems add to the capital stock, and also partially substitute for private savings. The capital output ratio is higher in the two economies with funded systems.

The PAYG pension system features a minimum retirement age after which workers, expecting a declining age-profile of productivity or alternatively a stable retirement pension, have a strong incentive to leave the labor market. Once it is eliminated, workers prolong their participation. The share of workers in the population older than 65 is 8.3% in the PAYG economy, but it is 48.8%,

Table 12: Aggregates in the PAYG, PS and BP simulations of 2068.

	Y	K/Y^*	L/Y^*	h^a	C/Y^*	G/Y^*	I/Y^*	X/Y^*	w	$r(\%)$
PAYG	1.79	2.98	35.81	33.39	50.13	21.62	24.11	–	1.44	7.68
PS	3.03	4.18	26.01	31.94	38.48	21.62	35.02	–	1.98	2.99
FF	3.09	4.56	24.01	31.86	42.59	21.62	32.79	2.24	2.14	2.04
BP	2.84	4.41	25.67	31.88	48.90	21.62	27.53	3.24	2.08	2.39

$X = B, M$ in the BP and FF economies, respectively. B denotes aggregate backpack savings, while M denotes aggregate pension savings in the FF economy. *In this table, variable Y is GDP at factor cost.
^{a}Variable h denotes the average share of disposable time allocated to the market.

35.0% and 24.9% in the PS, FF and BP economies, respectively.[21]

With highers earnings (higher wage rate and lower effective tax rates), workers can affoard to work less hours on average, and consume and save more. Household consumption and total savings are higher in all reformed economies, relative to the PAYG economy, but there are important differences between the three scenarios. Households save much more in the PS economy, as private savings are the only means to finance consumption after retirement. Savings continue until later in life, while annuity payments in the FF and BP economies allow agents to start desaving when they are around 60 years old, on average (roughly 10 years earlier than in the PS economy). Consequently, consumption is higher in the FF and BP economies, in particular during the last decades of life. The BP economy features the highest consumption (in all education groups) because of higher pension payments. Since the backpack tax rate is 21%, compared to the contribution rate of 11% in the fully funded FF system, pension payments are higher in the BP case. With higher aggregate retirement savings in the BP economy, workers can affoard to retire earlier in comparison to the other two reformed economies. In contrast, the PS economy displays the lowest share of retirees and the highest share of workers. This is explained by the average retirement age in each economy: 65.1 in the PAYG, 83.3 in the PS, 80.5 in the FF, and 78.3 in the BP economy.

Table 13: Labor Market Shares in the PAYG, PS and BP simulations of 2068 (% of population).

	W	U	I	R
PAYG	50.46	10.46	4.26	34.80
PS	67.16	13.89	4.66	14.29
FF	62.33	13.25	5.05	19.37
BP	58.84	13.52	3.73	23.91

W: workers, U: unemployed, I: inactive, R: retirees.

[21] Life expectancy at age 20, according to the 2068 survival rates, is 88.4 years old.

Table 14: Government Budget in the PAYG, PS and BP simulations of 2068 (% of output, Y, at factor cost).

	Public Expenditure				Public Revenues			
	G	T_r	P	U	T_c	T_k	T_y	T_p
PAYG	21.62	0.82	23.04	1.36	11.55	2.72	7.94	24.38
PS	21.62	2.24	–	1.23	15.20	1.49	6.92	1.23
FF	21.62	1.80	–	1.26	15.05	1.11	7.06	1.26
BP	21.62	1.32	–	1.30	13.91	1.25	7.56	1.30

G: government consumption, T_r: minimum income, P: pension payments, U: unemployment benefits expenditures; T_c: consumption tax collections, T_k: capital income taxes, T_y: household income tax revenue, T_p: payroll tax revenue.

Table 14 shows the output shares of the government taxes and revenues in the three scenarios.[22] Pay-as-you-go pension payments (P) are zero in the reformed economies, whereas they represent 23% of output in the PAYG economy. This difference explains the large decrease in the payroll tax rate in Table 15, from 51% in the PAYG economy to only around 3% in the reformed economies. Consequently, payroll tax collections are 24.4% in the PAYG economy versus 1.25% in the PS, FF or BP. Despite unemployment increasing significantly once the PAYG system is eliminated, unemployment benefit expenditures as a ratio of output are constant because output increases at approximately the same rate. Table 15 shows a large increase in social income transfers to the poorest agents in the economy once PAYG pensions are eliminated. The reason for this is the following: by eliminating PAYG pensions, some low productivity and low savings workers over 65 eventually loose their job but keep searching, staying unemployed while they don't find one (they would mostly choose to retire with PAYG pensions). After two years of unemployment, unemployment benefits expire and, once falling below the poverty threshold to qualify for social assistance, they start collecting government transfers. In the PS and BP economy, more households reach this state and hence aggregate transfers are higher. The aggreate amount of tranfers is lower in the BP economy, among the reformed scenarios, because retirement pensions are higher in that economy, and hence fewer households reach the minimum income level to quality for government assistance. Higher retirement pensions also imply higher income tax collections on the BP economy. This allows for a lower consumption tax rate (Table 15) and lower consumption tax collection, to balance the government budget at the steady state.

[22] Recall that government consumption as a share of output is fixed, and the level of government debt is also fixed. The other components react to any changes in the economy.

Table 15: Policy Parameters and tax revenues in the PAYG, PS, FF and in the BP economy.

	Tax Rates (%)				Revenue Y^* Ratios (%)			
	PAYG	PS	BP	FF	PAYG	PS	BP	FF
τ_c	23.05	39.45	28.45	35.33	11.55	15.19	13.91	15.05
τ_y	11.28	11.28	11.28	11.28	7.94	6.92	7.56	7.06
τ_k	11.88	11.88	11.88	11.88	2.72	1.49	1.26	1.10
τ_p	51.02	3.04	2.93	2.98	24.38	1.23	1.30	1.26
τ_x	0	0	21.00	11.00				
τ_e	64.69	38.31	47.46	43.61				

τ_c: consumption tax rate, τ_y: household income tax rate, τ_k: capital income tax rate, τ_p: payroll tax. τ_x fund tax rate; e.g. $x = b, f$, τ_e efficient labour tax (see Footnote 7).
* : As a share of output at factor cost.

Table 16: The Distributions of Earnings, Income, and Wealth

		Bottom	Quintiles					Top
	Gini	10	1st	2nd	3rd	4th	5th	10
The Earnings Distributions (%)								
PAYG	0.37	3.2	7.5	10.4	15.0	22.5	44.6	28.1
PS	0.34	3.5	8.2	11.6	15.4	23.3	41.6	26.3
BP	0.34	3.5	8.3	11.6	15.5	23.2	41.4	26.1
FF	0.34	3.6	8.4	11.6	15.5	23.3	41.3	26.1
The Income Distributions (%)								
PAYG	0.37	2.0	5.4	11.1	17.0	23.8	42.7	27.0
PS	0.43	1.9	4.8	8.9	14.6	23.2	48.5	30.5
BP	0.40	1.6	4.8	10.4	15.5	24.3	45.1	28.4
FF	0.41	1.8	4.6	10.3	14.9	24.2	45.9	29.2
The Wealth Distributions (%)								
PAYG	0.63	0.0	0.7	3.9	8.9	21.6	64.9	44.1
PS	0.54	0.0	0.7	5.5	13.4	25.5	54.8	33.6
BP	0.79	0.0	0.0	0.0	1.4	16.6	81.9	57.7
FF	0.65	0.0	0.0	2.0	9.5	23.7	64.7	42.3

Table 16 shows the distribution of income, earnings and wealth in the four economies. Changes in all inequality measures are mainly driven by the longer working lifetime in the reformed ecomomies (PS, BP, and FF) compared to the PAYG economy. In the reformed economies, earnings inequality decreases mainly because the difference in the deterministic labor productivity by educational type, which strongly decreases for the more educated workers as they become older. (Recall that people retire later in the reformed economies). In the reformed economies, income inequality increases mainly because the following. Retirees replace public retirememt income (sparsely unevenly distributed since there are only three types of public retirement pensions) by capital income and/or annuity income which is more unevenly distributed. Wealth inequality refers only to private assets holdings. In the PS economy, dropouts increase by more their saving rates, as there are no public pensions (the main income source for low educated retired people), so wealth inequality decreases. In the BP and FF economies, wealth inequality is higher than in the PS economies, as they deliver a forced saving scheme for the retirement period, so low educated people reduce by more savings during their working lifetime. The higher this compulsory saving, the higher this effect, so the higher the wealth inequality.

5.2 Welfare effects

We quantify the social welfare effects of the different pensions systems using a consumption equivalent variation measure (CEV). As explained above, we found the welfare maximizing pension contribution rates using the PAYG economy (2068) as the benchmark. Specifically, we compute the percentage change in a households lifetime consumption that equates its expected lifetime utility in the PAYG economy, to that in the alternative simulation (PS or BP). Formally, let $i \in J \times H \times \mathcal{Z} \times \mathcal{L} \times A$ denote the household's type.[23] Define $v^{PAYG}(i, \Delta(i))$ as the equilibrium value function of a household of type i in model economy PAYG, whose equilibrium consumption plan is changed by a fraction $\Delta(i)$ every period and whose leiture plan is unchanged. Then the CEV measure is found according to:

$$v^{PAYG}(i, \Delta(i)) = v^{R}(i), \tag{35}$$

where $v^R(i)$ denotes the equilibrium value function of household of type i in the PS economy ($R = PAYG$) or in the BP economy ($R = BP$).

Table 17 displays the large welfare gains at age 20 from eliminating PAYG pensions in the 2068 steady state. The gains are of the order of magnitude of the decrease in the payroll tax, necessary to finance the PAYG pension system. All education types are at least 46% better off without PAYG pensions. Despite the relatively high contribution rates in the BP and FF pension systems, aggregate welfare is even higher in those two economies compared to the fully private economy. The reason for this is the conversion of lifetime contributions into annuity payments after retirement, that allow for higher consumption and lower private savings during the entire lifecycle. Consumption is much higher in the PS and BP economies, specially before the first retirement in the PAYG system (age 63). And average work hours are much lower in these, again specially before age 63. The fact that agents retire later on has not significant effect, given the effective discount rate (β times survival probabilities).

[23] Recall the dimensions of household heterogeneity: age, education, productivity, labor market statys, assets.

Table 17: Consumption Equivalent Variation (Δ, %) in the PS, BP and Pension Fund economies, relative to the PAYG economy.

Simulation	Education			
	Dropouts	High School	College	All
PS	47.89	48.47	46.23	48.24
FF	56.15	56.76	55.55	56.62
BP	59.74	61.05	59.98	60.88

Table 18: Consumption Equivalent Variation (Δ, %) in the FF and BP economies, relative to the PS economy.

Simulation	Education			
	Dropouts	High School	College	All
FF	5.58	5.59	6.39	5.66
BP	8.01	8.47	9.43	8.53

Welfare is higher in the BP economy because of the additional flexibility of backpack contributions during periods of unemployment. Because workers can access these funds after job loss, it provides unemployment insurance. This makes it possible to increase the contribution rate (relative to what is socially desirable in the fully funded pension system) and deliver higher retirement pensions, compensating for the distortionary effect of a fixed contribution rate for all workers (irrespective of age, earnings or wealth). Table 20 shows the extent to which unemployed workers use backpack savings in the first period of involuntary unemployment, compared to private savings (Table 19).

Table 19: Private saving rates by education and level of private savings at age 30 and 50 (as a proportion of unemplyment benefits), for unemployed workers who lost the job in the previous period.

	Private Savings, a	Education		
		Dropouts	High School	College
Age 30	0.2 of per capita GDP	-98.4	-93.3	-63.7
	1.0 of per capita GDP	-110.0	-107.4	-80.2
	2.0 of per capita GDP	-116.8	-105.5	-97.3
Age 50	0.2 of per capita GDP	-92.6	-85.4	-57.2
	1.0 of per capita GDP	-129.6	-121.6	-86.8
	2.0 of per capita GDP	-64.0	-33.6	-103.5

Table 20: Backpack (de-)saving rates by education and level of private savings at age 30 and 50 (as a proportion of unemplyment benefits), for unemployed workers who lost the job in the previous period.

	Private Savings, a	Education		
		Dropouts	High School	College
Age 30	0.2 of per capita GDP	-4.8	-30.7	-19.8
	1.0 of per capita GDP	-7.7	-6.0	-4.1
	2.0 of per capita GDP	-9.7	-7.5	-5.1
Age 50	0.2 of per capita GDP	-5.4	-4.2	-2.8
	1.0 of per capita GDP	-8.9	-6.9	-4.7
	2.0 of per capita GDP	-11.5	-8.9	-6.1

6 The transition from the PAYG to the Backpack economy

The unanimous welfare gains of having a Backpack vs a PAYG social security system in the long-run steady-state provide ample fiscal capacity to design a Pareto improving transition from the current situation. Nevertheless, it's not obvious that a feasible and robust Pareto improving design exists. This section – still work in transition – explores this issue. We have constrained the comparison of different social security systems not to involve other fiscal reforms (e.g. keeping Unemployment and PAYG benefits expenditures financed with payroll tax revenues), and here there is only one instrument to finance the transition:public debt, which is exclusively used for this purpose. We also allow for the consumption tax to vary in order to balance the government budget. As a benchmark, and in line with the current situation, of low interest rates supported by the euro area institutions, we assume – unless, we state it differently – that the real interest rate on public debt financing the reform is zero.

Slow vs. fast transitions

The difficult political-economy of implementing deep structural reforms often calls for introducing them slowly. For example, a slow Spanish debt-financed transition can be implemented, starting in 2019, following five simple principles:

1. everyone who is 21 or older in 2019 remains in the PAYG system which keeps operating as long as they are workers with PAYG claims.
2. those entering the labour market in 2019 (i.e. age 20) and in future years, enter the Backpack system and remain on it.
3. benefits and payroll taxes of the PAYG system during the transition are basically the same

than those of the PAYG system through the demographic transition; more precisely, we can split the payroll tax into its unemployment and pension components; i.e. $\tau_{p,t} = \tau_{pu,t} + \tau_{pp,t}$, then $T_{pu,t} = U_{p,t}$, while $\tau_{pp,t}$ is as in the PAYG transition in year t.

4. benefits and backpack taxes, for those in the Backpack system, during the transition are as in the steady-state Backpack economy (i.e. $\tau_b = 21\%$) and payroll taxes only finance unemployment benefits (i.e. $T_{p,t} = T_{pu,t} = U_{p,t}$).

5. all the PAYG claims that are not covered with the current payroll tax revenues are financed with public debt (i.e. the PAYG retiree benefits not financed by workers in the backpack system)

In a stationary demographic environment, with a constant population – in particular, a constant dependency ratio – absent general equilibrium effects due to the introduction of the Backpack, this slow design is constrained-efficient. In other words, it is a design that should have been seriously considered if the reform of the social security system had started decades ago... Except that, even in such stationary economy, in as much as the Spanish economy is a closed economy, the positive general equilibrium effects would make a faster transition would enhance welfare. Alternatively, even without general equilibrium effects, the demographic transition calls for a transition from the PAYG to the BP ahead of the demographic transition to avoid the burden of having a high dependency ratio (close to 60%) while still having to finance PAYG liabilities. Since in Spain both elements play a role, a faster transition is in order. In fact, with the described slow 'Pareto improving transition' the debt needed to finance it amounts to: *almost 7 times Spain's 2019 GDP!*. Therefore, we explore a very fast transition...

A front-loaded transition

A front-loaded transition can be implemented, starting in 2019, following five simple principles:

1. all retirees remain in the PAYG system.

2. all the working-age population enters into the Backpack system, as well as those above the minimum retirement age who are still working in 2019.

3. those in the PAYG system receive their retirement benefits, as in the PAYG economy going through the demographic transition.

4. those that enter the Backpack system in year t receive an initial amount of backpack assets $b_{t,h,j,}(a) \geq 0$ that makes them (just) weakly prefer entering the Backpack system than to remain in the PAYG system; in particular, at $t \geq 2019$ those with $j = 20$ receive $b_{t,h,j,}(a) = 0$, and in 2019 those working with $j \geq$ minimum retirement age, receive $b_{t,h,j,}(a) > 0$ as to make them (weakly) prefer the BP to their PAYG pension retirement.

5. the initial backpack assets in 2019, as well as all PAYG pensions (from 2019 until the year the last retiree with PAYG claims dies) are financed with public debt.

As Figure 4 shows, in our calibrated Spanish economy, the initial level of debt – financing the initial backpack asset transfers – increases the level of public debt by 100% of GDP[24] and the payment of PAYG pensions in the following years increases this level of debt until it reaches circa 200% at the end of the 2050s, when PAYG claims disappear. A high level of debt, but only 28.5% of what would had been with the above slow transition. Figure 4 also shows how the payroll tax is not affected by the demographic transition and how – accounting for the additional 21% backpack tax – the total payroll tax is at least twenty points less than in the PAYG economy by the end of the demographic transition. The figure also shows how the share of employed increases – and of retirees decreases – in the BP economy with respect to the PAYG economy.

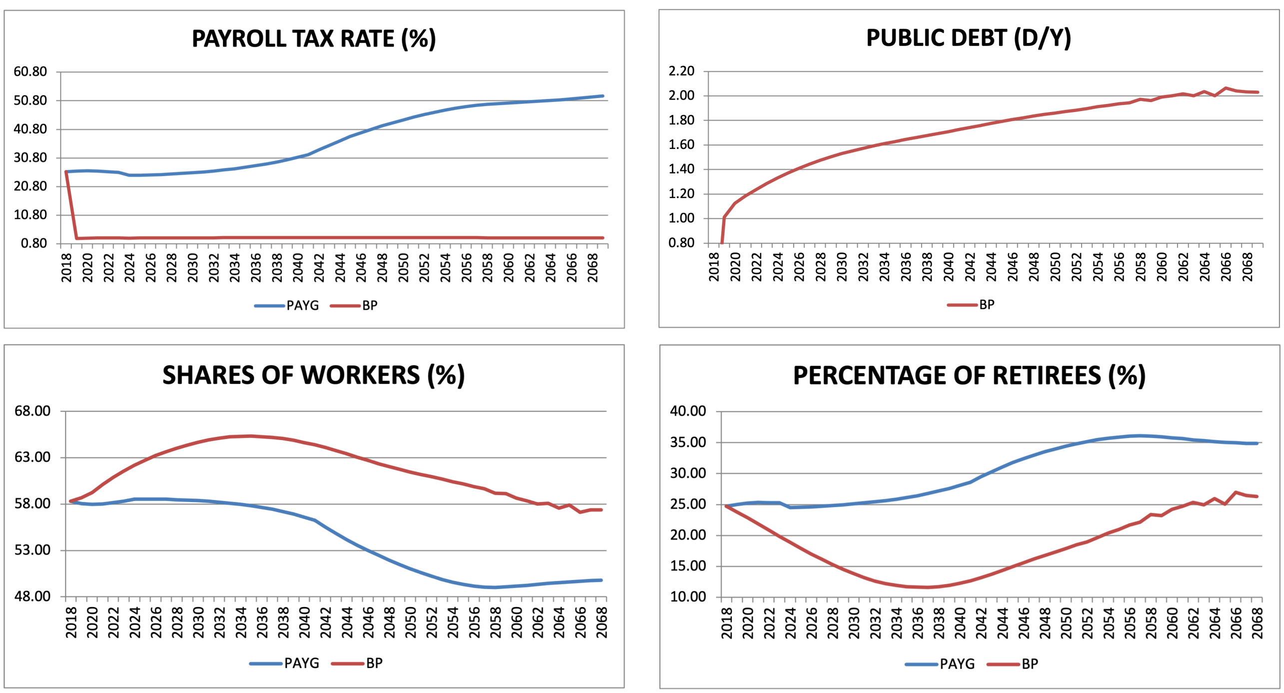

Figure 4: Payroll taxes, public debt and employment in the front-loaded transition PAYG to BP.

Figure 5 shows the transitional gains on output, capital and labour, as well as the increase in the wage rate. These, and related, gains together with the initial backpack transfers support the transition. Regarding the welfare gains, by construction all those who enter the Backpack system are better or equal as they would have been in the PAYG, with increasing welfare gains as cohorts reach, in the second half of the 21st Century, the steady-state welfare gains of Table 17.

[24] Note that we have not included the existing level of debt, which in 2019 was 95.5% of GDP (AMECO) and, consistently, we have excluded debt payments from government expenditures, as well as the corresponding taxes. That is, starting the reform requires doubling the level of public debt of Spain in 2019.

These are the gains that can make the reform to be a Pareto improvement – i.e. without losers – and robust to other specifications – such as, having to pay interest on public debt or having less positive general equilibrium effects. In the current simulation, the reform is almost but not a full Pareto improvement, since PAYG retirees, while they receive their full pension, they also face higher consumption taxes and their accumulated private savings have lower returns, due to the reduction of interest rates. However, there is fiscal capacity to compensate the losses of the PAYG retirees and implement a Pareto improving reform of the social security system.

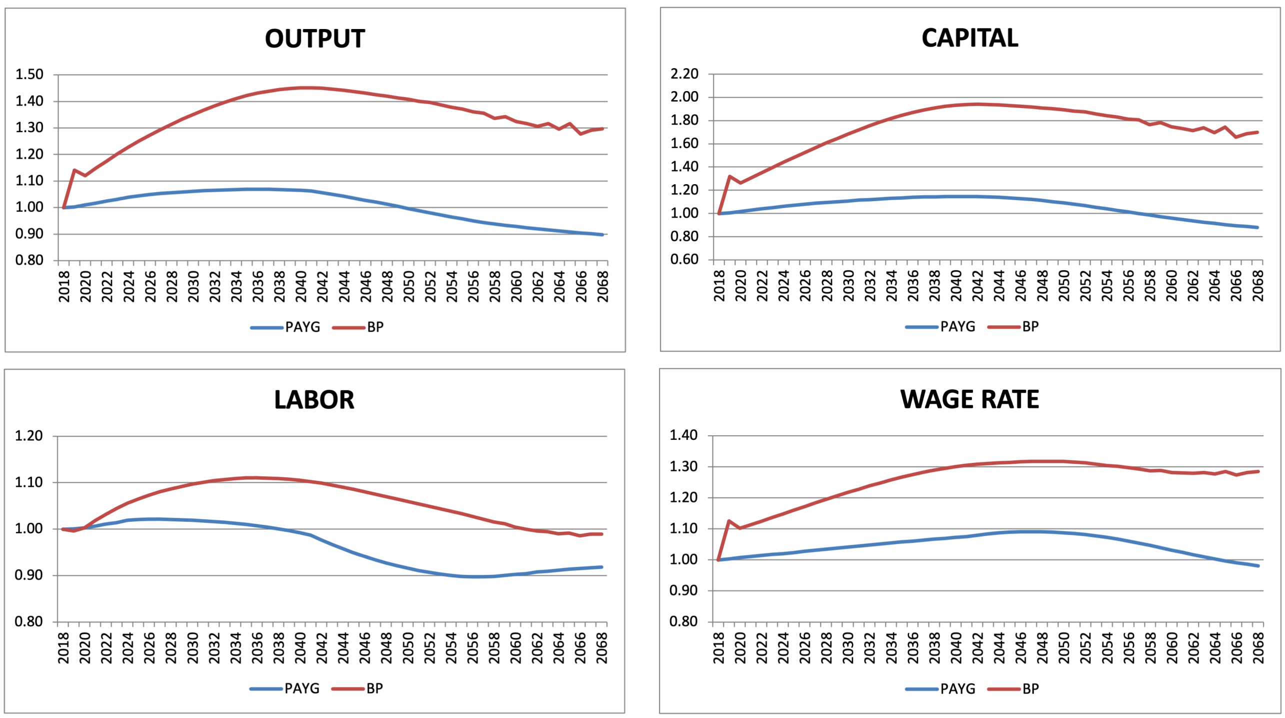

Figure 5: Output, capital, labour and wage rate in the front-loaded transition PAYG to BP.

Note that we could also front-load the PAYG liabilities by transforming the pensions of the retirees in 2019 into BP annuities, which it can be done at-par (i.e. give a retiree with education h backpack assets b, such that $p^B(b) = p^S_h$). Debt in 2019 would jump (to circa 2.00?), but capital would also increase and, therefore, wages and interest rates would change too. One could also increase the annuity to guarantee that retirees are not worst off in the BP system with a conditional annuity that accounts for their private assets, which have lower returns, and the fact that consumption taxes are higher (i.e. $p^B(b, a) \geq p^S_h$).

7 Conclusions

We have shown that there can be important allocative and welfare gains in introducing a backpack system in an economy with a pay-as-you-go pension system and unemployment insurance. The main mechanism behind these gains is to have a fully funded pension system in a aged population, with partial substitution of private savings by backpack savings (exempt from income taxation), while total savings and capital increase; as a result, interest rates decrease, while wages increase and effective labour taxes are seventeen points lower. Associated with this change there is a better allocation of employment, with higher share of employed – in particular, a higher percentage of high productive agents within the employed – and a lower share of inactive and retirees . Effectively, there is a more efficient allocation of savings in the economy, with a shift from pure transfers – to the unemployed and retirees – to savings and, therefore, investment in productive capital. Unemployed are better off due to the prospect of higher wages, and retirees are better off since in our economy pension benefits are linked to productivity, which is higher in the BP economy.

The final result is that a substantial Pareto improvement can be achieved by replacing the PAYG system with the BP. The BP steady-state also dominates the simple elimination of the PAYG, letting agents freely choose their savings for retirement; i.e. the Private Savings (PS) economy. In comparing the two, the PS has a lower effective labour tax, but all the savings are part of the taxable income and retirement income is not insured. Wealth is also higher than in an economy with a fully funded pension fund (FF), since agents can better manage their savings as to insure not only their retirement, but also their unemployment spells beyond what the existing unemployment insurance provides. To our knowledge, we have been the first to analyse general equilibrium employment effects in comparing alternative social security systems, among them the Backpack.

The immediate question that our results suggest is how to implement a Pareto improving transition – i.e. no losers in all generations involved– from the current PAYG to the steady-state BP. This would already be challenging in the Spanish economy, where pension payments are more than 10% of GDP and the dependency is 31%, if this ratio were to be the same in the decades to come, but it is even more difficult when the country faces a demographic transition in the first half of the 21st Century where the dependency ratio for the PAYG system doubles to 60%; i.e. from 3.2 workers per retiree to 1.6. Nevertheless, we show how a transition can be based in two elements. First, and foremost, the large welfare gains that the reform can achieve in the long-run once it has been implemented (60% in average CEV). This suggest the second element, which is how to finance the transition: with public debt; particularly, when the Spanish government (with the ECB holding more than 20% of its sovereign debt) is borrowing at close to zero interest rates.

However, a well designed transition must avoid over-borrowing, which will happen if the transition is slow and coincides with the demographic transition. To avoid this, we design a front-loaded transition, in which – with backpack asset transfers – the current labour force is better off with the Backpack system, rather than in the PAYG. This reduces the PAYG liabilities to the pensions of the current retirees. We show that such reform can be a Pareto improving transition – i.e. without losers – that minimizes the amount of debt needed to finance the transition. In our calibrated Spanish economy, the amount of financing debt is still large (100% of GDP in the first year, which becomes 200% at the end of the transition) but substantially lower than in the slow transition (circa one-fourth) and it is sustainable with reasonable low interest rates (our benchmark is zero interest rate).

In sum, further robustness analysis are needed (e.g. accounting for interest rate payments, considering Spain as an open economy, less contingent backpack asset transfers), but at least five things are clear from our analysis: *i*) the new quantitative estimates of the, already known, long-term cost of maintaining the PAYG system with an ageing population, in contrast to replacing it with a fully funded system; *ii*) the dominant features of the Backpack system with respect to other fully funded systems; *iii*) how in an environment of low interest rates, debt financing can be an efficient way to finance a Pareto improving transition from the PAYG to the BP; *iv*) that an effective reform calls for a fast, possibly front-loaded, transition ahead of the demographic transition, and *v*) a Backpack reform, as the one here proposed, may well be one of the best legacies that can be made to the *Next Generation*, particularly if it is generalized to the EU, since it will also improve the transferability of social insurance benefits across the Single Market.

Appendices

A Detailed description of model economies

A.1 Backpack economy: individual decision problem

In this subsection we present the model equations that describe the BP economy. An individual who is currently employed solves the following optimization problem:

$$W(j,h,z,a,b) = \max_{c,l,a'} \left\{ u(c,l)+\beta\psi_j \sum_{z'\in Z} \Gamma(z'|z) \Big[(1-\sigma_j) J(j+1,h,z',a',b') + \sigma_j U(j+1,h,z',a',b',0) \Big] \right\} \tag{36}$$

subject to:

$$(1+\tau_c)c + a' + \tau_y \hat{y} + (\tau_p + \tau_b) y \leq (1 + r(1-\tau_k))a + y + TR(y), \tag{37}$$

the backpack law of motion,

$$b' = \tau_b y + (1 + r(1-\tau_k))b, \tag{38}$$

and a no-borrowing constraint:

$$a' \geq 0. \tag{39}$$

Gross labor income is $y = \omega \epsilon z l$, $l \in [0,1]$, income tax base $\hat{y} = (1-\tau_p-\tau_b)y + r(1-\tau_k)a$ and government transfers for low income households are denoted by $TR(y) = t_r \mathbb{1}_{TR}(y)$, where $\mathbb{1}_{TR}(y) = 1$ if $y < \bar{t_r}$ and zero otherwise. z' evolves according to the Markov process Γ.

An agent who has been separated from a job and hasn't restarted work yet solves the following problem:

$$\begin{aligned} &U(j,h,z,a,b,d) = \\ &= \max_{c,a',b',e} \Bigg\{ u(c) - \gamma e + \\ &\qquad \beta\psi_j \sum_{z' \in Z} \Gamma(z'|z) \Big[e\Big(\lambda_j^{\mathbf{u}} J(j+1,h,z',a',b',d+1) + (1-\lambda_j^{\mathbf{u}}) U(j+1,h,z',a',b',d+1)\Big) \\ &\qquad\qquad + (1-e)\Big(\lambda_j^{\mathbf{n}} J(j+1,h,z',a',b',d+1) + (1-\lambda_j^{\mathbf{n}}) N(j+1,h,z',a',b')\Big)\Big] \Bigg\} \end{aligned} \tag{40}$$

subject to

$$(1+\tau_c)c + a' + b' + \tau_y \hat{y} \leq (1 + r(1-\tau_k))(a+b) + UB(d,e) + TR(y), \tag{41}$$

and

$$e \in \{0,1\}, \tag{42}$$

$$a' \geq 0, \tag{43}$$

$$b' \leq (1 + r(1-\tau_k))b. \tag{44}$$

The income tax base is given by $\hat{y} = r(1-\tau_k)a$. The unemployed worker may be entitled to unemployment benefits: $UB(d,e) = u_b \mathbb{1}_{UB}(d,e)$, with $\mathbb{1}_{UB}(d,e) = 1$ indicating eligibility for unemployment benefits. Formally:

$$\mathbb{1}_{UB}(d,e) = \begin{cases} 1 & \text{if } e = 1 \text{ and } d \leq \bar{d}, \\ 0 & \text{otherwise.} \end{cases} \tag{45}$$

The state variable d evolves deterministically according to $d' = d + 1$ if the worker continues unemployed in the following period, and $d = 0$ in the period immediately after a separation shock.

Finally, an agent may start the period without a job because he has previously decided not to work and has not started a new job yet. In this case, he solves the following problem:

$$N(j,h,z,a,b) = \max_{c,a',e}\Bigg\{u(c) - \gamma e + \beta\psi_j \sum_{z'\in Z}\Gamma(z'|z)\Big[e\Big(\lambda_j^{\mathbf{u}} J(j+1,h,z',a',b') + (1-\lambda_j^{\mathbf{u}})N(j+1,h,z',a',b')\Big) + (1-e)\Big(\lambda_j^{\mathbf{n}} J(j+1,h,z',a',b') + (1-\lambda_j^{\mathbf{n}})N(j+1,h,z',a',b')\Big)\Big]\Bigg\}, \tag{46}$$

subject to

$$(1+\tau_c)c + a' + \tau_y \hat{y} \leq (1 + r(1-\tau_k))a + TR(y), \tag{47}$$

and

$$a' \geq 0, \tag{48}$$

$$b' = (1 + r(1-\tau_k))b. \tag{49}$$

As before, $\hat{y} = r(1-\tau_k)a$. In this case the non-employed worker is not eligible for unemployment benefits, and he also cannot use backpack assets.

We consider now the the problem of the retiree after the retirement decision.

$$V(j,h,a,b) = \max_{c,a'}\Bigg\{u(c) + \beta\psi_j\Big[V(j+1,h,a',b)\Big]\Bigg\}, \tag{50}$$

subject to

$$(1+\tau_c)c + a' + \tau_y \hat{y} \leq (1 + r(1-\tau_k))a + p^B(b) + TR(y). \tag{51}$$

Pension payments are part of the income tax base: $\hat{y} = r(1-\tau_k)a + p^B(b)$. After retirement, labor market productivity is always zero and hence expectations take into account only the survival risk.

To close the description of the household's problem, we define the job acceptance and retirement decisions. These jointly pin down the value of having a job offer at the beginning of a period:

$$J(j,h,z,a,b,d) = \max\Big\{V(j,h,a,b), \max\{W(j,h,z,a,b), N(j,h,z,a,b)\}\Big\}. \tag{52}$$

The outermost max operator represents the retirement decision, while the inner operator is the job acceptance decision.

A.2 Fully Funded pensions economy: individual decision problem

In this subsection we present the model equations that describe the economy with a fully funded (defined contribution) pension scheme. Current worker pension claims are denoted by m. An individual who is currently employed solves the following optimization problem:

$$W(j,h,z,a,m) = \max_{c,l,a'} \left\{ u(c,l) + \beta\psi_j \sum_{z' \in Z} \Gamma(z'|z) \Big[(1-\sigma_j) J(j+1,h,z',a',m') + \sigma_j U(j+1,h,z',a',m',0) \Big] \right\} \tag{53}$$

subject to:

$$(1+\tau_c)c + a' + \tau_y \hat{y} + (\tau_p + \tau_b)y \leq (1 + r(1-\tau_k))a + y + TR(y), \tag{54}$$

and pension claims evolve according to,

$$m' = \tau_f y + (1 + r(1-\tau_k))m. \tag{55}$$

The no-borrowing constraint is:

$$a' \geq 0. \tag{56}$$

Gross labor income is $y = \omega\epsilon z l$, $l \in [0,1]$, income tax base $\hat{y} = (1-\tau_p-\tau_f)y + r(1-\tau_k)a$ and government transfers for low income households are denoted by $TR(y) = t_r \mathbb{1}_{TR}(y)$, where $\mathbb{1}_{TR}(y) = 1$ if $y < \bar{t_r}$ and zero otherwise. z' evolves according to the Markov process Γ.

An agent who has been separated from a job and hasn't restarted work yet solves the following problem:

$$\begin{aligned} &U(j,h,z,a,m,d) = \\ &\quad = \max_{c,a',b',e} \Bigg\{ u(c) - \gamma e + \\ &\qquad \beta\psi_j \sum_{z' \in Z} \Gamma(z'|z) \Big[e\Big(\lambda_j^{\mathbf{u}} J(j+1,h,z',a',m',d+1) + (1-\lambda_j^{\mathbf{u}}) U(j+1,h,z',a',m',d+1)\Big) \\ &\qquad\qquad + (1-e)\Big(\lambda_j^{\mathbf{n}} J(j+1,h,z',a',m',d+1) + (1-\lambda_j^{\mathbf{n}}) N(j+1,h,z',a',m')\Big)\Big] \Bigg\} \end{aligned} \tag{57}$$

subject to

$$(1+\tau_c)c + a' + m' + \tau_y \hat{y} \leq (1 + r(1-\tau_k))(a+m) + UB(d,e) + TR(y), \tag{58}$$

and

$$e \in \{0,1\}, \tag{59}$$

$$a' \geq 0, \tag{60}$$

$$m' \leq (1 + r(1-\tau_k))m. \tag{61}$$

The income tax base is given by $\hat{y} = r(1-\tau_k)a$. The unemployed worker may be entitled to unemployment benefits: $UB(d,e) = u_b \mathbb{1}_{UB}(d,e)$, with $\mathbb{1}_{UB}(d,e) = 1$ indicating eligibility for unemployment benefits. Formally:

$$\mathbb{1}_{UB}(d,e) = \begin{cases} 1 & \text{if } e = 1 \text{ and } d \leq \bar{d}, \\ 0 & \text{otherwise.} \end{cases} \tag{62}$$

The state variable d evolves deterministically according to $d' = d+1$ if the worker continues unemployed in the following period, and $d = 0$ in the period immediately after a separation shock.

Finally, an agent may start the period without a job after he has decided not to work and has not started a new job yet. In this case he solves the following problem:

$$\begin{aligned} &N(j,h,z,a,m) = \\ &\max_{c,a',e} \Bigg\{ u(c) - \gamma e + \beta\psi_j \sum_{z'\in Z} \Gamma(z'|z) \Big[e\Big(\lambda_j^{\mathbf{u}} J(j+1,h,z',a',m') + (1-\lambda_j^{\mathbf{u}}) N(j+1,h,z',a',m')\Big) + \\ &\qquad (1-e)\Big(\lambda_j^{\mathbf{n}} J(j+1,h,z',a',m') + (1-\lambda_j^{\mathbf{n}}) N(j+1,h,z',a',m')\Big)\Big]\Bigg\}, \end{aligned} \tag{63}$$

subject to

$$(1+\tau_c)c + a' + \tau_y \hat{y} \leq (1 + r(1-\tau_k))a + TR(y), \tag{64}$$

and

$$a' \geq 0, \tag{65}$$

$$m' = (1 + r(1-\tau_k))m. \tag{66}$$

As before, $\hat{y} = r(1-\tau_k)a$. In this case the unemployed worker is not eligible for unemployment benefits.

We consider now the the problem of the retiree after the retirement decision, with the final pension claim m.

$$V(j,h,a,m) = \max_{c,a'} \Big\{ u(c) + \beta\psi_j \Big[V(j+1,h,a',m) \Big] \Big\}, \tag{67}$$

subject to

$$(1+\tau_c)c + a' + \tau_y \hat{y} \leq (1 + r(1-\tau_k))a + p^F(m) + TR(y). \tag{68}$$

Pension payments are again part of the income side of the budget constraint: $\hat{y} = r(1-\tau_k)a + p^F(m)$. After retirement, labor market productivity is always zero and hence expectations take into account only the survival risk.

To close the description of the household's problem, we define the job acceptance and retirement decisions. These jointly pin down the value of having a job offer at the beginning of a period:

$$J(j,h,z,a,m,d) = \max\Big\{V(j,h,a,m), \max\{W(j,h,z,a,m), U(j,h,z,a,b,m)\}\Big\}. \tag{69}$$

The outermost max operator represents the retirement decision, while the inner operator is the job acceptance decision.

A.3 Baseline and PAYG economy: individual decision problem

In the Baseline and PAYG economies workers have access to a PAYG pension system. Therefore the state vector does not include variable recording pension claims. Workers solve the following optimization problem:

$$W(j,h,z,a) = \max_{c,l,a'} \left\{ u(c,l) + \beta\psi_j \sum_{z'\in Z} \Gamma(z'|z)\Big[(1-\sigma_j)J(j+1,h,z',a') + \sigma_j U(j+1,h,z',a',0)\Big] \right\} \tag{70}$$

subject to:

$$(1+\tau_c)c + a' + \tau_y \hat{y} + \tau_p y \leq (1 + r(1-\tau_k))a + y + TR(y), \tag{71}$$

and a no-borrowing constraint:

$$a' \geq 0. \tag{72}$$

An unemployed worker solves the following problem:

$$\begin{aligned} U(j,h,z,a,d) &= \\ &= \max_{c,a',e} \Bigg\{ u(c) - \gamma e + \\ &\qquad \beta\psi_j \sum_{z'\in Z} \Gamma(z'|z)\Big[e\Big(\lambda_j^{\mathbf{u}} J(j+1,h,z',a',d+1) + (1-\lambda_j^{\mathbf{u}})U(j+1,h,z',a',d+1)\Big) \\ &\qquad\qquad + (1-e)\Big(\lambda_j^{\mathbf{n}} J(j+1,h,z',a',d+1) + (1-\lambda_j^{\mathbf{n}})N(j+1,h,z',a')\Big)\Big]\Bigg\} \end{aligned} \tag{73}$$

subject to

$$(1+\tau_c)c + a' + \tau_y \hat{y} \leq (1 + r(1-\tau_k))a + UB(d,e) + TR(y), \tag{74}$$

and

$$e \in \{0,1\}, \tag{75}$$

$$a' \geq 0. \tag{76}$$

An agent who starts the period without a job, after having quit a job before solves the following problem:

$$N(j,h,z,a) = \max_{c,a',e}\Bigg\{u(c) - \gamma e + \beta\psi_j \sum_{z'\in Z}\Gamma(z'|z)\Big[e\Big(\lambda_j^{\mathbf{u}} J(j+1,h,z',a') + (1-\lambda_j^{\mathbf{u}})N(j+1,h,z',a')\Big) + (1-e)\Big(\lambda_j^{\mathbf{n}} J(j+1,h,z',a') + (1-\lambda_j^{\mathbf{n}})N(j+1,h,z',a')\Big)\Big]\Bigg\}, \tag{77}$$

subject to

$$(1+\tau_c)c + a' + \tau_y \hat{y} \leq (1 + r(1-\tau_k))a + TR(y), \tag{78}$$

and

$$a' \geq 0. \tag{79}$$

A retiree with age j, education level h and private savings a solves the following problem:

$$V(j,h,a) = \max_{c,a'}\Bigg\{u(c) + \beta\psi_j\Big[V(j+1,h,a')\Big]\Bigg\}, \tag{80}$$

subject to

$$(1+\tau_c)c + a' + \tau_y \hat{y} \leq (1 + r(1-\tau_k))a + p_h + TR(y). \tag{81}$$

Pension payments p_h depend on education level h and are part of the income side of the budget constraint. In this case, $\hat{y} = r(1-\tau_k)a + p_h$. After retirement, labor market productivity is always zero and hence expectations take into account only the survival risk.

Pension payments depend on the education level and on the average of labor market earnings in group h during the N_b years prior to the first retirement age R_0, the minimum statutory retirement age. Specifically, pension payments are given by:

$$p_h = p_r \bar{y}_h = p_r \frac{1}{N_b}\sum_{i=j-N_b}^{j-1} \bar{y}_{j,h}. \tag{82}$$

To close the description of the household's problem, we define the job acceptance and retirement decisions. These jointly pin down the value of having a job offer at the beginning of a period:

$$J(j,h,z,a,d) = \max\Big\{V(j,h,a), \max\{W(j,h,z,a), U(j,h,z,a,d)\}\Big\}. \tag{83}$$

The outermost max operator represents the retirement decision, while the inner operator is the job acceptance decision.

A.4 Private Savings economy: individual decision problem

The description of the decision problems in the PS economy is as in the previous subsection, but with $p_h = 0$ for all h.

B Definition of a stationary equilibrium in the BP economy

Let $j \in J$, $h \in H$, $z \in \mathcal{Z}$, $l \in \mathcal{L}$, $d \in \mathcal{D}$, $a \in A$, and $b \in B$ and let $\mu_{j,h,z,l,d,a,b}$ be a probability measure defined on $\Re = J \times H \times \mathcal{Z} \times \mathcal{L} \times \mathcal{D} \times A \times B$.[25] Then, a stationary competitive equilibrium for this economy is a government policy, $\{G, P, T_r, U, T_k, T_s, T_y, T_c, E\}$, a household policy, $\{c(j,h,z,d,a,b)$, $l(j,h,z,d,a,b)$, $s(j,h,z,d,a,b)$, $r(j,h,z,d,a,b)$, $a^{'}(j,h,z,d,a,b)$, $b^{'}(j,h,z,d,a,b)\}$, a measure, μ, factor prices, $\{r, w\}$, macroeconomic aggregates, $\{C, Y, K, L\}$, and a function, Q, such that:

(i) The government policy satisfy the consolidated government described in Expressions (8)-(9).

(ii) Firms behave as competitive maximizers. That is, their decisions imply that factor prices are factor marginal productivities $r = f_1(K, AL) - \delta$ and $\omega = f_2(K, AL)$.

(iii) Given the government policy, and factor prices, the household policy solves the households' decision problem defined in Expressions (13), through (**??**).

(iv) The stock of capital, consumption, the aggregate labor input, pension payments, unemployment benefit payments, lump-sum transfers, tax revenues, and accidental bequests are

[25] For convenience, whenever we integrate the measure of households over some dimension, we drop the corresponding subscript.

obtained aggregating over the model economy households as follows:

$$\begin{aligned}
K &= \int a + b \, d\mu \\
C &= \int c \, d\mu \\
L &= \int \epsilon_{jh} z l \, d\mu \\
U &= \int ub \, d\mu \\
T_r &= \int t_r \, d\mu \\
T_c &= \int \tau_c c \, d\mu \\
T_k &= \int \tau_k r a \, d\mu \\
T_p &= \int \tau_p y \, d\mu \\
T_y &= \int \tau_y \hat{y} \, d\mu \\
E &= \int (1 - \psi_j)(1 + r) a' \, d\mu
\end{aligned}$$

where all the integrals are defined over the state space $\Re$.

(vi) The goods market clears:

$$C + \int (a' + b' - (1 - \delta)(a + b)) d\mu + G = F(K, AL). \tag{84}$$

(vii) The law of motion for μ_j is:

$$\mu_{j+1} = \int_{\Re} Q d\mu_j. \tag{85}$$

Describing function Q formally is complicated because it specifies the transitions of the measure of households along its five dimensions: age, education level, productivity, employment status, and assets holdings. An informal description of this function is the following: We assume that new-entrants, who are 20 years old, enter to the economy as workers, unemployed, or inactive, following the shares of these groups for the 20-24 cohort in the Spanish economy in 2018, and that they own zero assets. Moreover, workers enter the economy with a job opportunity, that they draw the stochastic component of their endowment of efficiency labor units from its invariant distribution. Their educational shares are exogenous. The evolution of μ_{jh} is exogenous, it replicates the the distribution by age and education of the Spanish population in our calibration target year, 2018. The evolution of μ_z is governed by the conditional transition probability matrix of its stochastic component. The evolution of μ_l, is governed by the exogenous probabilities of find/loss a job, by the endogenous employment and search decisions, and by the optimal decision to retire. The evolution of μ_a is determined by the optimal savings decision and by the changes in the population. The evolution of μ_b is determined by the backpack law of motion. The evolution of μ_d is given by the deterministic evolution of unemployment spell duration.

C Calibration

C.1 Initialising the steady-state

In order to determine the steady-state, first we choose as an initial distribution of households $\mu_0 = \mu_{2018}$; that is, we take μ_{jh} at year 2018 directly from the Encuesta de Población Activa from the Spanish National Institute of Statistics. We also take from INE the conditional probabilities of surviving from age j to age $j+1$, ψ_j, at that same year. The labor market flow data used to calibrate the job finding and job destruction probabilities were provided by Lalé and Tarasonis (2017). The initial distribution of households imply an initial value for the capital stock. This value is $K_{2014} = 6.6037$. The initial distribution of households and the initial survival probabilities determine the initial value of unintentional bequests, E_{2018}. Finally, we must also specify the initial values for the productivity process, A_{2018}. Since A_{2018} determines the units which we use to measure output and does nothing else, we choose $A_{2018} = 1.0$.

C.2 Parameters

Once the initial conditions are specified, to characterize our model economy fully, we must choose the values of a total of 41 parameters. Of these 41 parameters, 5 describe the household preferences[26] 21 the process on the endowment of efficiency labor units, 2 the production technology, 5 the pension system rules, and 8 the remaining components of the government policy. To choose the values of these 41 parameters we need 41 equations or calibration targets which we describe below.

C.3 Equations

To determine the values of the 41 parameters that identify our model economy, we do the following. First, we determine the values of a group of 21 parameters directly using equations that involve either one parameter only, or one parameter and our guesses for (K, L). To determine the values of the remaining 20 parameters we construct a system of 20 non-linear equations. Most of these equations require that various statistics in our model economy replicate the values of the corresponding Spanish statistics in 2018. We describe the determination of both sets of parameters in

[26] The functional form for the utility function is $u(c,l) = \frac{c^{(1-\sigma}}{1-\sigma} - \alpha \frac{l^{1+1/\varphi}}{1+1/\varphi}$

the subsections below.

C.3.1 Parameters determined solving single equations

The life-cycle profile of earnings. We measure the deterministic component of the process on the endowment of efficiency labor units independently of the rest of the model. We estimate the values of the parameters of the three quadratic functions that we describe in Expression (86), using the age and educational distributions of hourly wages reported by the *Instituto Nacional de Estadística* (INE) in the *Encuesta de Estructura Salarial* (2010) for Spain.[27] This procedure allows us to identify the values of 9 parameters directly.

$$\epsilon_{jh} = \xi_{1h} + \xi_{2h} j - \xi_{3h} j^2 \tag{86}$$

The pension system. In 2018 in Spain, the payroll tax rate paid by households was 28.3 percent and it was levied only on the first 45,014 euros of annual gross labor income. Since we omit the tax cap, we impose that all gross earnings pay pension contributions. We also impose that payroll tax collections are used to finance both pension payments and unemployment benefits. This implies that the payroll tax rate in our model economy is 0.2474.

Our choice for the number of years used to compute the retirement pensions in our benchmark model economy is $N_b = 21$. This is because in 2018 the Spanish *Régimen General de la Seguridad Social* took into account the last 21 years of contributions prior to retirement to compute the pension. Finally, our choice for the first retirement ages is $R_0 = 61$.

Government policy. To specify the government policy, we must choose the values of government consumption, G_t, the share of accidental bequest that is confiscated by the government, E, of the tax rate on capital income, τ_k, of the tax rate on income, τ_y, and of the tax rate on consumption, τ_c.

We target the output shares of G, E, T_k, and T_y so that they replicate the GDP shares of Government Consumption, Inheritance Taxes, Corportate Profit Taxes, and Individual Income taxes. According to the INE, in 2018, Government Consumption was 208,875 million euros, and the Inheritance Tax, Corportate Profit Tax and the Individual Income tax collected 2,687, 29,711 and 93.247 million euros, respectively.[28] Consequently, the ratios of these variables to GDP at market prices are 17.40, 0.20, 2.24, and 7.05 percent. Finally, the government budget is an additional equation that allows us to obtain residually the consumption tax rate.

[27] Since we only have data until age 64, we estimate the quadratic functions for workers in the 20–64 age cohort and we project the resulting functions from age 65 onwards.

[28] We exclude from Government Consumption the expenditure in Subsidies and Investment Aid.

Table 21: Parameters determined solving single equations

	Parameter	Value
Parameters determined directly		
Earnings Life-Cycle		
	$\xi_{1,1}$	0.9189
	$\xi_{1,2}$	0.8826
	$\xi_{1,3}$	0.5064
	$\xi_{2,1}$	0.0419
	$\xi_{2,2}$	0.0674
	$\xi_{2,3}$	0.1648
	$\xi_{3,1}$	0.0006
	$\xi_{3,2}$	0.0008
	$\xi_{3,3}$	0.0021
Preferences		
Curvature	σ	2.0000
Labor elasticity	φ	0.1000
Technology		
Capital share	θ	0.4846
Public Pension System		
Number of years of contributions	N_b	21
First retirement age	R_0	62
Parameters determined by guesses for (K, L)		
Public Pension System		
Payroll Tax Rate	τ_p	0.2597
Government Policy		
Government consumption	G	0.3894
Capital income tax rate	τ_k	0.1188
Consumption tax rate	τ_c	0.2064
Income tax Rate	τ_y	0.1128

Preferences. Of the four parameters in the utility function, we choose the value of σ and φ directly. Specifically, we choose $\sigma = 2.0$ and $\varphi = 0.1$.

Technology. According to the Spanish National Institute of Statistics data (INE), the capital income share in Spanish GDP was 0.4846 in 2018. Consequently, we choose $\theta = 0.4846$. We also assume that the labor augmenting productivity growth rate is $g = 0$, in line with the recent behavior of labor productivity growth in Spain.

Adding up. So far we have determined the values of 21 parameters either directly or as functions of our guesses for (K, L) only. We report their values in Table 21.

C.3.2 Parameters determined solving a system of equations

We still have to determine the values of 20 parameters. To find the values of those 20 parameters we need 20 equations. Of those equations, 15 require that model economy statistics replicate the value of the corresponding statistics for the Spanish economy in 2018, and 5 are normalization conditions.

Table 22: Macroeconomic Aggregates and Ratios in 2014 (%)

	C/Y^{*a}	P/Y^*	U/Y^{*b}	T_r	K/Y^{*c}	W^d	I^e
Spain	54.35	10.47	1.32	0.83	2.94	59.59	5.16

[a]Variable Y^* denotes GDP at market prices.
[b]The ratio U/Y^* is the Unemployment benefits as a share of Output at market prices.
[c]The target for K/Y^* is in model units and not in percentage terms.
[d]Variable W is the share of workers in the Spanish population with 20+ years old.
[e]Variable I is the share of inactive in the Spanish population with 20+ years old.

Aggregate Targets. According to the BBVA database, in 2016 the value of the Spanish capital stock was 3,281,631 million euros.[29] According to the *Instituto Nacional de Estadística* (INE) in 2016 the Spanish Gross Domestic Product at market prices was 1,113,840 million euros. Dividing these two numbers, we obtain $K/Y = 2.94$, which is our target value for the model economy capital to output ratio.

According to the INE, Private Consumption plus indirect taxes was 654,574 million euros in 2018, and unemployment benefits amounted 17,469 million. That same year, and according to the Spanish Instituto Nacional de la Seguridad Social, pension payments were 125,899 million euros. Finally, and according to Ayala Cañon (2016), the sum of different subsidies aimed to protect those people

[29]This number can be found at *http://www.fbbva.es/TLFU/microsites/stock09/fbbva_stock08_index.html*.

who do not receive any public benefit amounted 8,976 million euros in 2015.[30] Consequently, the ratios of these variables to GDP at market prices are 54.35, 1.32, 10.47 and 0.83 percent.

Finally, and according to the Encuesta de Población Activa (INE), in Spain in 2018 there were 32,433,800 people aged 20+ years old.[31] That same survey reports that 19,327,700 were workers and 3,479,100 were unemployed. Consequently, these numbers imply that the share of workers was 59.59 percent and the share of unemployed were 10.72 percent.

Distributional Targets. We target the 3 Gini indexes and 5 points of the Lorenz curves of the Spanish distributions of earnings, income and wealth. We have taken these statistics from the Spanish National Institute of Statistics (INE), the OECD, and Budría and Díaz-Giménez (2006), and we report them in bold face in Table 23. Castañeda et al. (2003) argue in favor of this calibration procedure to replicate the inequality reported in the data. These targets give us a total of 8 additional equations.

Table 23: The Distributions of Earnings, Income, and Wealth*

		Bottom	Quintiles					Top
	Gini	10	1st	2nd	3rd	4th	5th	10
The Earnings Distributions (%)								
Spain	**0.34**	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
The Income Distributions (%)								
Spain	**0.33**	2.1	**6.3**	**12.1**	17.2	23.7	**40.7**	25.0
The Wealth Distributions (%)								
Spain	**0.57**	0.0	**0.9**	6.6	12.5	20.6	**59.5**	42.5

*The source for the Spanish data of earnings and income are the Spanish National Institute of Statistics (INE) and the OECD. The source for the Spanish data of wealth is the 2004 *Encuesta Financiera de las Familias Españolas* as reported in Budría and Díaz-Giménez (2006).

Normalization conditions. In our model economy there are 5 normalization conditions. The transition probability matrix on the stochastic component of the endowment of efficiency labor units process is a Markov matrix and therefore its rows must add up to one. This gives us three normalization conditions. We also normalize the first realization of this process to be $z(1)=1$. Finally, we impose that the replacement rate, as a share of per capita output, of public transfers is 0.71. This number is the ratio between public transfers as a percentage of GDP per capita, and the maximum income available to access them, also as a percentage of GDP per capita.

[30] These types of subsidies were the minimum income program, the agricultural and income programs, the Active Insertion Income, the temporary program of protection for unemployment and insertion, and the Activation Program for Employment.

[31] We exclude students and people who do household chores.

The Parameters. The 15 parameters determined by the system are the following:

- Preferences: β, α, and γ.
- Technology: δ.
- Stochastic process for labor productivity: $z(2), z(3), z_{11}, z_{12}, z_{21}, z_{22}, z_{32}$, and z_{33}.
- Pension system: p_r.
- Fiscal policy: b_0, and $\overline{t_r}$.

C.3.3 Methodology

To solve this system of equations we use a standard non-linear equation solver. Specifically, we use a modification of Powell's hybrid method, implemented in subroutine DNSQ from the SLATEC package.

The DNSQ routine works as follows

1. Choose the weights that define the loss function that has to be minimized
2. Choose a vector of initial values for the 14 unknown parameters
3. Solve the model economy
4. Update the vector of parameters
5. Iterate until no further improvements of the loss function can be found.

Table 24 provides the parameter values of our calibration and of their accuracy.

Table 24: Initial Values, Final Values, Weights, and Errors.

Parameter	Initial Value	Final Value	Statistic	Weight (%)	Target	Result	Error (%)
β	0.9950	0.9915	K/Y^*	300	2.94	2.94	0.00
α	28×10^4	28×10^4	W (%)	800	59.59	58.31	–2.15
γ	1.0353	1.2812	I (%)	800	5.16	5.30	2.71
δ	0.0860	0.0858	$(C + T_c)/Y^*$ (%)	50	54.35	50.99	–6.19
ϕ	0.6657	0.7650	P/Y^* (%)	300	10.47	10.49	0.19
$\overline{t_r}$	0.0591	0.0700	T_r/Y^* (%)	30	0.83	0.83	0.00
b_0	0.2200	0.3518	U/Y^* (%)	300	1.32	1.18	–10.61
$z(2)$	2.5082	2.3490	GY	800	0.33	0.37	12.12
$z(3)$	7.0000	5.9042	GE	800	0.34	0.33	–2.95
z_{11}	0.9908	0.9821	1QY (%)	50	6.30	6.20	–1.59
z_{12}	0.0091	0.0177	4QW (%)	1	20.60	22.72	10.29
z_{21}	0.0303	0.0291	2QW (%)	1	6.60	4.84	–26.67
z_{22}	0.9696	0.9708	5QY (%)	50	40.70	44.02	8.10
z_{32}	0.0001	0.0003	2QY (%)	50	12.10	11.91	–1.58
z_{33}	0.9998	0.9996	GW	800	0.57	0.60	5.26

C.4 Calibration results

Table 25: The Distributions of Earnings, Income, and Wealth*

		Bottom	Quintiles					Top
	Gini	10	1st	2nd	3rd	4th	5th	10
The Earnings Distributions (%)								
Spain	**0.34**	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Model	0.33	3.7	8.5	11.4	15.7	23.5	40.9	26.0
The Income Distributions (%)								
Spain	**0.33**	2.1	**6.3**	**12.1**	17.2	23.7	**40.7**	25.0
Model	0.37	2.1	6.2	11.9	15.2	22.6	44.0	27.9
The Wealth Distributions (%)								
Spain	**0.57**	0.0	0.9	**6.6**	12.5	**20.6**	59.5	42.5
Model	0.60	0.0	0.9	4.8	10.4	22.7	61.2	40.7

*The source for the Spanish data of earnings and income are the Spanish National Institute of Statistics (INE) and the OECD. The source for the Spanish data of wealth is the 2004 *Encuesta Financiera de las Familias Españolas* as reported in Budría and Díaz-Giménez (2006).

D The Spanish Social Security

The Spanish contributory pension system, is the most important program of social protection in Spain, where public contributory pensions are provided by the following three programs. First, the *Régimen General de la Seguridad Social* covers the private sector employees and the members of cooperative firms and the employees of most public administrations other than the central governments. Second, the *Regímenes Especiales de la Seguridad Social* cover the self-employed workers and professionals.[32] And third, the scheme for government employees, or *Régimen de Clases Pasivas* covers public servants employed by the central government and its local branches.

In this article we focus exclusively on the retirement pensions payed by the *Régimen General de la Seguridad Social*. Consequently, this section describes the key features of this system and its 2011 and 2013 reforms.

Financing and elegibility. The Régimen General de la Seguridad Social is a mandatory pay-as-you-go scheme. The payroll tax rate is proportional to covered earnings, which are defined as total earnings, excluding payments for overtime work, between a floor and a ceiling that vary by broadly defined professional categories. The payroll tax rate is 28.3 percent, of which 23.6 percent is attributed to the employer and the remaining 4.7 percent to the employee.

Entitlement to an old-age pension requires at least 15 years of contributions. The retirement age that entitles workers to receive a full retirement pension is 65 for workers who have contributed at least 36 years and three months. Previous to the 2011 Pension reform, every worker aged 61 or older could retire earlier paying an early retirement penalty, as long as they had contributed to the pension system for at least 30 years. Exceptionally, workers who had entered the system before 1967 could retire at age 60. The 2011 Reform of the Spanish pension system delayed the early retirement age from 61 to 63 for those workers who decide to retire on a voluntary basis, and it also delayed the full entitlement retirement age from 65 to 67. The delay in the early retirement age was immediate, and the delays in the normal retirement are gradual: one month per year between 2013 and 2018, and two months per year between 2019 and 2027. Consequently, the full entitlement retirement age in Spain will be 66 in 2021 and 67 in 2027.

Retirement Pensions. The main component of the retirement pension is the *Regulatory Base*, defined as the average covered earnings of the last 21 years before retirement. Labor income earned in the last two years prior to retirement enters the calculation in nominal terms, and the covered earnings of the remaining years are revaluated using the rate of change of the Spanish Consumer Price Index. The 2011 Reform of the Spanish pension system extended the number of years of earnings used by the Regulatory Base up to the last 25 years before retirement. The extension of the number of years used to compute the pensions was phased in gradually and it will end in 2022. In addition, the Regulatory Base in multiply by a percentage which depends on the age of the retirees and on the number of years of contributions. And, each year worked after the full entitlement retirement age increases the Regulatory Base in 2 or 3 percentage points depending on the length of the contributory career. Finally, retirement pensions are bound by a minimum and a

[32] This program includes self-employed, agricultural workers and small farmers, domestic workers, sailors, and coal miners.

maximum pension, where minimum pensions depend the pensioner's age and on the composition of the household.

The Revaluation of pensions. In 2018, the Spanish pension system returned to a full price indexation of pensions.[33]

The Pension Reserve Fund. Since 2000, part of the surpluses generated by the pension system are deposited in a Pension Reserve Fund. However, and since the stock of assets of this fund only represented 0.4 percent of GDP at the end of 2018, which is our calibration target year, we assume that there is no Pension Fund in our model economy.

D.1 Changes in the Fiscal and Pension Policies between the initial and the final steady states

- In the final steady state, the legal retirement ages are 63 and 67 years, rather than 62 and 66 years old as it is the case in the initial steady state
- In the final steady state, the number of years of labor income used to compute the pension are the last 25 years before retirement, rather than the last 21 as it is the case in the initial steady state.
- The above changes follow the 2011 Spanish pension reform. The extension of the retirement ages and the number of years used to compute the pensions was phased in gradually.
- Finally, we assume that the final steady state does not introduce the last reform related to the Spanish Minimum Income scheme, approved by the Spanish government in 2020.

[33]The two main measures of the 2013 Pension Reform, the Sustainability Factor and the Pension Revaluation Index, have recently been eliminated by the Spanish government.

E Welfare maximizing BP and FF tax rates

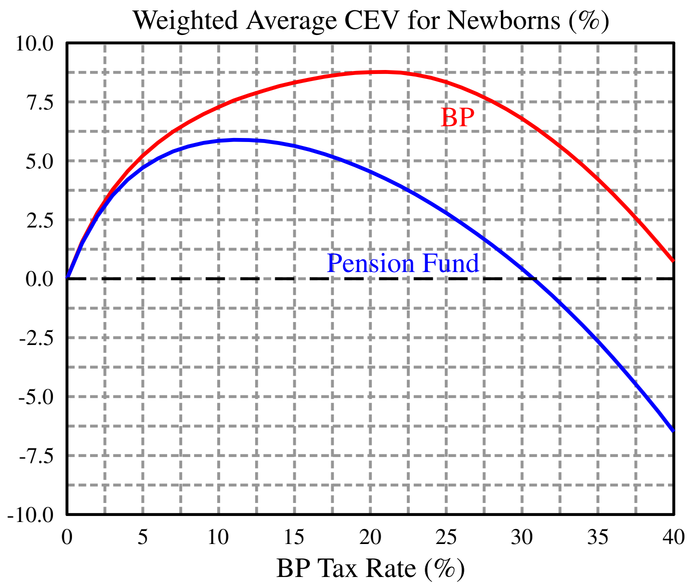

Figure 6: Utilitarian welfare at age 20 in reformed economies relative to PAYG economy, 2068. Red line: BP economy; Blue line: FF economy. Horizontal axis: τ_b (blue line) and τ_f (red line).

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