Pensions in Spain: A Reform that Backfires*

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July 18, 2025

Abstract

After the pension policy reversal that took place at the end of the past decade, the Spanish government approved a pack of new parametric changes to its public pension system, to cope with the present and future Spanish pension system imbalance. To study these changes, we use a large-scale overlapping generations model calibrated to the Spanish Economy, and show that this pension reform backfires. This is because these changes bring no significant variation to the sustainability problems that plague the Spanish public pension system. In addition, this pension reform hurts current and future high earners' welfare, because the higher payroll taxes they have to pay. Thus, we conclude that further reforms are imminent in the near future of Spanish pensions. Policymakers should seriously consider overhauling the current Spanish public pension system and replacing it with a model that combines a sustainable contributory pay-as-you-go pensions with mandatory individual retirement accounts.

Keywords: OLG, social security reform, demographic trends, dynamic analysis

JEL classification: C63, H55, J11

*We thank Thiess Buettner (the Editor), and two excellent anonymous referees. Julián Díaz Saavedra thanks the Cátedra Cobas AM sobre Ahorro y Pensiones for financial support, as well as Grant PID2022-139843NB-I00, funded by MICIU/AEI/10.13039/501100011033 and by FEDER, EU; and Grant C.SEJ.010.UGR23, funded by the Consejería de Universidad, Investigación e Innovación, by ERDF, EU, and by the ERDF Andalusia Program 2021–2027.

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1 Introduction

At least since the year 2000, academic researchers have concluded unanimously that the Spanish pay-as-you-go, defined-benefit public pension system, which was in force before the 2011 and 2013 Reforms, was unsustainable. Likewise, many research papers also found that that these reforms substantially improved the sustainability of Spanish pensions, and that they limited the tax increases that would have been necessary to finance the future pension system deficits. But a few papers (Díaz-Giménez and Díaz-Saavedra 2017, and De la Fuente et al. 2018) called attention to the risk of a policy reversal of these reforms, since the improvement in the sustainability of the system was achieved at the expense of large reductions in the real value of pensions. Hence, at the end of the last decade, such a policy reversal took place, and Spain probably returned again to an unsustainable public pension system.[1]

To cope with the present and expected pension system imbalance, the Spanish Government approved a pack of parametric changes in 2022 and 2023. These changes increased the payroll tax collections, reduced the contributivity of the system, increased the incentives of workers to delay retirement, and increased pension adequacy. Specifically, and first, the *Intergenerational Equity Mechanism* was enacted, which increased the payroll tax rate by 0.6 percentage points in 2023, rising up to 1.2 percentage points in 2029, the year from which it will remain constant at that level. These additional revenues are accumulated in a Reserve Fund to compensate for mismatches between payroll revenues and pension expenditure. Second, the pension reform increased the *annual pension reward* for every year worked after the full entitlement retirement age from 2 to 4 percent. Third, the reform also increased both the *payroll tax cap and the maximum pension*. The payroll tax cap will increase 1.2 percentage points per year between 2024 and 2050, while the maximum retirement pension will increase 0.1115 percentage points per year that same period.[2] Fourth, the Spanish government also approved the so-called *solidarity quota*, an additional contribution on labour earnings that exceed the payroll tax cap.[3] Finally, the Spanish government enacted that the *minimum retirement pension* should increase to 60 percent of the median income by 2027.

In this paper we analyse the quantitative consequences of both the policy reversal and these new parametric changes of the Spanish pension system during 2022 and 2023. Specifically, we compare

[1] The 2011 and 2013 Reforms were mainly eliminated in 2021. These reforms introduced two Automatic Adjustment Mechanisms. First, the Pension Revaluation Index, which uncoupled annual pension updates from the Consumer Price Index increases, but set the annual increase in pensions on the basis of a formula derived from the balance between the system's revenue and expenditure. And second, a Sustainability Factor that only affected the first pension received and with a factor whose dynamics depended on the evolution of age-65 cohort life expectancy. See Section 2 for an extensive description of the Spanish pension reforms during the last 15 years.

[2] From 2051 to 2065, the maximum retirement pension will increase an additional 20 percent in order to reduce the gap with the maximum payroll tax cap.

[3] The contribution will be 5.5 percent on the part of the remuneration between the cap of the regulatory base and 10 percent higher than that cap, 6 percent on the part of the remuneration between that 10 and 50 percent higher than the cap, and 7 percent on earnings that exceed the cap by more than 50 percent. These additional contribution rates will gradually increase between 2025 and 2045.

relevant time series of both a benchmark and a reformed economy that include all the parametric changes as described above. We also study these changes one at a time to explore which of them is quantitatively more important. The objective is to analyse both the aggregate consequences of the pension policy reversal and whether the Spanish government has designed a new pension reform that not only improves its future financial sustainability but also increases the well-being of current and future cohorts.

To achieve this, we simulate an overlapping generations open model economy with job creation and destruction, with search frictions and three employment states (employed, unemployed and inactive), populated by heterogeneous households, a representative firm, and a government, as described in Díaz-Saavedra et al. (2023). Specifically, our model economy allows for a detailed description of the Spanish Welfare State: there are transfers for low-income households, a public unemployment insurance, and a pay-as-you go pension system 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 close the model. We simulate the economy in the following decades, accounting for the projected demographic changes in the age and education distributions.

However, the model economy we analyze here differs from the one used in that study in four key aspects. First, this version incorporates a detailed representation of the Spanish public pension system, including features such as minimum and maximum pensions, early and standard retirement ages, penalties for early retirement, and bonuses for delayed retirement. This detailed representation is crucial for accurately assessing the impact of the reforms we examine in this paper. Second, the model includes a payroll tax cap, emphasizing not only the number of workers subject to this cap but also their distribution across different age and education groups. In Section 4.1, we demonstrate that our model accurately replicates the relevant Spanish data. Third, the model assumes that households consider the link between payroll taxes and pensions when making decisions about consumption, savings, and retirement. This is important because pension entitlements constitute a significant portion of worker compensation and have a considerable influence on work-related decisions, especially as individuals reach the early retirement age.[4] And fourth, the model incorporates labor productivity growth, calibrating it to align with Spain's historical long-term growth rate. This aspect is vital, as labor productivity growth can mitigate the sustainability challenges

[4]Social security regulations can often incentivize early retirement by setting eligibility ages and benefit formulas that make it financially attractive for workers to retire before reaching the standard retirement age. For instance, if the system allows individuals to begin receiving benefits at a reduced rate starting at an early age, some workers—particularly those in physically demanding jobs or with health issues—may opt to retire sooner rather than continue working. Additionally, generous early retirement provisions or lack of penalties for early exit can further encourage this decision, potentially impacting the sustainability of the pension system.

faced by public pension systems, such as Spain's, since most of advanced economies index pensions, particularly pension rights, to the Consumer Price Index (CPI), rather than labour productivity growth. Consequently, this feature of pension systems therefore means that productivity gains are transferred to pensions with a certain time lag, so the future financial burden of the system decreases (see Díaz-Saavedra 2016).[5]

Our simulations show three main results. First, the pension policy reversal made the Spanish pay-as-you-go, defined-benefit public pension system completely unsustainable. Specifically, we show that after the pension policy reversal that took place in 2021, the pension system expenditures would increase by almost 5 additional percentage points of GDP by 2050, while the pension system revenues would remain virtually unchanged. The pension deficit would therefore reach more than 6 percent of output in 2050, and if the Spanish government increases the consumption tax rate to finance this pension deficit, this tax should increase by more than 12 percentage points, from 18.60 percent in 2022 to 30.66 percent in 2050.

Second, the parametric changes implemented from 2022 onwards do not solve the sustainability problems that plague the Spanish pension system following the policy reversal. This is because the changes aimed at increasing the payroll tax collections are almost completely offset by the measures aimed at increasing the pension adequacy of certain socioeconomic groups of the Spanish population. Thus, we find that the pension reform only reduces the pension deficit from 6.10 to 5.72 percent of output in 2050. And third, our results show that this pension reform entails welfare losses for current and future high earners. Specifically, high-earning workers would face welfare losses mainly due to both the increase in the payroll tax cap and the new payroll tax rate for those earnings above the cap. Our results also show that the losses for those with high incomes and who were alive at the time of the pension reform are equivalent to 0.3 percentage points of that year's GDP. As a conclusion, then, this policy reversal effectively squandered two decades that could have been used to implement structural reforms to address the country's demographic and economic challenges.

Our results show that the Spanish public pension system is heading towards financial unsustainability due to both policy reversals and recent reforms that are inadequate to address future imbalances. Further reforms are imminent, raising two critical questions: what type of reform should be implemented, and how can these reforms avoid causing long-term welfare losses for certain socioeconomic groups? For the first question, a combination of policy adjustments, including taxation, benefits, and retirement age changes, could be recommended. For instance, Automatic Adjustment Mechanisms have proved to be useful tools to prevent pension schemes from becoming increasingly unsustainable as populations age (OECD, 2021). Regarding the second question,

[5] An additional difference is that the demographic scenario used in our simulations is based on the latest projection from the Spanish National Institute of Statistics (INE). This projection suggests a less dramatic increase in the demographic dependency ratio over the coming decades compared to previous forecasts.

strategies to mitigate the negative impact of reforms could include exemptions, tax incentives, and compensatory transfer programs. In conclusion, Spain needs comprehensive pension reforms, but to ensure their success and minimize opposition, the government should consider compensatory measures for those adversely affected.[6]

There are different approaches available in the literature that study the effects of the aging of the population on Social Security expenditures, and these can be grouped into three main categories: *i)* aggregate accounting; *ii)* computable large scale OLG models; and *iii)* individual life-cycle profiles (see Jimeno et al. (2008)). However, most of the literature uses computable OLG models to study the aggregate effects of parametric reforms on social security systems, which we build on (see, e.g., Conesa and Krueger, (1999); De Nardi et al. (1999); Imrohoroğlu and Kitao, (2012), and Fehr et al. (2012)). For instance, Bouchet et al. (2017) uses an overlapping generation model calibrated to the Luxembourg economy to design a pension reform to cope with the deep demographic changes, and they find that a single parametric change would imply severe backlashes on the rest of the economy, so that their suggested pension reform should consist of a policy mix including taxation, benefits and changes in the legal retirement ages. However, the papers most similar to ours are those from AIReF (2023) and De la Fuente (2023). They study the budgetary consequences of the Spanish parametric changes enacted in 2022 and 2023, and they conclude that these reforms bring no significant variation in the sustainability of Spanish pensions during the next decades. Unfortunately, however, these papers abstract from several dimensions in their analysis such as the tax increases needed to finance the pension system deficits, the aggregate consequences, or the welfare outcomes for certain socioeconomic groups. Addressing this gap is one of the primary objectives of our paper.

The paper is organized as follows: section 2 describes the latest pension reforms in Spain; section 3 presents the model economy; section 4 describes the calibration procedure and its results; section 5 describes the simulations; section 6 describes the baseline scenario used in our simulations; section 7 presents the results; section 8 discusses policy implications derived from our results; and, lastly, section 9 concludes.

2 Pension Reforms in Spain

The Spanish social security system has undergone a series of significant reforms since 2011 aimed at addressing demographic and economic challenges, including an ageing population, and consequently, an increasing pressure on public pensions. While these pension reforms initially focused on the balancing act between ensuring financial sustainability, they were later geared toward maintaining

[6]Spain is not the only country facing serious financial problems in its public pension system. For example, projections from the Ageing Report 2024 reveal significant increases in public pension spending over the coming decades in several European countries.

adequate pension benefits. In other words, long-term sustainability took a backseat.

The 2011 reform introduced key changes: the statutory retirement age was gradually raised from 65 to be 67 by 2027, with provisions allowing retirement at 65 for those contributing for at least 38 years and six months. The calculation base for pensions shifted from the last 15 years to the last 25 years before retirement, implemented gradually from 2013 to 2022. Early retirement ages and conditions also changed: voluntary retirement was delayed to age 63, and minimum contribution periods were set at 33 years for voluntary and 35 years for compulsory retirement. Reduction coefficients were also increased for early retirees based on contribution history, establishing progressive penalties. Compatibility rules for unemployment and early retirement were clarified, and access to partial retirement was gradually aligned with the statutory age.

To ensure long-term balance between contributions and benefits, a sustainability factor was proposed, linking initial pension amounts to life expectancy at retirement age. A follow-up reform in 2013 reinforced this trajectory, requiring the sustainability factor to be applied, starting in 2019 and revised every five years based on life expectancy at age 65, using official projections. The purpose of the sustainability factor was to adjust the initial pension with life expectancy at retirement so that the life-time cost of retirement was approximately the same for every cohort. Díaz-Giménez and Díaz-Saavedra (2017) show that by 2050 the Sustainability Factor would have reduced the real yearly value of Spanish new pensions by 17.4 percentage points.

Additionally, the reform replaced the consumer price index (CPI) as the sole metric for pension revaluation with the Pension Revaluation Index (PRI), an index which included social security system income, expenditures, and the number of pensions. The purpose of the Pension Revaluation Index was to reduce the real value of pensions as needed to adjust the pension system outlays to its revenues smoothly over the business cycle. Moreover, according to this new formula, annual pension increases were capped at a minimum of 0.25% and a maximum linked to the CPI plus 0.5%, though in practice pensions increased by only 0.25% due to financial limitations.

However, the 2018 reform marked a shift away from the previous emphasis on expenditure containment. Both the sustainability factor and the Pension Revaluation Index (PRI) were suspended in order to protect replacement ratios, even though these ratios in Spain exceed the EU average. Instead, the government adopted a revenue-focused strategy, raising both contribution bases and rates.

In line with the 2018 approach, a new reform was introduced in 2021. It permanently eliminated the PRI, reinstated full pension indexation based on the Consumer Price Index (CPI), and replaced the sustainability factor with the Intergenerational Equity Mechanism (IEM). The IEM imposes a 0.6% labour tax—shared between employers (0.5%) and employees (0.1%)—applicable from January 2023 to 2032. The revenue collected through this tax will be allocated to the Social Security Reserve Fund. From 2033 to 2052, the Spanish government will be allowed to draw from

this fund to help reduce the imbalance between payroll tax revenues and pension expenditures.[7]

In line with encouraging longer working lives, the 2021 reform introduced a framework for voluntary delayed retirement. As of January 2022, individuals who defer retirement past the statutory age face a permanent monthly increase to their pension of 4% for each full year worked beyond the retirement age. This measure aims to reduce the dependency ratio and enhance the sustainability of the pension system by incentivizing continued labour force participation for older workers.

In 2023, additional reforms were implemented in order to further enhance sustainability and equity. A progressive 1.2% increase in the maximum contribution base from 2024 to 2050 was enacted, alongside a gradual increase in contribution rates to be completed by 2029. The IEM's rate will increase annually by 0.10% until it reaches 1.2% in 2030, with employers covering 83% of the increase. The 2023 reform also includes the so-called *solidarity quota (QUOTA)*, an additional contribution on earnings from work that exceed the cap of the regulatory base. The contribution will be 5.5 percent on the part of the remuneration between the cap of the regulatory base and 10 percent higher than that cap, 6 percent on the part of the remuneration between that 10 and 50 percent higher than the cap, and 7 percent on earnings that exceed the cap by more than 50 percent. These additional contribution rates will gradually increase between 2025 and 2045. The reform also strengthened disincentives for early retirement. Individuals retiring before the statutory age face steeper reductions in their pensions, now calculated monthly instead of quarterly. Those retiring at age 63 with fewer than 36.5 years of contributions would face a 21% reduction (up from 16% previously), while longer contributors face a 13% reduction. However, the Spanish government passed a rule by which the minimum retirement pension has to be equal to 60 percent of the median income by 2027. [8]

The intended evolution of Spain's pension reforms reveals a tension between maintaining the financial health of the system and protecting the adequacy of benefits. While early reforms emphasized cost containment through delayed retirement, stricter access rules, and automatic adjustment mechanisms like the sustainability factor and PRI, subsequent policies have shifted toward enhancing benefit adequacy and addressing equity issues. The use of tax-based contributions such as the IEM and SC reflects an attempt to diversify the financing base of the system, reducing reliance on cutting expenditures. Meanwhile, both the increase in the minimum retirement pension and the CPI-based revaluation restoring purchasing power guarantees for pensioners, reflect political and social priorities to protect older populations from poverty and inflation.

But this strategy, aimed at shoring up the system's financial foundation through increased revenues and prolonged working lives, is not without controversy, particularly given Spain's complex

[7] Additionally, to address gender disparities in pensions—often stemming from wage gaps, caregiving responsibilities, and interrupted careers—the Gender Gap Supplement was introduced.

[8] Currently, the minimum retirement pension is set at 55 percent of the median income in Spain.

demographic reality. Put differently, long-term sustainability could continue to depend largely on broader structural pension reforms.

3 The Model Economy

We study an overlapping generations open model economy with heterogeneous households, a representative firm, and a government. Our model economy is an enhancement of the model economy described in detail in Díaz-Saavedra et al. (2023). Since these modelling improvements are mainly introduced within the public pension system of the model, we describe this system in detail. However, and for the sake of brevity, we only briefly present the rest of our economic model.[9]

3.1 The Households

Households in our baseline 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, $s \in \mathcal{S}$; in their pension rights, $b \in B$; in their pensions, $p \in P$; and in their private assets, $a \in A$. Sets J, H, $\mathcal{Z}$, $\mathcal{S}$, B, P, and A, are all finite sets and we use $\mu_{j,h,z,s,b,p,a}$ to denote the measure of households of type (j, h, z, s, b, p, a). 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 $j + 1$.

Education. Households can either be high school dropouts, high school graduates who have not completed college, or college graduates. A household's education level is exogenous and determined forever at the age of 20.

Labor market status. Households in our economy are either employed, unemployed, inactive, or retired. Among the unemployed, there are individuals who are eligible to receive unemployment benefits, and others who are not eligible (either because eligibility expired, or because they quit work). Workers 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

[9] Time is discrete and runs forever, and each time period represents one calendar year. During transitional dynamics, out of a steady state, all variables depend on calendar time t, where this dependence comes from the ageing transition that is modelled as a change, over time, of the age-specific survival probabilities and the share of age groups and education levels as new cohorts enter the economy, as well as from any changes to policy variables. In this section we omit this dependence.

both optimal work and job search decisions (described below), and exogenous job separation and job finding probabilities.

Workers. A worker provides labor services and receives a salary that depends on his endowment of efficiency labor units and his hours worked. This endowment has two components: a deterministic component, and a stochastic component. The deterministic component depends on the household age and education, and we use it to characterize the life-cycle profiles of earnings. We model these profiles using quadratic functions, because it allows us to represent the life-cycle profiles of the productivity of workers in a very parsimonious way.

The stochastic component is independently and identically distributed across the households, and we calibrate it to match moments of the Spanish earnings and wealth distribution, following Castañeda et al. (2003). 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. We assume that this stochastic component can take three values, and we make this assumption because it turns out that three states are sufficient to account for the Lorenz curves of the Spanish distributions of income and labor earnings in enough detail, and also because we want to keep this process as simple as possible.

Finally, we also assume that workers face a probability of losing their job at the end of the period. 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 can receive unemployment benefits. Eligibility for unemployment benefits is conditional on having lost a job during the previous two years and not having started a new job yet. Eligibility expires when one the conditions is not met. Agents who have quit work are not eligible for unemployment compensation (we often refer to this group as unemployed non-eligible). Active job searchers receive a job offer at the end of the period according to some probabilities that depend of age, and we use it to generate the observed labor market flows between unemployment and employment. The job offer involves employment at a wage rate that corresponds to a productivity level that is drawn from the unconditional distribution of productivity. Once a household is re-employed, the future values of these shocks are determined by the conditional transition probabilities.

Non-Active. Agents without a job and who do not actively search for a new one are labeled non-active. Those agents are not eligible for unemployment benefits, and receive a job offer for next period with a lower probability than an unemployed agent. This probability is also age dependent,

and we use it to generate the observed labor market flows between non-activity and employment.[10]

Retirees. Workers who are R_0 years old or older decide whether to to retire and collect the retirement pension. They take this decision after observing their current labor productivity. If they decide to retire, they loose the endowment of labor efficiency units for ever and exit the labor market. Unemployed and inactive households who are R_0 years or older are forced to retire.

Pension rights. Workers, unemployed, and inactive also differ in the pension rights, and these rights are used to determine the value of their pensions when they retire. The rules of the pension system, which we describe below, include the rules that govern the accumulation of pension rights, and the rules that determine the mapping from pension rights into pensions. Differently from Díaz-Saavedra et al. (2023), this version of the model economy assumes that households take this mapping into account when they decide how much to work and when to retire.

Pensions. Retirees differ in their retirement pensions, and we assume that there exist minimum and maximum retirement pensions, in accordance with the Spanish Public Pension System.

Assets. Households in our model economy 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.[11]

Preferences. 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. Non-active and retired agents dedicate all the time endowment to leisure consumption.

Timing. At the beginning of each period, households' stochastic productivity component, is realized. When entering the economy (at age 20) agents additionally learn their education level and draw a job opportunity, that they can either accept or reject. For older households, if they start a period with a job opportunity, 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, unemployed or inactive. Wages and unemployment benefits are received, and decisions on consumption and savings are taken. At the beginning of the next period, workers observe the job separation shock, and unemployed or inactive learn if the found a job for next period. After reaching the first retirement age, workers can choose to retire at the beginning of the period, and once they do they leave the labor market permanently.

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

[10] Those households who search for a job are more likely to find it, in comparison to non-active households.

[11] An important feature of the model is that there are no insurance markets for the stochastic component of the endowment shock nor for unemployment risk.

model different public insurance systems that help agents in the economy smooth consumption in the face of these shocks.

3.2 The Firm

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

$$Y = K^{\theta}(B\ L)^{1-\theta} \tag{1}$$

where B is the labor augmenting growth factor, whose law of motion is $B^{'} = (1+g)B$, and where g is the labor augmenting growth rate.

Factor and product markets are perfectly competitive and the capital stock depreciates geometrically at a constant rate, δ. The firm rents capital in the international capital market at an exogenous interest rate r, and hires workers in the domestic market at a wage rate ω per efficiency unit of labour. Under these assumptions, the international interest rate r pins down the wage rate ω. Finally, the profit maximizing behavior of firms implies that their demand of both capital and labor are such that

$$r = F_K(K, BL) - \delta \tag{2}$$

and

$$\omega = F_L(K, BL) \tag{3}$$

where $F_K(K, BL)$ and $F_L(K, BL)$ are the marginal productivities of capital and labor, respectively.

3.3 The Government

The government has two roles in our model economy: it runs an unfunded defined benefit pension system, and it also sets the fiscal policy. We describe these two roles in turn.

3.3.1 The Pension System

Differently from Díaz-Saavedra et al. (2023), this version of the model economy introduces many of the institutional features of the current Spanish public pension system in very much detail. Consequently, we carefully describe this system below.

In our benchmark model economy we choose the payroll tax and the pension system rules so that they replicate as closely as possible the *Régimen General de la Seguridad Social* of the Spanish pay-as-you-go pension system in 2022, which is our calibration target year.[12]

Payroll Taxes. In our model economy, as in Spain, the payroll tax is capped. Specifically, the payroll tax function is given by:

$$t_p(y^l) = \begin{cases} \tau_p y^l & \text{if } y^l < \overline{y}^l \\ \tau_p \overline{y}^l & \text{otherwise} \end{cases} \tag{4}$$

where parameter τ_p is the payroll tax rate, y^l is the gross labor earnings, and $\overline{y}^l$ is the maximum covered earnings. Finally, we also assume that eligible unemployed also pay social security contributions, so that the payroll tax function becomes $t_p(y^u) = \tau_p y^u$, where y^u is the unemployment benefit.

Retirement Ages. In our model economy the early retirement age is R_0, and the full entitlement retirement age is R_1. Workers who choose to retire early pay a penalty, λ_j, which is determined by the following function

$$\lambda_j = \begin{cases} \rho_0 - \rho_1(j - R_0) & \text{if } j < R_1 \\ 0 & \text{if } j \geq R_1 \end{cases} \tag{5}$$

where ρ_0 and ρ_1 are parameters which we choose to replicate the Spanish early retirement penalties.

Retirement pensions. A household of age $j \geq R_0$, that chooses to retire, receives a retirement pension, $p(b)$, which we compute following the Spanish pension system rules. The main component of the retirement pension is the *Regulatory Base*, RB, which averages labor earnings up to the maximum covered earnings, during the last $N_b = 25$ years prior retirement. If a household has not reached the full entitlement retirement age, its pension is subject to an early retirement penalty. If the household is older than R_1, its pension claims are increased by 2 percent for each year worked after this age. Finally, the Regulatory Base is multiplied by a pension replacement rate, p_r, which we use to replicate the pension expenditures to output ratio.

Note that the Regulatory Base considers a relative long vesting period. Consequently, it can be relatively frequent that contribution gaps occur; that is, years during the vesting period in which the household does not credit any contribution. This is the case, for instance, for noneligible unemployed. In order to mitigate the negative effects of these gaps, the Spanish pension rules establishes that these unlisted periods will be integrated with fictitious quotes. In our model

[12] In 2022, this regime included 76.0 percent of all Spanish workers. See Díaz-Saavedra (2020) for a description of the Spanish Public Pension System.

economy, we assume that these fictitious quotes, y^{fq}, are a constant proportion of per capita output.

In our benchmark model economy we calculate the retirement pensions using the following formula:

$$p(b) = p_r(1.02)^v(1-\lambda_j)RB \tag{6}$$

where v denotes the number of years that the worker remains in the labor force after reaching the full entitlement retirement age. The Regulatory Base, RB, is given by:

$$RB = \frac{1}{N_b}\sum_{s=j-N_b}^{j-1} min\{y_s^l, \overline{y}^l\} \tag{7}$$

Note that in this expression, labor earnings, y_s^l, is replaced by y_s^u or y_s^{fq} in the case of eligible or non-eligible unemployed households. Expressions (6) and (7) replicates most of the features of Spanish retirement pensions. The main difference is that in Spain the pension replacement rate depends of the number of years of contributions. We abstract from this feature of Spanish pensions because it would require an additional state variable. Finally, we require that the retirement pension is bounded by a minimum and maximum retirement pension, $\underline{p} \leq p(b) \leq \overline{p}$.

3.3.2 The Fiscal Policy

The government in our model economy taxes capital income, household total income (net of capital income taxes and social security contributions), and consumption, and it confiscates part of unintentional bequests. It uses its revenues to consume, and to make transfers to households other than pensions.

Similarly to Díaz-Saavedra et al. (2023), we assume proportional capital income and consumption tax rates. However, and differently from that paper, we model the household income tax with the following function:

$$\tau_y(y_t^b) = a_0\left\{y_t^b - \left[a_1 + (y_t^b)^{-a_2}\right]^{-1/a_2}\right\} \tag{8}$$

where y_t^b is the income tax base. This expression, where a_0, a_1, and a_2 are parameters, is the function chosen by Gouveia and Strauss (1994) to model effective personal income taxes in the United States, and it is also the functional form chosen by Calonge and Conesa (2003) to model effective personal income taxes in Spain.[13]

[13] Additionally, Guner et al. (2014) conclude that this functional form generates a better statistical fit for average tax rates, in comparisons to other alternatives.

3.3.3 The Consolidated Government Budget

The consolidated government and pension system budget constraint is

$$G + Z + P + U = T_k + T_y + T_c + T_p + E \tag{9}$$

On the expenditure side, G denotes government consumption, Z denotes government transfers other than pensions, P denotes pensions, and U denotes unemployment benefits. And, in the revenue side, T_k, T_y, and T_c, denote the revenues collected by the capital income tax, the household income tax, and the consumption tax, T_p denotes the revenues collected by the payroll tax, and E denotes the part of unintentional bequests collected by the government, and we assume that the portion of accidental bequests that is not taxed by the government is wasted.

In the initial steady state (our calibration target year, see below), we assume that government consumption adjusts to clear the government budget. Thereafter, instead, we assume that it is the consumption tax rate that varies to match expenditures and revenues in the consolidated government budget. As a result, the consumption tax is increased as much as needed, mainly, to cover the deficit of the public pension system over the next decades.

4 Calibration

To calibrate our model economy, we choose 2022 as our calibration year. Then we 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 institutional details of Spain in 2022.

More specifically, to characterize our model economy fully, we must choose the values of a total of 52 parameters. Of these 52 parameters, 5 describe the household preferences, 21 the process on the endowment of efficiency labor units, 4 the production technology, 11 the pension system rules, and 11 the remaining components of the government policy. To choose the values of these 52 parameters, we need 52 equations which formalize our calibration targets. In Brogueira de Sousa et al. (2022) and Díaz Saavedra et al. (2023) we describe in detail the calibration procedure. However, and having in mind that our model economy is an enhancement of that model economy, in the Appendix we describe how we calibrate the new parameters that appear in this version.

4.1 Calibration Results

In this section we show that our calibrated, benchmark model economy replicates reasonably well both most of the Spanish statistics that we target, and also untargeted moments in our calibration

procedure. To differentiate targeted from untargeted moments, we present the first group of Spanish statistics in bold face.

Macroeconomic Aggregates and Ratios. In Table 1 we report the macroeconomic aggregates and ratios in Spain and in the benchmark model economy for 2022. We find that the benchmark model economy does a good job in replicating most of the main Spanish macroeconomic aggregates and ratios. The exceptions are the ratios to GDP of private consumption and investment, and net exports. The divergence in the ratio public consumption to output was expected as government this ratio is obtained residually to close the government budget constraint at our calibration target year.

Table 1: Macroeconomic Aggregates and Ratios in 2022 (%)*

	K/Y	C^a/Y	I^a/Y	X^a/Y	G/Y	P/Y	U/Y	Tr/Y	T_y/Y	T_p/Y	T_k/Y	T_c/Y	E^b/Y
Spain	**2.94**	53.24	25.89	1.10	20.36	**12.91**	**1.54**	**0.83**	**9.15**	**12.16**	**2.71**	**6.99**	**0.20**
Model	3.05	44.54	35.83	4.83	14.80	12.92	1.51	0.80	9.03	12.21	2.71	6.98	0.20

*In this table, variable Y is GDP at market prices.

[a]Variables C, I, and X denote private consumption, investment, and net exports.

[b]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). But in our model economy, aggregate accidental bequests as a fraction of output are significantly higher in the initial steady state. Consequently, we assume that the portion of accidental bequests that is not taxed by the government is wasted.

The Pension System. For the results from our model economy to be taken seriously, it should approximate some of the more important features of the Spanish public pension. Table 2 shows the proportions of retirees collecting the minimum and maximum pensions, the average retirement age, and the share of workers whose earnings are above the maximum contribution cap. We find that our model economy does a good job at replicating most of their empirical counterparts.

Table 2: The Spanish Pension System in 2022*

	$\underline{p}^a$	$\overline{p}^b$	Av. Age^c	Capped^d
Spain	26.0	4.8	64.8	10.4
Model	27.9	4.2	64.1	10.3

* : The source of Spanish data is the Spanish Social Security Statistics.

a : Share of retirees collecting the minimum pension.

b : Share of retirees collecting the maximum pension.

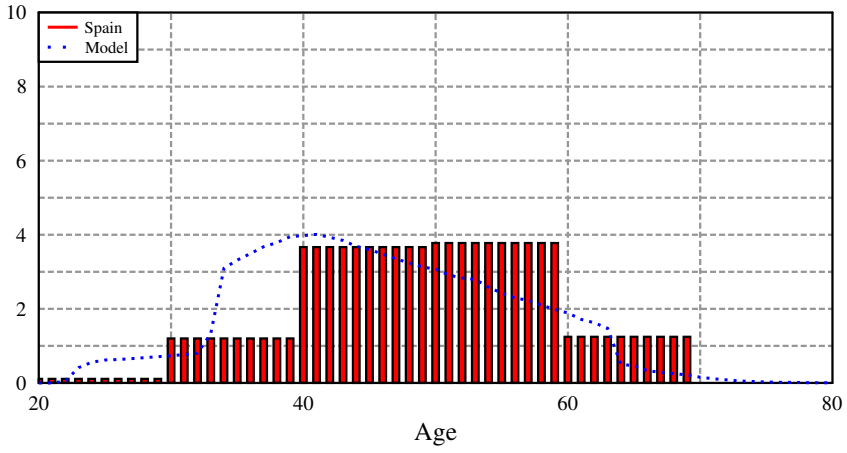
c : Average Retirement Age.

d : Share of workers with earnings above the maximum contribution cap.

Figure 1 shows the distribution of the 10.3 percent capped workers by age. We find that the model does a good job at replicating the fact that most of these workers are between 30 and 60

years old. If we look at the fine print, we find that the model predicts more workers in the age range of 30 to 40 years old, and that it underestimates the share between ages 50 and 60.

Figure 1: Distribution of Workers by Age with Earnings Above the Payroll Tax Cap in 2022 (%)*



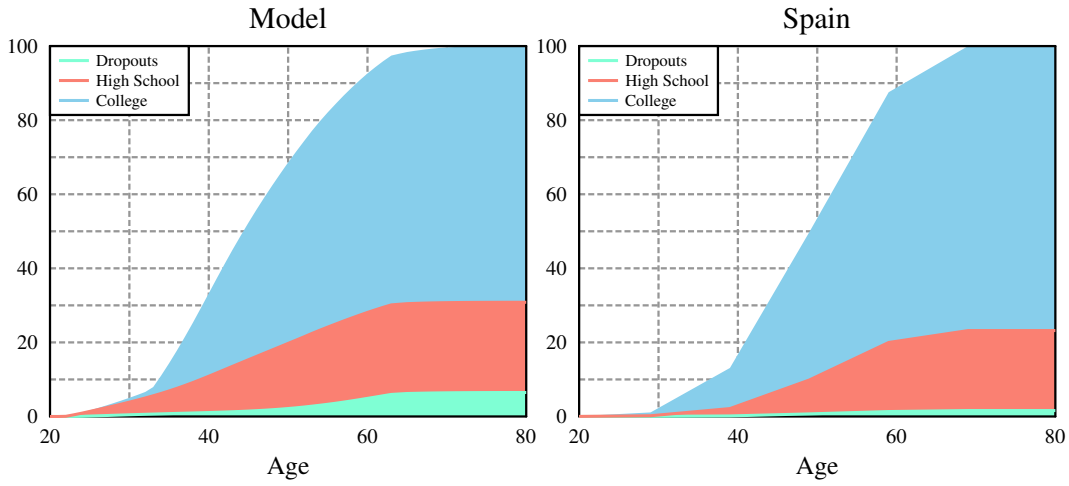
*The series of workers are the shares of workers by age in the sum of total workers with earnings above the payroll tax cap. We compute this share for Spain from the *Encuesta de Estructura Salarial (2022)*, reported by the INE.

Figure 2 shows the cumulative distribution of workers with earnings above the payroll tax cap by age and education, both in Spain and in our model economy. We find that the model is able to replicate the empirical cumulative distribution in great detail. Again, if we look at the fine print, we find that the model overestimates the share of dropouts and high-school workers, and it somehow underestimates the share of college workers. Overall, we find these results very encouraging since we did not target explicitly any of these statistics in our calibration procedure.

Inequality. In Table 3 we report the Gini indexes for earnings, income, and wealth in Spain and in our benchmark model economy. 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 Anghel et al. (2018). Again, the model economy does a good job in replicating inequality in Spain, although we also find that earnings is somewhat more concentrated in Spain, and that wealth is more concentrated in the model economy.

The labor market. Table 4 shows the profiles of the employed, and unemployed households by age and education. When carrying out this comparison we must keep in mind that there are some fundamental differences between Spain and our model economy. In Spain, working-age people fall into one of five categories: employed, unemployed, retired, inactive, and other non-participants. In our model economy we only have four of these categories: employed, unemployed, inactive and retired. Since these differences necessarily would distort our comparisons, we opted for excluding other non-participants people from the Spanish data. Finally, Figure 3 shows the profiles of employee,

Figure 2: Cumulative Distribution of Workers with Earnings Above the Payroll Tax Cap by Age and Education in 2022 (%)*



* We compute this distribution for Spain from the *Encuesta de Estructura Salarial (2022)*, reported by the INE.

Table 3: Inequality in Spain and in the model*.

	GE	GI	GW
Spain	**0.34**	0.33	**0.67**
Model	0.32	0.35	0.70

GE: Gini Index of net earnings, *GI*: Gini Index of net income, *GWI*: Gini Index of net wealth. *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 Anghel et al. (2018).

unemployed, inactive and retired households by age.

Again, the model economy does a good job in replicating the shares and age-profiles of labor status, although we also find that it predicts a higher (lower) unemployment (employment and inactivity) rate in comparison to Spain.

5 The Simulations

In this section we describe the different model economies that we simulated in this paper. And the next section describes the demographic, educational, growth, inflation rate, and fiscal policy scenarios that share our simulations.

The Benchmark Economy (BEN). Our benchmark economy is the economy that we modeled and

Table 4: Labor Market Shares in 2022 (% of population).

	W	U	I	R
Spain	**61.09**	8.83	**5.57**	24.50
Model	58.20	12.91	2.97	25.92

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

calibrated to approximate the Spanish economy in 2022. Specifically, this economy features the Spanish public pension rules just after the pension policy reversal, when the Sustainability Factor and the Pension Revaluation Index were eliminated. Apart from this, the rest of the introduced Spanish pension rules do not change. Specifically, we assume that the early retirement age is $R_0 = 62$, the full retirement age is $R_1 = 66$, and pension entitlements are calculated taking into account the last 25 years of pre-retirement contributions. Our benchmark model economy also revalues the minimum and maximum pensions so that their share of per-person output remains constant at their 2022 values, and we also assume that the real value of all other pensions does not change.

The Reformed Model Economy. The reformed model economy introduces the main measures adopted as part of the recent reforms of the Spanish public pension system, approved by the Spanish government during 2022 and 2023. These main changes are as follows:

- The *Intergenerational Equity Mechanism (IEM)*, increases the payroll tax rate. The increase goes from 0.6 percentage points in 2023, to 1.2 percentage points in 2029, the year from which it will remain constant at that level. These additional revenues will be accumulated in a Reserve Fund to compensate mismatches between income and tax expenses. From 2033 to 2052, the Spanish Government can make withdrawals from this fund in order to partially reduce the imbalance between payroll tax revenues and pension expenditures (see Panel A of Figure 4).

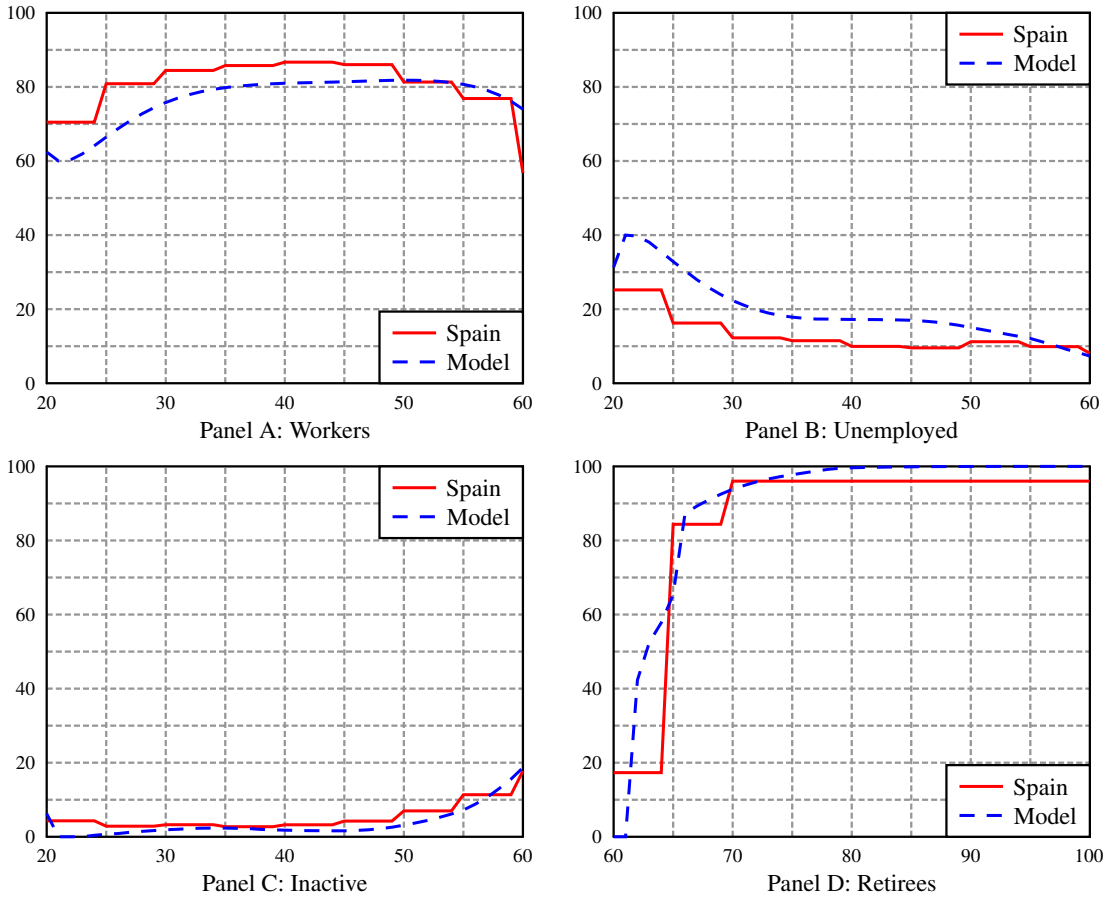
  In our model economy, we assume that the pension reserve fund evolves between 2023 and 2032 according to

$$F^{'} = (1 + r^*)F + \Delta T_p \tag{10}$$

  where $F^{'}$ is the value of the Pension Reserve Fund at the beginning of the next period, and ΔT_p are the additional payroll tax revenues collected by the increase of the payroll tax rate. After 2032, the law of motion of this fund is given by

$$F^{'} = \begin{cases} (1 + r^*)F - x_t\, Y, & \text{if } T_p - P < 0. \\ (1 + r^*)F, & \text{otherwise.} \end{cases} \tag{11}$$

Figure 3: Labor Market Shares by Age in Spain and the Model Economy in 2022 (%)*



*The shares of workers are the shares of workers in the sum of workers and unemployed. We compute this share for Spain from the *Encuesta de Población Activa (2022)*, reported by the INE.

where r^* is the rate of return for the pension fund and x_t is the maximum disbursements from the Pension Reserve Fund per year as a share of the Gross Domestic Product. We assume that $r^* = 1\%$, and that x_t is given by the values approved by the Spanish Government in 2023 (see Panel A of Figure 4).[14] Finally, we require the pension reserve fund to be non-negative, so that when the pension fund assets ran out, the government removes this fund.[15]

- Under the current Spanish public pension system, the *annual pension reward (APR)* for every year worked after the full entitlement retirement age depend of the number of years worked during the working lifetime, and it varies between 2 and 3 percent. The last Spanish pension

[14]The rationale for our 1 percent choice for the rate of return for the pension fund is because this is approximately the number of the average rate of return for the assets invested in the Spanish Pension Fund over the last 10 years, from 2014 to 2023 (see Ministerio de Inclusión, Seguridad Social y Migraciones, 2024).

[15]The values of these maximum annual disbursements from the Pension Reserve Fund have been approved through the Spanish Royal Decree-Law 2/2023, of March 16, 2023, and published in the Spanish Official State Gazette, BOE-A-2023-6968, page 21. We assume that after 2052, the maximum annual disbursements from the Pension Reserve Fund continues to be 0.51 percent of output while this fund still has assets.

reform increases this number until 4 percent, regardless of the number of worked years.

- The reform also increases both the *real cap of the regulatory base and the real maximum pension (CAPS)*. The cap of the regulatory base will increase 1.2 percentage points per year between 2024 and 2050, while the maximum retirement pension will increase 0.1115 percentage points per year that same period. From 2051, and until 2065, the maximum retirement pension will increase an additional 20 percent in order to reduce the gap with the cap of the regulatory base (see Panel B of Figure 4).

- The 2023 reform also includes the so-called *solidarity quota (QUOTA)*, an additional contribution on earnings from work that exceed the cap of the regulatory base. The contribution will be 5.5 percent on the part of the remuneration between the cap of the regulatory base and 10 percent higher than that cap, 6 percent on the part of the remuneration between that 10 and 50 percent higher than the cap, and 7 percent on earnings that exceed the cap by more than 50 percent. These additional contribution rates will gradually increase between 2025 and 2045 (see Panel C of Figure 4).

- According to the last Spanish pension reform, the *minimum retirement pension (PMIN)* should be equal to 60 percent of the median income by 2027. According to the Spanish National Institute of Statistics (INE), the GDP per person who was 20 or older was 37,498 euros in 2023. Also according to the INE, the 60 percent of the median income is equal to the Poverty Risk Threshold which was 10,989 euros that same year. Dividing these two numbers we obtain 0.2933, so that in our model economy the pension reform increases the minimum retirement pension from 0.2736 to 0.2933 of GDP per person 20+.

- Finally, we simulated a final reform where we introduce *all previous parametric changes (ALL)*.

We do not simulate two additional changes introduced by these pension reforms. First, there is a change in the payroll taxes payed by the self-employees that implies that these workers will pay payroll taxes according to their earnings, rather than the possibility of choosing the amount to pay. And this parametric change could have two opposite effects. According to De la Fuente (2023), this measure would increases payroll tax revenues by 0.75 percent of GDP in 2050. On the other hand, he also estimates that the higher future retirement pensions of these self-employees workers would increase pension expenditure by 0.72 percent of GDP that same year, so that the overall effect of this policy change would be almost zero in the long run. And second, the reform will increase in 2043 the number of years used to compute the pension to the last 29 years of working life, from which the 24 worst months will be excluded. Between 2026 and 2040, a dual system will be in force in which new pensioners will choose the regulatory base that is more favorable between the current and that new system. And also according to De la Fuente (2023), this parametric change will increase pension expenditure by only 0.18 percent of GDP in 2050.

6 The Scenario

In the following section, we analyze the aggregate and welfare effects of the recent pension system reforms enacted by the Spanish government. All model economies begin with identical initial conditions and are based on a common baseline scenario. The key features of this scenario are described below.

Demography. The demographic evolution replicates the demographic projections for Spain for the period 2022–2072 estimated by the *Instituto Nacional de Estadística* (INE) in 2022.[16] In Panel A of Figure 5 we plot the changes in the 65+ to 20–64 dependency ratio that result from this scenario. This ratio increases from 33.1 in 2022 to 52.8 in 2070.[17]

Education. The initial educational distribution of our model economies replicates the educational distribution of the Spanish population in 2022, as reported by the INE.[18] After 2022, we assume that the educational shares for the 20-year old entrants are 7.33 percent, 62.62, and 30.05 percent forever for drop-outs, high school graduates, and college graduates. Those shares are the educational shares of the most educated cohort ever in Spain, which corresponds to the 1980 to 1984 cohort.[19] In Panel B of Figure 5 we plot the changes in the distribution of education shared by all model economies. The shares of high school drop-outs, high school graduates, and college graduates change from from 25.9, 54.3, and 19.9 percent in 2022 to 7.1, 64.7, and 28.2 percent in 2070.

Growth. We assume that the labor productivity growth rate is 0.9 percent after 2022. The rationale for this choice is because the Spanish average annual labor productivity growth rate between 1995 and 2012 was precisely 0.9 percent, according to the OECD.

Fiscal Policy. Recall that the consolidated government and pension system budget constraint in our model economy is given by:

$$G + Z + P + U = T_k + T_y + T_c + T_p + E \tag{12}$$

and that in the initial steady state, we assume that government consumption adjusts to clear the government budget. [20] In all model economies the capital income tax rates and the parameters

[16] These projections can be found at $https://ine.es/dyngs/INEbase/es/operacion.htm?c = Estadistica_C cid = 1254736176953 menu = resultadosidp = 1254735572981$.

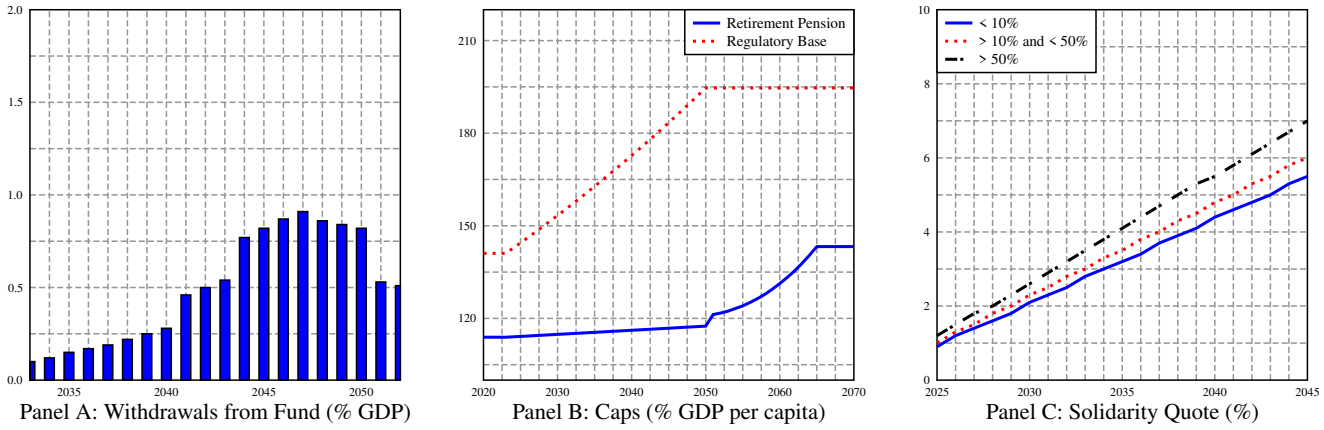
[17] We assume that the age distribution remains constant after 2072.

[18] The INE reports the educational distribution of the population by five-year age groups. We smooth this distribution through the estimation of polynomial curves.

[19] This educational transition enhances somehow the long-term sustainability of public pension systems (see, for example, Díaz-Giménez and Dáz-Saavedra, 2006), primarily due to two key mechanisms associated with rising educational attainment. First, more educated workers contribute more in payroll taxes. Second, these same individuals become entitled to higher pension benefits in the future. However, given the redistributive nature of public pension systems—typically transferring resources from high- to low-income earners—the first effect tends to dominate. As a result, educational improvements help mitigate the fiscal pressures of demographic aging. Similarly, Conesa et al. (2019) also show that higher college attainment leads to increased revenues from labor income taxes, consumption taxes, and capital income taxes.

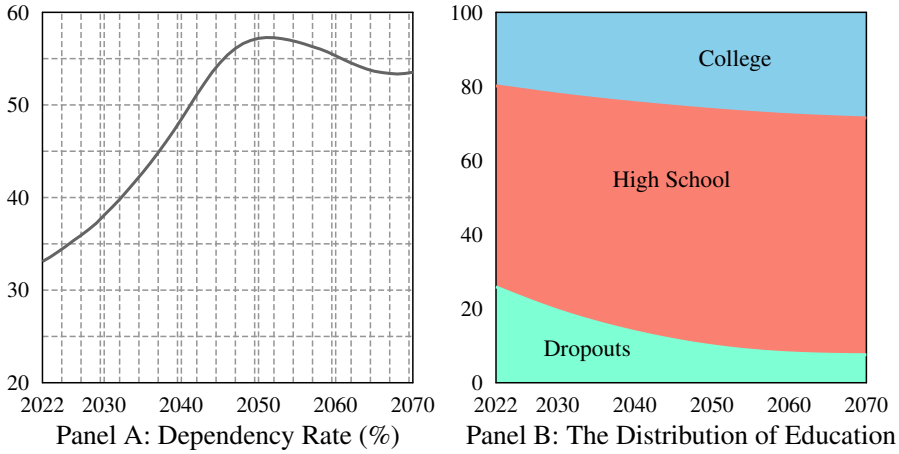
[20] We assume that during the transitional dynamics, public consumption, G_t, is a constant proportion of output at

Figure 4: The Fund, the Caps and the Solidarity Quote*



* Source: Spanish Royal Decree-Law 2/2023, of March 16, 2023, and published in the Spanish Official State Gazette, BOE-A-2023-6968, page 21.

Figure 5: The Simulation Scenarios in All Model Economies



[a] This is the ratio between the number of households in the 65+ age cohort and those in the 20–64 age cohort.
[b] This is the distribution of education of the households in the 20–64 age cohort.

that determine the household income tax function are identical and they remain unchanged at their 2022 values. The part of unintentional bequest taxed by the government is identical across the economies. The consumption tax rates differ across the economies because we adjust them to close the consolidated government budget after 2022. Every other variable in Expression (12) varies with time and differs across all economies because they are all endogenous.

Inflation. The exogenous yearly inflation rates in our model economy after 2022 is 2 percent because this is the inflation rate targeted by the European Central Bank. This assumption has two implications: first, the real value of the lower bound of the PRI is $-1.75(= 0.25 - 2.00)$ percent; and, second, the real value of the upper bound of the PRI from 2022 onwards is 0.5 percent.

Reform Announcement. We assume that all the reforms of Spanish pensions are announced and implemented at the beginning of 2023, and we also assume that these reforms were unexpected by households.

7 Results

We simulate the previous model economies using the baseline scenario that we have described in Section 6 and we illustrate the main results of our simulations in Table 5 and Figures 6 to 8.

7.1 The Spanish Pension System After the Policy Reversal.

Recall that in the *Benchmark Model Economy*, we assume that the Spanish government eliminates both the Sustainability Factor and the Pension Revaluation Index introduced by the 2011 and 2013 Pension Reforms. Our simulations show that the pay-as-you-go, defined benefit pension system that prevailed in Spain after that policy reversal was completely unsustainable. Specifically, we find that the pension system deficit would be 6.10 percent of GDP by 2050 (see third block of Table 5 and Panel C of Figure 6), and that the consumption tax rate needed to finance this pension deficit would be 30.66 percent that same year, 12.06 percentage points higher than the value observed in 2022 (see Panel E of Figure 6).[21]

market prices. Alternatively, one might assume that public consumption remains constant at the Benchmark economy level throughout the transition path of the Reformed Economy. This approach is convenient if one considers that public consumption also generates some utility benefits for households, so that they can be neglected in the welfare calculation. In contrast, our modelling choice assumes that public consumption remains constant as a fixed proportion of GDP in both transitional dynamics (the Benchmark and the Reformed economies), so that the consumption per capita differs throughout both economies. However, since the pension reform brings non-significant variation over the output level, the differences in per capita public consumption across both economies under this assumption are almost insignificant.

[21] Figure 6 shows the dynamics of key macroeconomic variables for both the Benchmark Economy and the economy in which all parametric changes to the public pension system (ALL) are implemented simultaneously.

We also find that this sustained increase in the pension deficit is mainly structural. Specifically, we find that the pension system expenditures increase by more than 4.5 percentage points of GDP over the coming decades, from 12.92 percent of GDP in 2022 to 17.66 percent in 2050 (see Panel B of Figure 6). However, the variation in the pension system revenues is much lower since payroll tax revenues are 12.16 percent of GDP in 2022 and 11.56 percent in 2050 (see Panel A of Figure 6). [22]

Thus, we conclude that the policy reversal on the public pension system carried out by the Spanish government was a bad idea, since the 2011 and 2013 Pension Reforms would have improved the sustainability of Spanish pensions substantially, avoiding the tax increases that would have been necessary to finance the pension system deficits.[23]

7.2 The Sustainability of the Reformed Pension System.

Recall that this is the model economy where we introduce all the aforesaid parametric reforms implemented by the Spanish government since 2022. We start by studying these reforms one at time to explore which parametric change is quantitatively more important.

We begin by analysing the consequences brought about by the introduction of the Intergenerational Equity Mechanism (IEM). Our results show that the additional payroll tax revenues collected by the government with this new tax reach 0.52 percent of GDP in 2050, a number which is in line with the findings reported by AIReF (2023) and De la Fuente (2023). In addition, we also find that this parametric change would reduce the tax rate needed to finance the pension deficit, since the consumption tax rate is 30.66 percent in the Benchmark Model Economy in 2050, and 29.51 percent after this parametric change that same year. This is because, under the IEM, the government can sell a limited amount of assets from the accumulated pension fund in order to finance part of the aforesaid deficit (see Figure 4). Consequently, and in conclusion, the IEM helps very little to cope with the sustainability problems that plague the Spanish Public Pension System.

We also find that the increase of the annual pension reward (APR) for those who delay retirement after the full entitlement retirement age does not bring significant variation to the pension system balance, and this is because this change causes two main effects that tend to cancel each other. First, the increase in the annual premium induces workers to delay retirement, since the average retirement age has increased by 0.40 years in 2050, so that there is an increase in payroll tax collections and a reduction in pension expenditure. However, this increase in the annual premium also increases the average retirement pension by 2.98 percent that same year. Consequently, there

[22] The pension system revenues include the government's transfers to the system, which account for 1.10 percentage points of GDP. The rationale for this is because this was the amount of fiscal resources that the Spanish government transferred to Social Security in 2022, to pay non-contributory pensions and those of public employees.

[23] This is the conclusion of previous studies such as Díaz-Giménez and Díaz-Saavedra (2017) and De la Fuente et al. (2018).

is no significant variation in the pension system imbalance.

Another parametric change, remember, is the increase in both the payroll tax cap and the maximum pension (CAPS). As the growth rate of the payroll tax cap is higher than the growth rate of the maximum pension, these changes reduce the long-run pension deficit from 6.10 percent to 5.63 percent of output in 2050. Consequently, the consumption tax rate needed to finance the pension deficit decreases by 0.59 percentage points that same year, from 30.66 percent to 30.07 percent. On the negative side, however, this change reduces the contributivity of the system, due to the increasing gap between the payroll tax cap and the maximum Retirement Pension.

Table 5: Simulation Results

Model	Rev	Exp	Def	Deb	τ_c	AvP	AvA	Y
2022								
BEN	12.16	12.92	0.76	0.00	18.60	100.00	64.06	100.00
2030								
BEN	12.02	13.66	1.64	8.84	21.50	108.20	64.45	108.63
IEM	11.97	13.54	1.57	8.02	21.73	107.20	64.43	108.85
APR	12.07	13.31	1.24	6.49	20.53	107.87	64.62	109.07
CAPS	12.21	13.68	1.47	7.61	21.05	107.51	64.40	108.46
QUOTA	12.17	13.57	1.40	7.47	21.07	107.21	64.46	108.53
PMIN	12.00	13.77	1.76	9.41	21.62	108.40	64.41	108.27
ALL	12.29	13.73	1.44	8.38	21.47	110.75	64.60	109.10
2050								
BEN	11.56	17.66	6.10	85.79	30.66	134.50	66.04	125.46
IEM	11.53	17.83	6.30	86.77	29.51	134.14	65.87	125.36
APR	11.60	17.49	5.88	79.97	30.28	138.51	66.44	126.87
CAPS	12.12	17.75	5.63	78.90	30.07	133.96	65.95	125.08
QUOTA	11.53	17.67	6.14	80.35	30.91	134.24	65.96	125.48
PMIN	11.51	17.90	6.38	91.15	31.32	134.61	65.84	124.71
ALL	12.17	17.89	5.72	78.04	28.29	139.43	66.68	126.70
2070								
BEN	11.58	17.45	5.87	207.81	30.25	165.32	65.53	152.70
IEM	11.55	17.40	5.85	209.11	29.51	163.68	65.46	152.84
APR	11.63	17.27	5.63	195.38	29.77	170.25	66.06	154.31
CAPS	12.19	17.20	5.00	186.26	28.92	162.20	65.57	152.79
QUOTA	11.58	17.31	5.72	200.05	30.14	163.90	65.59	152.69
PMIN	11.56	17.47	5.91	215.22	30.49	164.01	65.44	152.00
ALL	12.18	17.93	5.75	196.30	29.34	174.96	65.88	154.12

Rev: Pension revenues (% GDP); Exp: Pension expenditures (% GDP); Def: Pension system deficit (% GDP); Deb: Accumulated pension debt (% GDP, 2022=0); τ_c: Consumption tax rate needed to finance the pension system (%); AvP: Average pension (2022=100); AvA: Average retirement age; Y: Output index (2022=100); BEN: No change in pension policy; IEM: Increases the payroll tax rate; APR: Increases the annual pension reward for working beyond the full retirement age; CAPS: Increases both the real cap of the regulatory base and the real maximum pension; QUOTA: Increases the payroll tax rate for workers whose earnings exceed the regulatory base cap; PMIN: Increases the minimum retirement pension; ALL: Includes all of the above parametric changes.

In contrast to previous research papers, we find that the introduction of the solidarity quota

(QUOTA) also brings no significant variation in pension revenues, even though it involves an additional payroll tax on those earnings that exceed the cap of covered earnings.[24] This is so because our model economy predicts that high earners choose to retire earlier in order to avoid paying more payroll taxes. Finally, and as expected, the rise of the minimum retirement pension (PMIN) increases pension expenditure. For instance, pension expenditure to output ratio increased from 17.66 to 17.90 percent in 2050, and this is due to two main reasons. First, because the average retirement pension increases by 0.1 percent that same year. And second, because a higher minimum pension decreases the average retirement age by 0.2 years, especially for low-earning workers. Not surprisingly, then, this last parametric change increases the long-run pension imbalance while reducing the contributory nature of the pension system.

Overall assessment. We quantified the effects of different parametric changes enacted by the Spanish government since 2022. Some of these changes affect pension expenditure and others affect pension revenues. Other differences concern the consequences of these changes over the contributivity, the tax burden, or the incentives to remain in the labour market after the first retirement age. For instance, the parametric changes CAPS and PMIN reduce the contributivity of the system; QUOTA increases the effective payroll tax rate on high earners; and PMIN and IEM reduce the incentives to work beyond the first retirement age. Finally, APR increases the incentives to delay retirement after the full entitlement retirement age.

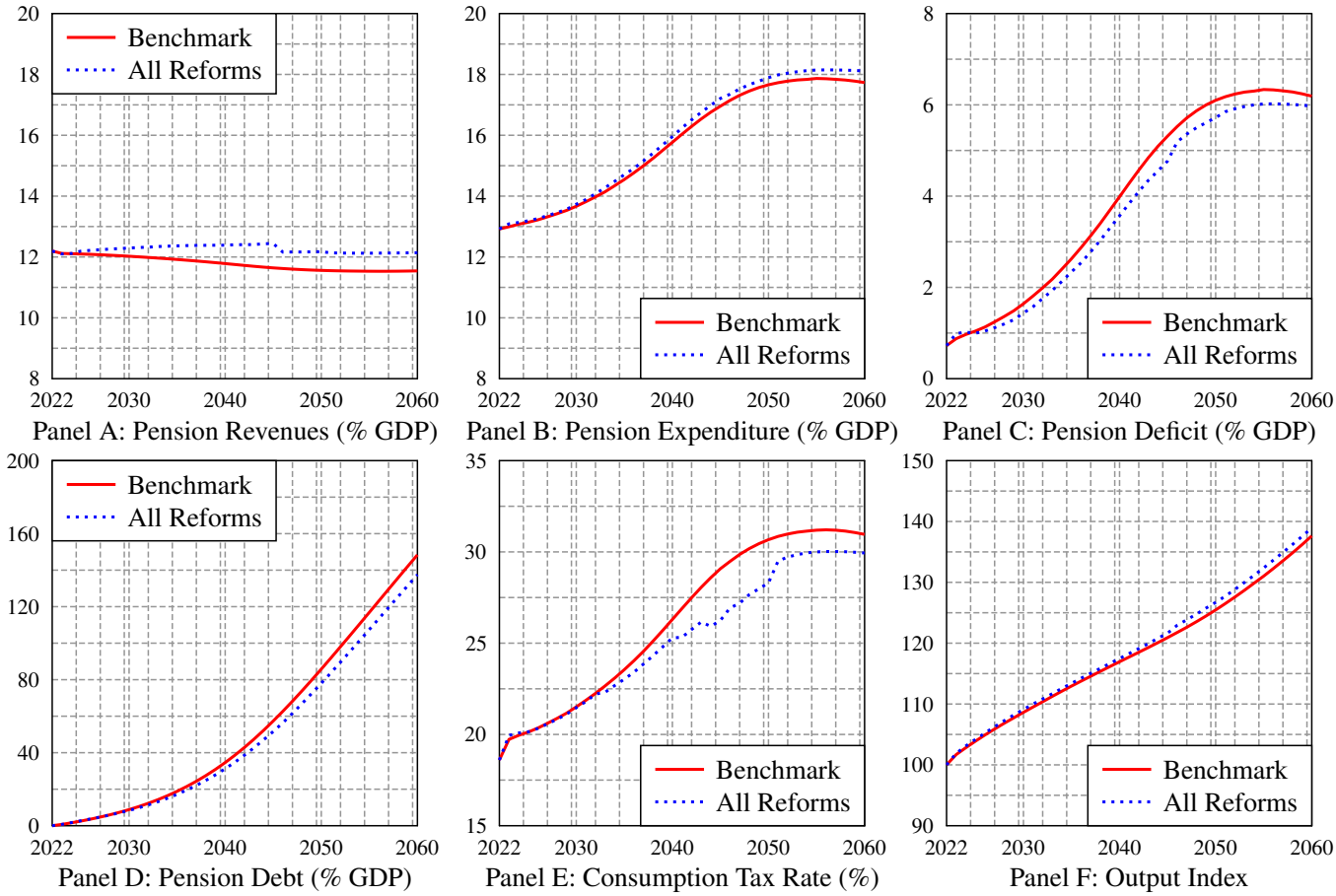
However, these parametric changes share a common feature: when they are simulated one at a time, their quantitative effects on the Spanish Pension System balance are rather limited. This is also reflected in the evolution of the debt, as a share of output, accumulated by the system in the long run, since this ratio is rather similar across all economies (see column five of Table 5).[25] Thus, and not surprisingly, when we then simulate all these changes simultaneously (ALL), we continue to find no significant differences in the medium- and long-term pension imbalance, since, for instance, the pension deficit only decreases from 6.10 to 5.72 percent of GDP in 2050. Put differently, the long-run sustainability problems that plagued the Spanish Public Pension System after the pension policy reversal that took place in 2021 are not solved by the new wave of changes approved thereafter.[26] Similarly, the aggregate consequences do not differ significantly across economies, since output developments are rather similar across them.

[24] Both AIReF 2023 and De la Fuente 2023 find that this change will increase payroll tax collections by 0.1 percent of GDP.

[25] To compute this ratio, we sum the pension deficits, as a share of output, starting in 2023.

[26] Looking at the fine print, this reform reduces the consumption tax rate needed to finance the pension deficit by more than two percentage points, from 30.66 to 28.29 percent in 2050, also because part of this deficit is financed with the withdrawals from the Pension Reserve Fund.

Figure 6: The Benchmark and the Reformed Model Economies



7.3 Welfare Consequences

Our work assumes that the aforesaid parametric changes in the Spanish pension system are unexpected by households. As a result, since the reform is announced and implemented immediately, this could therefore lead to important changes in the well-being of people alive at the time of the pension reform, at least for some socioeconomic groups.

To analyse the welfare consequences of the aforesaid pension reform, we compute the change in the expected lifetime utility by age and education, $x_{j,h}$, for both, those alive at the moment of the reform, 2023, and those newborns since this same year. Specifically, we compute:

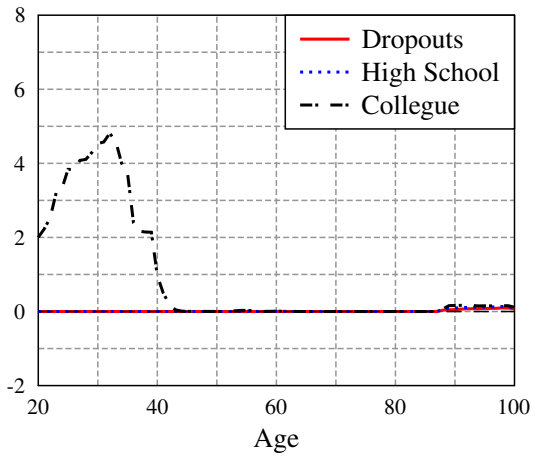
$$x_{j,h} = \left[\frac{V^R_{j,h}}{V^B_{j,h}} - 1 \right] \times 100$$

where $V^B_{j,h}$ and $V^R_{j,h}$ are the expected lifetime utility by age j and education h in the Benchmark and the Reformed Model Economies, respectively. Moreover, and following Díaz-Saavedra et al. (2023), the expected lifetime utility is computed as

$$V_{j,h} = \mathbb{E}\sum_{j=i}^{100} \beta^{i-20}\psi_i \Big[u(c_{i,h}, l_{i,h}) - \gamma e\Big] \tag{14}$$

where β is the time discount factor, u satisfies standard assumptions, $c_{i,h}$ and $l_{i,h}$ are consumption and labor supply of households aged i with education h, γ represents a job search utility cost, and e equals 1 in periods of active job search and is zero otherwise. Finally, $i = 20$ in the case of newborns, and $i > 20$ otherwise.

Figure 7: The compensation to those alive in 2023 (% GDP per capita)



Alive. We find that for those households alive at the moment of the reform, young high-earning workers face welfare losses. This is due to several reasons: *i)* these workers have earnings well above the payroll tax cap, so that the increase in the payroll tax cap involves a larger part of their earnings subject to the payroll tax; *ii)* because they must pay a new tax rate on earnings from work that exceed the cap of the payroll tax, where this additional tax ranges from 5.5 to 7 percent; *iii)* because these workers are also those who suffer the most from the loss of contributivity of the system due to the increasing gap between the payroll tax cap and the maximum retirement pension; *iv)* because they also pay higher payroll taxes due to the implementation of the IEM; and *v)*, since this group does not benefit from the increase in the minimum retirement pension due to their high past earnings.[27].

On the other hand, low earners face small welfare gains because although they pay higher contributions (IEM), the use of the Reserve Fund slightly reduces the consumption tax rate needed

[27]These short term welfare losses are consistent with the findings from other research papers on social security reform (see for example Conesa and Garriga (2008); McGrattan and Prescott (2017), and Díaz-Saavedra et al. (2023))

to finance the pension deficit. In addition, these workers will benefit the most from the higher minimum retirement pension that they could receive when they leave the labour market.

We then analysed the potential fiscal cost for the Spanish government if it decides to implement a transfer programme to compensate those currently alive households that face welfare losses, so that they would not, ex-post the government transfers, feel adversely affected under the reformed public pension system. According to this scheme, those households alive in 2023 facing welfare losses would receive a one-time transfer to overcome their losses, so that they become indifferent over whether they are living in the Benchmark or the Reformed Economy.

Finally, to quantify the fiscal cost of this hypothetical compensation programme, we simply add up the amounts, as a percentage of GDP per capita, that should be received by people facing welfare losses due to the introduction of the pension system reform. The compensation for these welfare losses is shown in Figure 7.[28] Specifically, this figure shows that college workers aged 20 to 42 years old in 2023 should be compensated to cover their welfare losses, and that these unique transfers they should receive may reach up to 5 percent of output per person aged 20 and over.[29] This is so, since this is the earnings group that in the near future will hold the highest labour income in the economy, and which will therefore be the most affected by the gradual increase in the payroll tax cap, the solidarity quota, and the Intergenerational Equity Mechanism. Moreover, if this transfer programme was implemented, its fiscal cost would result in 0.3 percent of GDP, approximately 4.5 billion in 2023 euros.

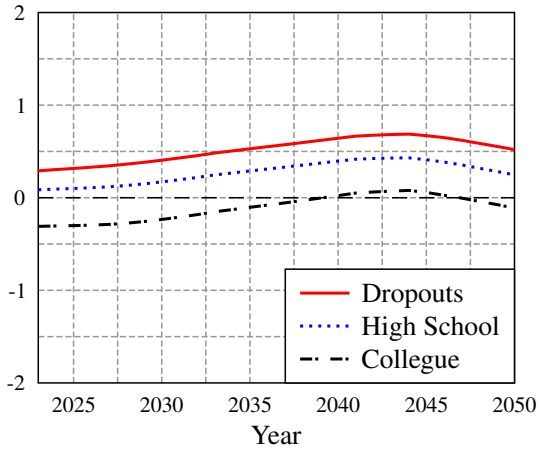
New Borns. Similar to those alive at the moment of the reform, newborns aged 20 years old would face welfare gains or losses depending on their educational attainment. Figure 8 shows the change in the expected lifetime utility of newborns according to their education. The figure shows short-term welfare losses for college households, but their less-educated counterparts gain in terms of expected lifetime utility, mainly because of the higher minimum pension and the slightly lower consumption tax rate.

Overall assessment. Our results shows that this pension reform hurts current and future high earners' welfare, mainly because the higher payroll taxes they have to pay. On the other hand, however, dropouts and high school households benefit slightly from the reform despite the introduction of the Intergenerational Equity Mechanism (IEM), which increases the payroll tax rate, because the

[28] Figure 7 shows the one-off public transfers, disaggregated by age and educational attainment—measured as a percentage of per capita GDP for individuals aged 20 and over—needed to compensate exclusively those adversely impacted by the pension system reform.

[29] This number was around 2,000 euros in 2023, according to the Spanish National Institute of Statistics. These results reflect the fact that the reformed economy delivers a lower consumption tax rate during the household's lifetime, since part of the pension deficit is financed with the withdrawals from the Pension Reserve Fund. Consequently, this positive effect reduces the losses faced by middle-aged and college workers. In auxiliary simulations where we have assumed that both model economies, the Benchmark and the Reformed economies, share the same sequence of consumption tax rates, not only are the compensations for college workers higher, but also the transfers to their less-educated counterparts become positive.

Figure 8: The change in Expected Lifetime Utility of future Newborns (%)



higher minimum pensions and the lower consumption tax rate.

However, a closer look at the results shows that the welfare consequences we report are also influenced by the fact that pension fund withdrawals help to reduce the pension system deficit. As a result, these withdrawals ultimately lower the consumption tax rate required to balance the consolidated government budget. Alternatively, if these pension fund withdrawals were instead used to finance additional public spending that does not benefit households directly, rather than covering part of the pension system deficit, the required consumption tax rates to balance the government budget would be higher. As a result, welfare gains would be diminished (and losses amplified).[30]

8 Policy Implications

Our previous findings suggest that the policy reversal implemented in 2021 has led the Spanish public pension system back to a future of financial unsustainability. Moreover, the recent reforms enacted in 2022 and 2023 are demonstrably insufficient to address these projected imbalances. Therefore, we conclude that further reforms to the public pension system in Spain are likely imminent.

Two key questions naturally emerge. First, what type of reform should be implemented? Second, considering that these reforms often result in welfare losses for certain socioeconomic groups,

[30]In an auxiliary exercise, we re-simulated the reformed economy under the assumption that it maintains the same consumption tax rate as the benchmark economy and that withdrawals from the Pension Fund are effectively discarded. The results indicate that: (*i*) all future generations experience welfare losses; (*ii*) Welfare losses among households alive at the time of the 2023 reform increase markedly across all educational groups; and (*iii*) the fiscal cost of compensating these households for their welfare losses increases up to 4.8 percent of GDP.

particularly those living during their implementation, how can such reforms be prevented from persisting over time?

Regarding the first question, Bouchet et al. (2017) demonstrate that a single parametric change would have severe repercussions on the broader economy. Therefore, they advocate for pension reforms comprising a policy mix that includes taxation, benefits, and adjustments to the legal retirement age. Automatic Adjustment Mechanisms (AAMs) can serve as effective tools to prevent pension schemes from becoming increasingly unsustainable as populations age (OECD, 2021). Two AAMs, in particular, are especially effective in restoring pension sustainability while also functioning as mechanisms of intergenerational solidarity. First, sustainability factors, which adjust the initial benefit based on changes in life expectancy; and second, pension indexation rules, aimed at ensuring a balanced budget of the pension scheme.

The low replacement rates, however, have yet another significant consequence: the necessity for lower retirement pensions to be supplemented through private savings. As a result, the introduction of mandatory individual capitalization accounts for both workers and companies emerges as not only prudent but essential. This measure ensures that individuals can build a more secure financial cushion for their retirement, compensating for the inadequacies of public pension schemes. By compelling the establishment of these accounts, it promotes a culture of personal responsibility and long-term financial planning, which is increasingly vital in the face of demographic changes.

In relation to the second question, James and Brooks (2001) highlight various strategies that governments have employed to compensate those negatively affected by policy changes, aiming to gain support for pension reform. Notable among these strategies are the ability to exempt specific groups from the reform's provisions, provide cash benefits and tax incentives, offer concessions to other sectors, and make political appointments to facilitate the reform process. Thus, a compensatory transfer programme seems to be an essential complement to any reform of the pension system, if such reform is to last over time.

On the other hand, Spain is not the only country facing serious financial problems in its public pension system. For instance, The 2024 Ageing Report (European Commission, 2024) projects significant increases in public pension expenditure across European countries, with Luxembourg facing the largest increase in pension expenditure as a percentage of GDP. Consequently, and to ensure the future sustainability of their pension systems, these countries need reforms that limit the tax increases required to finance pension deficits. While some countries, such as Italy, Latvia, and Sweden, have successfully implemented Automatic Adjustment Mechanisms (AAMs) to address demographic changes, many others lack these mechanisms (Cyprus, Hungary, Ireland, Malta, and Slovenia, are some examples), which are crucial for maintaining pension sustainability (see Pensions at Glance 2021).

In conclusion, many countries, apart from Spain, will eventually need comprehensive reforms

to their pension systems. However, such reforms, which may reduce retirement income, could face political opposition. To mitigate this, governments could introduce compensatory transfer programs for those negatively impacted by the reforms. In a companion paper, we show that it is possible to design a package that includes a reform of the Spanish pension system, aimed at addressing its sustainability challenges, while also introducing a public transfer scheme, and that this reform would ensure a Pareto-improving transition from the current pension system to the new one (see Díaz-Giménez and Díaz-Saavedra, 2025).

9 Conclusions

The pension reforms enacted in Spain in 2011 and 2013 significantly improved the sustainability of the country's public pension system and reduced the need for tax increases to finance future deficits. However, this progress came at the cost of substantial reductions in the real value of pensions, leading to a reversal of these policies in 2021. As a result, Spain returned to an unsustainable pay-as-you-go public pension system.

To address the issue, the Spanish government approved a series of parametric changes beginning in 2022. Unfortunately, the findings of this study indicate that these recent reforms fail to resolve the system's financial challenges and, more critically, squander valuable time that could have been used to implement a more sustainable long-term solution.

The 2011 and 2013 reforms, although incomplete, marked a critical step toward ensuring sustainability. However, they were not accompanied by additional measures, such as guaranteeing a real minimum pension, introducing tax incentives for savings in individual capitalization accounts to complement retirement savings, or compensating households that were negatively affected by the reforms. These missed opportunities now appear more appropriate than the policy reversal that followed.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

[1] AIReF, (2023). Opinión, sobre las sostenibilidad de las Administraciones Públicas a largo plazo: la incidencia de la demografía. Opinión 1/23.

[2] Anghel B., H- Basso, O. Bover, J. M. Casado, L. Hospido, M. Izquierdo, I. A. Kataryniuk, A. Lacuesta, J. M. Montero, and E. Vozmediano, (2018). La Desigualdad de la Renta, el Consumo, y la Riqueza en España. *Documentos Ocasionales 1806*, Banco de España.

[3] Bouchet, M., L. Marchiori, and O. Pierrard, (2017). Pension Reform in a Worst Case Scenario: Public Finance Versus Political Feasibility. *Journal of Pension Economics and Finance*, 16(2), 173-204.

[4] Brogueira de Sousa, J., J. Díaz-Saavedra, and R. Marimon, (2022): Introducing an Austrian Backpack in Spain. *SERIEs, Journal of the Spanish Economic Association*, vol. 13 (3), pp 513-556.

[5] Calonge S., and J. C. Conesa, (2003). Progressivity and Effective Income Taxation in Spain: 1990 and 1995. *Centre de Recerca en Economia del Benestar*.

[6] Castaneda, A., J. Díaz-Giménez and J.-V. Rios-Rull, (2003). Accounting for the US earnings and wealth inequality. *Journal of political economy*, vol. 111 (4), pp 818–857.

[7] Conesa J.C., T. J. Kehoe, V. N. Nygaard, and G. Raveendranathan, (2020). Implications of Increasing College Attainment for Aging in General Equilibrium. *European Economic Review* vol. 122.

[8] Conesa, J. C., and C. Garriga, (2008). Optimal Fiscal Policy in the Design of Social Security Reforms. *International Economic Review*, vol. 49 (1), pp 291–318.

[9] Conesa J., and D. Krueger, (1999). Social security with heterogeneous agents. *Review of Economic Dynamics* 2, 757–795.

[10] De la Fuente, A., M. A. García-Díaz, and A.R. Sánchez-Martín, (2018). La salud financiera del sistema público de pensiones español: proyecciones de largo plazo y factores de riesgo. *Fedea Policy Papers*, 2018/03.

[11] De la Fuente, A., (2023). Los efectos presupuestarios de la reforma de pensiones de 2021-23: iii) impacto total y la cláusula de salvaguarda del MEI. FEDEA, Estudios sobre la Economía Española 2023/13.

[12] De Nardi M., S. Imrohoroglu, and T. Sargent, (1999). Projected US demographic and social security. *Review of Economic Dynamics* 2, 575–615.

[13] Díaz-Giménez J., and J. Díaz-Saavedra, (2025). Public pensions reforms: financial and political sustainability. *European Economic Review*, vol. 175, Issue C.

[14] Díaz-Giménez J., and J. Díaz-Saavedra, (2017). The Future of Spanish Pensions. *Journal of Pension Economics and Finance*, vol. 16 (2), pp 233-265.

[15] Díaz-Saavedra J., (2020). The Fiscal and Welfare Consequences of the Price Indexation of Spanish Pensions. *Journal of Pension Economics and Finance*, vol. 19 (2), pp. 163-184.

[16] Díaz-Saavedra J., (2016). Productividad y Viabilidad del Sistema Público de Pensiones. *Hacienda Pública Espaõla / Review of Public Economics*, vol. 218, pp. 11-32.

[17] Díaz-Saavedra J., J. Brogueira de Sousa, and R. Marimon (2023). A Worker's Backpack as an alternative to PAYG pension systems. *Journal of the European Economic Association*, vol. 23 (5), pp 1944-1993.

[18] Díaz-Giménez J., and J. Díaz-Saavedra, (2006). The Demographic and Educational Transitions and the Sustainability of the Spanish Pension System. *Moneda y Crédito*, 222, 223–270.

[19] European Commission (2024). The 2024 Ageing Report: Economic and budgetary projections for the EU Member States (2022-2070). European Economy Institutional Paper 279, April 2024. Brussels.

[20] Fehr H., M. Kallweit, and F. Kindermann (2012). Pension reform with variable retirement age: a simulation analysis for Germany. *Journal of Pension Economics and Finance*, 11(3), pp. 389-417.

[21] Gouveia M., and R. P. Strauss, (1994). Effective Federal Individual Income Tax Functions: An Exploratory Empirical Analysis. *National Tax Journal*, vol. 47, 2, pp 317–339.

[22] Guner, N., R. Kaygusuz, and G. Ventura (2014). Income Taxation of US Households: Facts and Parametric Estimates. *Review of Economic Dynamics*, 17(4), pp. 559-581.
Imr Imrohoroğlu S., and S. Kitao, (2012). Social Security Reforms: Benefit Claiming, Labor Force Participation and Long-run Sustainability. *American Economic Journal: Macroeconomics*, vol. 4(3), pp 96-127.

[23] James, E., and S. Brooks, (2001). The Political Economy of Structural Pension Reform. *New Ideas about Old Age Security*, Robert Holzmann and Joseph Stiglitz, eds., World Bank.

[24] Jimeno, J. F., J. A. Rojas, and S. Puente, (2008). Modelling the impact of aging on social security expenditures. *Economic Modelling*, vol. 25(2), pp 201-224.

[25] McGrattan, E. R., and E. C. Prescott, (2017). On financing retirement with an aging population. *Quantitative Economics*, vol. 8 (1), 75–115.

[26] Ministerio de Inclusión, Seguridad Social y Migraciones, (2024). Fondo de Reserva. Informe a las Cortes Generales.

[27] OECD, (2021). Pensions at a Glance 2021: OECD and G20 Indicators, OECD Publishing, Paris.

Appendix

In Brogueira de Sousa et al. (2022) and Díaz Saavedra et al. (2023) we describe in detail the calibration procedure. However, and having in mind that this version of the model is an enhancement of that model economy, we describe below how we calibrate the new parameters that appear in this model economy.

New calibrated parameters

The fiscal policy. This version of our model economy assumes the income tax function proposed by Gouveia and Strauss (1994). To identify this function, we must choose the values of parameters a_0, a_1, and a_2. Following Díaz Saavedra (2020), we set $a_0 = 0.45$, $a_1 = 1.071$. To determine a_2, we impose that the model economy ratio income tax revenues to output at market prices, should replicate its Spanish counterpart in 2022. According to the Spanish National Institute of Statistics, INE, this ratio was 9.15 percent in that same year. Consequently, we set $a_2 = 0.4094$.

The pension system. In 2022 in Spain, the payroll tax rate paid by households was 28.3 percent and it was levied only on the first 49,672 euros of annual gross labor income, which corresponds to 141.75 percent of per GDP per person aged 20+.[31] Consequently, we set the both the maximum tax cap and the maximum covered earnings as 1.4175 of model economy per capita output. To determine the payroll tax rate, we impose that the model economy ratio payroll tax collections to output at market prices be 11.06 percent, which is the value observed in the Spanish economy in 2022. This implies that the payroll tax rate of our model economy is $\tau_p = 0.251$.[32]

Our choice for the number of years used to compute the retirement pensions in our benchmark model economy is $N_b = 25$. This is because in 2022 the Spanish *Régimen General de la Seguridad*

[31] In Spain in 2022, the GDP per person who was 20 or older was 35,040.3 euros.

[32] However, the total pension system revenues that we target include the government's transfers to the pension system, which account for 1.1 percentage points of GDP. This is because this was the amount of fiscal resources that the Spanish government transferred to Social Security in 2022, to pay non-contributory pensions and those of public employees.

Social took into account the last 25 years of contributions prior to retirement to compute the pension. Our choice for the first and normal retirement ages are $R_0 = 62$ and $R_1 = 66$, so that to identify the early retirement penalty function, we choose $\rho_0 = 0.28$, and $\rho_1 = 0.07$. This is because we have chosen $R_0 = 62$.

We assume that the minimum and the maximum pension, are also directly proportional to per capita income. Specifically, we assume that the minimum pension, $\underline{p}$, is 27.36 percent of model economy output per capita. For the maximum pension, $\overline{p}$, we assume that this number is 112.65 percent. These numbers correspond to their values in 2022, since in that year, the minimum yearly retirement pension in Spain was 9,590.1 euros, and the maximum yearly pension was 39,474.3 euros. Finally, we assume that the fictitious quote is 24 percent of per capita output, so that we set $y^{fq} = 0.24y$.

9.1 Changes with respect to the previous version.

Recall that this version of the model chooses 2022 as a calibration target year. In addition, this version introduces many of the institutional features of the current Spanish public pension system in great detail. Consequently, we have had to change the value of some of the parameters with respect to their assigned values in Díaz Saavedra et al. (2023) during the calibration process . Table 6 shows the previous and the current values for these parameters. The rest of parameters of the model economy continue to have the same values as in that paper.

Table 6: Parameters: actual and past values

	Parameter	This version	Díaz Saavedra et al. (2023)
Preferences			
Time preference	β	0.9803	0.9965
Leisure weight	γ	1.6812	1.7281
Disutility of labor	α	78.0001	28×10^4
Int. elast. of subst.	φ	0.5000	0.1000
Productivity			
Productivity shock	$z(2)$	2.4301	2.3490
Productivity shock	$z(3)$	7.9001	5.9042
Probability	z_{21}	0.0330	0.0291
Probability	z_{22}	0.9670	0.9708
Technology			
Productivity growth rate	g	0.0090	0.0000
Depreciation rate	δ	0.1185	0.1138
Public Pension System			
Replacement rate	p_r	0.9924	0.7650
Payroll tax rate	τ_p	0.2510	0.2599
Fiscal Policy			
Unemployment replacement rate	b_0	0.3958	0.3751
Consumption tax rate	τ_c	0.1860	0.2599
Capital income tax rate	τ_k	0.2940	0.2500