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Abstract

This paper simulates the future performance of the Spanish pension system using a large OLG model. We compare the system in place after the 2011 pension reform to that emerging after the latest (2013) institutional changes. In particular, we explore the workings of the new indexing mechanism, linking pension payments to life expectancy and to the system's aggregate flows of income and expenditure. We consider several alternative eco-demographic environments in our analysis and assess the welfare consequences for the different cohorts affected. Overall, the new *automatic adjusting mechanism* is broadly successful in its goal of stabilising the financial condition of the system. But the welfare costs imposed on some cohorts (*e.g.* young workers at the beginning of the reform) is very heavy.

Keywords: pension reform, automatic adjustment mechanism, population aging, Spain.

JEL classification: D58, H55, J11.

Resumen

En este trabajo se utiliza un modelo de generaciones solapadas (OLG) para simular el comportamiento futuro del sistema de pensiones en España. Se compara el sistema en vigor tras la reforma de 2011 con varias alternativas que incluyen diversos diseños institucionales. En concreto, se explora el funcionamiento de los nuevos mecanismos de indexación introducidos en 2013 (que vinculan los pagos de pensiones con la esperanza de vida y con los flujos agregados de ingresos y gastos del sistema). El análisis contempla diversos entornos ecodemográficos para la simulación y evalúa el impacto de las reformas sobre el bienestar de las diversas cohortes afectadas. Encontramos que, en conjunto, el nuevo sistema de ajuste automático tiene bastante éxito en su objetivo de estabilizar la condición financiera del sistema de pensiones. Pero los costes de bienestar impuestos sobre algunas cohortes (especialmente sobre los trabajadores jóvenes en el momento en que la reforma se pone en marcha) son muy elevados.

Palabras clave: reforma de pensiones, mecanismos de ajuste automático, envejecimiento poblacional, España.

Códigos JEL: D58, H55, J11.

1 Introduction

The 2007's financial and economic crisis marks the beginning of period of turmoil for Spanish Fiscal institutions. Among them, the pension system is probably the one that has seen the biggest changes. It has found itself under the double threat of substantial immediate deficits (due to the drop in affiliation) and long term financial insolvency (due to demographic change). This situation has led to a major institutional reform, implemented in two steps in August 2011 and December 2013. The process started with the pass (as part of a global austerity package under the supervision of the European Commission) of law 27/2011 (BOE (2011)). It combined a *parametric* reform delaying the “legal” retirement ages of the system and the extension of the averaging period in the pension formula. And, more importantly, the introduction of an “automatic balancing mechanism” (ABM) to be started in 2027, but whose design was postponed for later development. The inclusion of an ABM was a significant break with a previous history characterized by numerous *parametric* reforms¹. In May 2013 a dedicated committee of experts produced a concrete proposal for the design of the Spanish's ABM. It advocated the ending of the current indexation of pension payments to inflation. Instead, it proposed a doubled indexation to changes in life expectancy and to the financial condition of the pension system (see section 4.2.1 for a detailed discussion). The proposal became law in December (BOE (2013)), although the finally approved version reduced the scope of the initial proposal (by forcing the new indexing rules to stay within a narrow corridor of upper and lower limits).

After these policy decisions, Spain joins the growing group of countries whose pension systems includes automatic adjustments mechanisms.² Adjusting for gains in life expectancy, in particular, is becoming increasingly popular among OECD countries.³ Linking retirement ages to life expectancy is the top proposal in the latest EU “aging report” (European-Commission (2012b)). In contrast, the number of countries with macro-linked ABM is clearly smaller. Germany, Japan and Sweden are the most outstanding examples (see Boado-Penas et al. (2009)). With the exception of Sweden, none of these countries's schemes feature an explicit mechanism that *guarantees* the correction of emerging deficits. It is in this regard that the Spanish reform stands out among its international peers.

In this paper we analyze the future financial health of the Spanish PAYG pension system, after and before the recent reforms. More specifically, we have two main specific **research targets** for this project:

1. Evaluate in quantitative terms the ability of the new ABM system to restore the long term financial health of the Spanish PAYG pension system. The system in place after the 2011 reform is taken as the reference for comparison.
2. Explore the consequences of the ABM mechanism on the welfare of the different cohorts involved.

The original proposal by the expert committee was designed to guarantee the financial equilibrium, measured over a broad interval representing a complete business cycle. The inclusion of exogenous bounds on the dynamics of the index used for the annual updating of pensions,

¹The Spanish pension system has seen reforms of importance in 1986, 1997 and 2001, together with numerous less ambitious changes.

²The economic literature that discusses the different approaches is also expanding. A good summary of the arguments can be found in, for example, Diamond (2004). Reducing *Political risk* is one of the strongest points favoring automatic adjustment. See, for example, Cremer and Pestieau (2000).

³According to OECD (2011), “around half of OECD countries have elements in their mandatory retirement-income provision that provide an automatic link between pensions and a change in life expectancy.”

however, puts this target in jeopardy. Furthermore, the mechanism proposed in the final law ignores the balance sheet of the system (ie, its implicit liabilities) and waits to take action until the imbalances emerge in the systems' flow of income.⁴ This strategy has distributional consequences, shifting a larger share of the burden from older to younger and future cohorts.

Our **modeling strategy** rests on building and calibrating a large *general equilibrium* model of the Spanish economy. Following recent developments in the Auerbach and Kotlikoff (1987) tradition, we build a world of overlapping generations with substantial intra-cohort heterogeneity.⁵ This technique is very computationally intensive, but has the crucial advantage of guaranteeing aggregate consistency. This is of paramount importance for pension analysis because (as argued in eg. Jimeno et al. (2008)), changes at the micro level modify the behavior of pension's aggregates and macroeconomic variables. For example, the increase in pension expenditure resulting from a change in the pension formula cannot be analyzed using historical participation rates and pension coverage rates. Both variables will change endogenously with the reform and should be computed at the same time as the new pension replacement rates (the obvious target of the reform). General equilibrium models provide a natural environment for the analysis of large institutional reform, like big changes in pension's structure. This methodology has been extensively used to explore pension reform, including a few analysis of existing ABM schemes and alternative proposals.⁶

Unfortunately, general equilibrium models also have some remarkable drawbacks. Two of them are particularly relevant for pension modeling: (1) they tend to be very stylized, lacking detail in the reproduction of public institutions and (2) they tend to be quasi-deterministic.⁷ Both problems emerge from the acute programming and computational costs involved in reproducing realistic versions of real world economies. The complexity of calibrating the model also becomes more challenging as the realism in the model increases. Our modeling effort in this paper addresses (1) by including a substantial degree of institutional detail and a lot of observed and unobserved heterogeneity. We (i) model the details of retirement and survival pensions; (ii)

⁴The adjustment in pensions only takes place once an imbalance between *current* revenues and expenses reveals itself. As the bulk of population aging will not take place in the next fifteen to twenty years, this risks a dangerous inaction in the meantime. Note that, although the system is already in deficit, the current difficulties are of cyclical nature and, hopefully, will revert in time. But the bulk of the demographic shift still waits in the future. It is not visible in the current flow of funds of the system, but we have enough information about it to start taking action.

⁵Other widely used competing methodologies use accounting projections (as in eg. De la Fuente and Doménech (2012)), Generational and National Transfer Accounts (as in eg. Patxot et al. (2013)), micro-simulation (as in eg. Conde and González (2011) or Moral-Arce (2013)) and modeling of the balance sheet of the pension system (as in Boado-Penas (2014)). All these references correspond to papers exploring recent reforms or proposals of reform of the Spanish pension system. Auerbach and Lee (2011) is an outstanding example of the use of stochastic time-series simulations to explore the effectiveness of alternative ABM mechanisms.

⁶For example, Robalino and Bodor (2009) explore the sustainable rate of return (IRR) in earnings-related systems (inspired by an argument over the long term balance of the Sweden pension system). They compare six rules to determine the IRR across a large number of economic and demographic scenarios, using a simplified deterministic model economy, with exogenous savings. A more advanced economic model is used in Fehr and Habermann (2006)'s comparison of the impact of indexing to changes in either life-expectancy or the dependency ratio in Germany. They proceed by feeding stochastic population projections into a quasi-deterministic, perfect foresight OLG model of the German economy. A similar type of general equilibrium model is used in Auerbach, Kueng, and Lee (2011) to study how shocks of particular types play out over time and generations. Finally, a fully consistent treatment of aggregate uncertainty is achieved in Ludwig and Reiter (2010). They explore the intergenerational redistribution of the gains and cost from the the baby-boom and baby-bust cycle in Germany.

⁷Stochastic simulations are possible, but individuals are then assumed to either (i) expect no further shocks, as in Altig and Carlstrom (1991), or (ii) to know the future path of all exogenous variables as in Fehr and Habermann (2006). Ludwig and Reiter (2010) is an exception by properly factoring in uncertainty into the optimal behavior of agents.

consider the effects of time-varying unemployment, schooling, productivity and (of course) demographics; (iii) allow for endogenous reactions via changes in retirement ages and (iv) consider intra-cohort differences in education and in the valuation of leisure (leading to a well defined within-cohort distribution in retirement ages). Regarding drawback (2), unfortunately, we do not make any headway. We still compute behavior by assuming perfect foresight at the household level. At the policy-maker level, we deal with the uncertainty about the future paths of productivity, unemployment and immigration flows by implementing a scenario-based approach. We construct one *base* eco-demographic setting and a large number of alternative environments. We do sensitivity analysis (by exploring a set of one-at-a-time changes in the *base* environment, and extreme case analysis (combining several changes in best/worst case scenario analysis).

The **main findings** in our simulations are as follows.⁸ First, pension expenditure (as a proportion to GDP) will increase markedly as the economy moves into the second half of the century. There is no parallel increase in the revenues of the pension system, leading to acute financing shortfalls. This is so even after the changes introduced in 2011, that trigger significant behavioral reactions. Depending on the eco/demographic background of the simulation, the deficits (and their corresponding tax hikes) vary from substantial to truly overwhelming. Second, the ABM scheme implemented in December 2013 changes this general picture in a substantial way. Undoubtedly, it is the most ambitious attempt to restore the pensions' financial balance up to now. In our base environment, it fails to fully restore the health of the system because the adjustments needed to that aim are simply too big, hitting the lower bound established for pension depreciation. Notwithstanding, the remaining imbalances are far smaller than without the reform. This general conclusion is however, very dependent on the eco/demographic background. In the more favorable scenario, the reform does accomplish its target, while in tougher environments the remaining imbalances are still large. Finally, there are large redistributive consequences from the ABM mechanism. Roughly speaking, all the gains are captured by future cohorts (those that in 2010 are still to arrive to the labor market). And, consequently, all the burden is placed on current cohorts of workers and, to a much lesser extent, on current retirees. Among the former, however, the damage is far from even. The general pattern is simple: for cohorts born before 1980 the burden is heavier the younger the cohort considered. This pattern reverses for cohorts born after 1980. Those already retired in 2010 pay a very small part of the costs, while the burden is largest for cohorts retiring around 2040.

The manuscript is structured in four basic sections. It starts with a detail description of the model in Section 2. Then, Section 3 deals with the alignment of the theoretical model with the targeted Spanish economy in our *base* scenario and in our set of alternative settings. The simulation results are presented in three blocks: Section 4.1 presents the results under system in place before the inclusion of the ABM scheme, while the simulated performance including the ABM (and/or other reform proposals) are discussed in Section 4.2. The robustness of those findings to changes in the *base* eco-demographic background are studied in section 4.3. Our basic conclusions are provided in Section 5. Some additional results are confined to a set of dedicated appendices at the end of the paper (Appendices A to C).

⁸Needless to say, our literal results only apply to the model economy solved and simulated. To the extent that our artificial world mimics the real world (and we do go to great lengths to *calibrate* the model), they can be suggestive of the future performance of the Spanish economy. But the reader should not treat them as literal predictions for the real world economy.

2 The model

This section presents a detailed revision of our simulation model. We start with an overview of the main features of the model in subsection 2.1. We then discuss the working of demography (2.2), the behavior of the agents (2.3) and the institutional details (the pension system in 2.4 and the rest of the public sector in 2.5). The section closes with a description of the supply-side and the overall notion of equilibrium in section 2.6. This final subsection also acknowledges some areas of the model that should be improved in future work.

2.1 Overview

We consider an OLG economy populated by *ex-ante* heterogeneous agents that live up to a maximum of I periods.⁹ The economic environment is strongly non-stationary but deterministic. At the individual level, however, individuals are uncertain about the length of their life. There are no other sources of uncertainty in the model. Individuals are organized according to their year of birth, education and relative value of leisure in a set of representative households. It is at the level of those representative households (or *agents*) that life-cycle decisions are made.

The model takes as exogenous inputs the composition of the population by age and education, the employment and participation rates of the different agents, the growth rate of labor productivity and the dynamics of government debt. Conditional on those processes, the model calculates the endogenous behavior of consumption and savings and the retirement ages of all representative households, together with the time series of the prices of capital and labor and (residually) all the other macro-aggregates. The economy is open to flows of migrants from overseas and we allow the government to sell debt to foreigners at an exogenously fixed external interest rate, r^d . In all other aspects, the model reproduces the workings of a close economy. In particular, the stock of productive capital, interest rates and wages are formed internally. All variables are real in nature and the model abstracts from monetary considerations, although we include explicit inflation assumptions when dealing with the 2013 reform (it includes nominal thresholds that lead to different real consequences depending on the inflation rate π).

A period in the model stands for one year of real time, which we denote by t when referring to calendar time and by i when referring to age. The simulation runs from $t_0 = 2001$ to $t_3 = 2270$ (when a steady state is assumed to be reached). Consequently, t takes values in $\mathcal{T} = \{t_0, \dots, t_3\}$. The cohort the individual belongs to is denoted by $u = t - i + 1$, and g is used to distinguish between the household members (first/second wage earners). We solve for cohorts u born between 1902 and 2250, ie. $u \in \mathcal{U} = \{u_0, \dots, u_1\}$. Individuals are grouped in **representative households** (*agents*) at the age of 20, when their economic life begins. At that point, they are classified according to their educational attainment into one of J possible categories (denoted by $j \in \mathcal{J} = \{1, \dots, J\}$). Furthermore, households differ in their valuation of leisure, which is not observable *ex ante*, but leads to different retirement ages, τ . In the model, we let τ vary between 60 and 70. Summing up, *agents* in our model differ in their cohort of birth, educational level and retirement age.

⁹The model is built in the Auerbach and Kotlikoff (1987) tradition. It incorporates some of the large number of improvements experienced by this methodology in recent years (see, for example, Fehr (2009)). This work contributes to this growing literature by including a considerably large number of heterogeneous individuals, by modeling retirement and survival pensions and by allowing different retirement ages within each representative household.

2.2 Demography

The population of the model is generated endogenously by a stylized, one-sex, demographic model described in appendix A.1. It is controlled by (i) the profiles of age-specific fertility rates for each simulated cohort $u \in \mathcal{U}$; (ii) the profiles of age-specific survival probabilities by cohort and gender, and (iii) the time series ($t \in \mathcal{T}$) of net inflows of immigrants of different ages and gender. These variables constitute the *fundamentals* of the demographic process. These *fundamentals* are time-varying in the interval $\{t_0, t_1\}$, and constant during the rest of the simulation time span \mathcal{T} (t_1 is calibrated to 2100 in all the simulations). Our modeling efforts are focused on the conditions prevailing during the $\{t_0, t_1\}$ simulation interval. After $t_2 = t_1 + I$ the age-distribution of the population stays invariant (ie. the population becomes *stable*), and the entire economy eventually converges to a *balance growth* path after $t_3=2270$.¹⁰

2.3 Representative households: the economic agents of the model

Households are formed at the age of 20, when economic behavior begins. Initially, they are made up of two people and a number of children that varies with the fertility of the cohort. We assume both spouses share the same age of birth, u , and educational attainment, j .¹¹ Households also differ in the relative value of the leisure enjoyed by each member, represented by θ . Its cross-section distribution is denoted by F_θ . Thanks to this heterogeneity, households born on the same date with equal education may retire at different ages. We consider an invariant distribution F_θ throughout the simulation.¹² After formation, households remain in the simulation during the ensuing 80 periods. During those years, the composition by gender of each *agent* (ie, inside the representative household) changes due to the effects of mortality at the individual level. As the mortality hazard takes its toll on the progressively older family members, widows and widowers arise. As a result, the household income (at any particular age) is a weighted sum of the income of both earners, with weights equal to the fraction of families in which the g-earner is still alive. In effect, people in our model are organized in *mutual insurance groups* (defined by cohort of birth, education and relative value of leisure). These mutual groups are the economic *agents* of the model.

Households make decisions about their optimal life cycle profiles of consumption and asset holdings (c_i^t and a_i^t respectively, with $t = u + i - 1$) and take a coordinated decision about the retirement age, τ , of the active members of the household. The life-cycle profiles of employment and participation rates (at all ages before τ) of the household members, $e_{i,g}^t$ and $\bar{e}_{i,g}^t$ respectively, are exogenously given. Household choices are obtained from the solution of an intertemporal optimal control problem. Preferences are represented by a pure time-discount factor $\beta < 1$ and a period utility function, $U(c, \tau|\theta)$, that takes the life-cycle profiles of consumption and leisure as arguments¹³. The same function characterizes households of different cohorts and educational levels, while we explicitly recognize the different valuation of leisure value (captured

¹⁰The final *balance growth* is only asymptotically reached. In the simulations, however, we approximate by assuming it to be reached in a finite period, t_3 . We check that the particular value chosen for t_3 does not affect the performance of the economy in the interval of interest (t_0, t_1).

¹¹This simplifying assumption implies an overstatement of the degree of *assortative mating* in the economy, which, in Spain, varies between 60 and 70% depending on the educational attainment.

¹²We do not consider different F_θ by education. Therefore, the differences in the average retirement age of workers with different education are entirely the result of the endogenous incentives to retire created by the pension system.

¹³The life-cycle profile of leisure depends on the endogenous retirement age and the exogenous life-cycle profiles of employment and hours worked.

by θ). The problem of the household belonging to cohort u (omitting the educational *type* to simplify notation) is:

$$\begin{aligned} \tau^u, \{c_i^t, a_i^t\}_{i=1}^I \quad & \text{Max} \quad \sum_{i=20}^I \beta^{i-1} s_i^u U(c_i^t, \tau^u | \theta) \\ & c_i^t + a_{i+1}^{t+1} = LI_i^t + (1 + \bar{r}^t) a_i^t \\ & a_{20}^u = 0 \quad a_I^{u+I-1} = 0 \quad a_i^t \geq 0 \quad \forall i \geq \tau^u \end{aligned} \quad (1)$$

where s_i^u represents the survival probability (of at least one household member) to age i and \bar{r}^t stands for the net-of-taxes return on capital (ie. $\bar{r}^t = r^t(1 - \varphi^t)$, with gross interest rate r^t and income tax rate φ^t). Household labor income, LI_i^t , is the sum of the wages and pensions contributed by each of the family earners $W_{i,g}^t$, with $g = \{1, 2\}$. Before retirement, the net wage of member g takes the form:

$$W_{i,g}^t = (1 - \varphi^t) [w^t e_{i,g}^t \varepsilon_{i,g}^t - \varsigma cov_{i,g}^t] \quad (2)$$

Gross labor wages are the product of the endowment of efficient labor units, $\varepsilon_{i,g}^t$, the employment rate, $e_{i,g}^t$, and the market value of time w^t . Payroll taxes are a fixed proportion, ς , of *covered earnings* (defined in section 2.4). Household income before retirement combines wages and survival pensions:

$$LI_i^t = \pi_{i,1}^t W_{i,1}^t + \pi_{i,2}^t W_{i,2}^t + surv_i^t \quad (3)$$

where $\pi_{i,g}^t$ is the proportion of families that, under the effect of mortality, still include the g -earner at age i and $surv_i^t$ is income from survival pensions.¹⁴

Similarly, we can write the household “labor” income of retirees as:

$$LI_i^t = \pi_{i,1}^t \xi_{i,1}^t B_{i,1}^t + \pi_{i,2}^t \xi_{i,2}^t B_{i,2}^t + surv_i^t \quad (4)$$

where $B_{i,g}^t$ is the old-age pension of member g at age i (computed as indicated in section 2.4) and $\xi_{i,g}^t$ is the share of members (of gender g and cohort $u = t - i + 1$) that are entitled to get retirement pensions (again, in accordance with the legal dispositions discussed in section 2.4). Income from survival pensions $surv_i^t$ is computed in a similar way as before retirement.

Individuals are credit-constrained at the end of their life-cycles by the requirement of keeping a positive net-worth after retirement ($a_i^t \geq 0, \forall i \geq \tau^u$). This is intended to prevent people from borrowing from future pensions. It does not prevent households from borrowing early in their life-cycle. Note finally that, as our simulation starts in 2001, problem (1) (which solves for the choices during a complete life-cycle) really applies only to cohorts born after 1980. For the preceding cohorts the problem is similar, but only for the part of the life-cycle that remains to be solved at the time the simulation starts. We take from the data all the initial conditions needed to complete the life-cycle problem of those earlier cohorts (see the model calibration in section 3).

¹⁴Survival income is the sum of all survival pensions collected by currently alive household members, $surv_i^t = \sum_{o=1}^{i-1} \sum_{g=1}^2 \bar{\pi}_{o,g}^u cual_{o,g}^u iv_{o,g}^t$ where $\bar{\pi}_{o,g}^u$ stands for the measure of those (of gender g and cohort $u = t - i + 1$), that die at age o , $cual_{o,g}^u$ is the proportion of those deceased at age o whose relatives are entitled to a survival pension, and $iv_{o,g}^t$ is the corresponding survival pension income defined in section 2.4.

2.4 Pension system

The pension system is the cornerstone of the public social protection network, covering retirees (old-age pensions), widows and widowers (survivors pensions). The system is financed on a PAYG basis, with most of its income coming from workers' contributions and a small part (that corresponding to expenditure on minimum pensions) coming from general taxation. Employees pay a fixed proportion, ς , of their *covered earnings*, cov_i^t which, in turn, are also a fixed proportion, $1 - \chi$, of their individual gross labor income.¹⁵ Annual floors and ceilings on covered earnings (C_m^t and C_M^t respectively) are set annually by the government. The unemployment protection agency covers the contributions of the unemployed.¹⁶

Eligible workers (ie. those with a long enough contributive record, $h \geq 15$) can claim an old-age pension at any time after the *early retirement age*, τ_m , following a complete withdrawal from the labor force. The individual payment is computed according to a *Defined-Benefit* formula. For an individual belonging to cohort u who retires at age τ after h years of contributions, the initial pension is:

$$b(\tau, h, u) = \alpha^E(\tau) \alpha^H(h) \left(\frac{\sum_{e=\tau-D}^{\tau-1} cov_e^{u+e-1}}{D} \right) \quad (5)$$

The formula combines a moving average of *covered earnings* in the D years immediately preceding retirement (called *benefit base*) and two linear replacement rates: $\alpha^E(\tau)$ associated to early retirement penalties and a penalty for insufficient contributions, $\alpha^H(h)$. The details of these replacements rates have changed with recent reforms (see section A.2). Recall that τ is endogenous in our model, while h is computed from the exogenous employment rates. The *initial* pension $b(\tau, h, u)$ is indexed (under the system resulting from the 2011 reform) to price inflation and subject to annually legislated maximum and minimum payments, bM^t and bm^t respectively.¹⁷ Therefore, the *effective* pension income in year t for the individual of cohort $u = t - i + 1$ would be:

$$ib_i^t(\tau) = \min\{bM^t, \max\{bm^t, b(\tau, h, t - i + 1)\}\} \quad (6)$$

The pension system also provides survival pensions to widows and widowers. They are defined-benefit, subject to (lax) eligibility rules, indexed to consumer prices and bounded from below by an annually fixed minimum guarantee, bm_V^t . The initial survival pension depends on a complex set of individual circumstances. We simplify the institutional details and compute the

¹⁵The contributive wedges χ reflect two aspects of the institutional setting. First, that some components of the overall remuneration do not generate pension rights (eg. travel expenses, food tokens and other in-kind remuneration). Second (and more importantly) that there are appreciable differences in the treatment of *covered earnings* across the different Social Security schemes. Self-employed workers, in particular, can decide on the size of their declared *covered earnings*. In response, a majority opt to contribute the legal minimum during most of their careers (see eg. Boldrin et al. (2004)). The wedges make it possible to reproduce the average proportionality between income and *covered earnings* in the data without explicitly modeling the different Social Security schemes. Note, however, that the importance of the former motivation for the χ -wedges may be reduced by legislative changes introduced at the end of 2013.

¹⁶In reality, the unemployment agency covers the employer contributions and pays (for up to two years) an unemployment benefit equivalent to between 60 % and 70% of the gross labor income in the immediately preceding employment spell. For workers older than 52 (55 after the 2011 reform), the agency contributes the minimum covered earnings independently of the length of the unemployment spell. In the model we assume that the "post-52" rule applies at all ages.

¹⁷The value of the minimum guaranteed pension is conditional on age (higher after 65) and on the presence of a dependant spouse.

initial payment as a fraction α^V of the *benefit base* of the deceased and assume that all surviving spouses older than τ_m^v are granted a pension.

Two further qualifications are needed before we address the financial balance of the system. For accounting purposes, total contributions are divided in two groups, COT_R^t and COT_o^t , according to their destination: used to finance retirement and survivors pensions or used to finance other contributive and non-contributive pensions. Similarly, total pensions are split between the expenditure on minimum pensions PP_m^t (which are deemed a “welfare” expense and consigned to the general budget rather than to the pension system) and the expenditure in regular pensions (denoted PP_c^t hereafter). All in all, the total balance of the pension system is the difference between the revenue and expenses of its contributive and non-contributive components:

$$SSB^t \equiv \sum_{j \in \{c, nc\}} SSB_j^t \quad \text{with} \quad \begin{cases} SSB_c^t = PP_c^t - COT_R^t \\ SSB_{nc}^t = PP_m^t - COT_o^t \end{cases} \quad (7)$$

2.5 The public sector budget constraint

In addition to running the pension system, the public sector collects taxes via a (very stylized) fiscal system, incurs a certain amount of public expenditure, CP^t , issues public debt, D^t , and manages the surplus of the pension system by running a trust fund (“Fondo the reserva”) with accumulated assets F^t . The tax rate is annually set in such a way that all these elements together conform to a global budget constraint. We model each of these components as follows:

- There are two sources of **fiscal revenues**. First and foremost, a proportional tax is levied on all forms of labor and capital income. The (marginal and average) tax rate of the system, φ^t , is adjusted annually to guarantee that the overall budget constraint of the public sector is fulfilled each period. A second source of income derives from the full taxation of involuntary bequests (the assets belonging to the individuals that die in the period, whose aggregate value is represented by BI^t).
- **Public expenditure**, CP^t , includes (i) the running cost of the public administrations, (ii) the expenses associated to the provision of public goods (defense, justice, etc) and (iii) other social expenses. The later represents both the provision of in-kind goods and direct cash transfers to households.¹⁸ They include the public expenditure in health, long term care and public education and the transfers associated with unemployment insurance, other contributive pensions (eg. disability) and non-contributive pensions.
- **Debt policy**. At each period, there is a stock of outstanding real public debt D^t . We simply assume that the government pays an annual interest r^d on that debt and decides on the proportion to be rolled-over for the next period. This proportion is set in such a way that an exogenous Debt-to-GDP path is observed.
- **Trust Fund policy** and the interaction between pensions and general expenditure.

Since 2000, part of the surpluses generated by the pension system are deposited with a Trust Fund and invested in fixed income instruments. We represent this policy in the model

¹⁸We do not explicitly model the several types of transfers included in this category. Instead, we make the simplifying assumption that all those welfare transfers are immediately consumed, and simply reflect them as part of public consumption in our set of National Accounts. We are clearly cutting a corner here, as a proper modeling would obviously treat these transfers as income of the households (which may save rather than consume part of these transfers). We conjecture that the error involved in this approximation is, however, small.

by including a stock of accumulated assets F^t , yielding an annual interest r_F^t . During the simulation, a proportion ω^t of the annual “contributive” surplus in (7) is credited to the fund (while the contributive pension system remains in surplus), ie:

$$F^{t+1} = (1 + r_F^t) F^t + \omega^t SSB_c^t \quad \text{if } SSB_c^t > 0 \quad (8)$$

The rest of the surplus is transferred from the pension system to the general budget as additional fiscal revenue. The total social security transfer to the Treasury, SST^t , combines the remaining balance from the “contributive” pension system and the full balance of the non-contributive pension system.

$$SST^t = SSB_{nc}^t + (1 - \omega^t) SSB_c^t \quad (9)$$

Conversely, once the systems’ revenues fall short of annual expenditure, the Trust Fund is progressively consumed and its funds employed for paying pensions. The unwinding of the Fund takes place according to an smoothed exogenous schedule, meaning that part of the annual pension deficit is progressively passed to general taxation (via a negative SST^t) even when F^t is still positive. Once the Fund is exhausted, the entire pension balance is transferred to the general budget.

- The overall **budget constraint** of the public sector.

Each period, the government must collect enough income to cover all its financing needs (including, when present, the deficits of the pension system). Debt policy and income from bequest are treated exogenously by the authorities, leaving the income-tax-revenue as the variable of adjustment in the effort to balance the overall annual budget. To achieve equilibrium we start by computing the total annual revenue needs of the public sector, RN^t :

$$RN^t = CP^t + r^d D^t - (D^{t+1} - D^t) - SST^t - BI^t$$

then, we calculate the minimum tax rate needed to collect exactly that amount, given the *fiscal base* of the economy.¹⁹

2.6 Supply side and equilibrium

The production side of the model is entirely neoclassical. We assume a constant returns to scale production function, $F(K, L)$, that combines private capital K and effective labor L . There are no adjustment costs of investment and we assume an exogenous (but time-varying) process of improvement in labor productivity, captured by the index A^t . Gains in productivity are of the labor-augmenting type and accumulate at the rate ρ^t .

An **equilibrium** path over the time interval \mathcal{T} is a set of time series of population aggregates and distributions, household decisions (consumption, savings and labor supply), aggregate inputs, prices and public policies (tax rates, public consumption and minimum and maximum pensions and contributions) that exhibit a standard set of properties: (i) households are rational (ie., they solve the problem in (1) taking as given all the other elements in the equilibrium

¹⁹Both pension expenditure and the income from involuntary bequests depend on the tax rate, meaning that a recursive method should be applied to reach the equilibrium in the annual budget. Of course, the equilibrium condition must be observed at all points in the simulation path.

definition); (ii) factor markets clear; (iii) prices are competitive; (iv) the public budget is annually balanced and (v) an aggregate feasibility constraint is observed. Appendix A.3 presents those properties in a formal way. Note that, as in the standard Auerbach and Kotlikoff (1987) methodology, we assume the convergence of the equilibrium path to a final balanced growth path in finite time. In contrast, our initial equilibrium is strongly non-stationary as in eg. Kotlikoff et al. (2007).

2.7 Limitations of our modeling framework

Before proceeding, a word of caution on the limitations of the modeling environment is overdue. The reader should keep in mind that the current model is only a very stylized representation of the complexities of the real world. Important relevant factors are still unsatisfactorily covered in the model (and it may take modelers a long time before a substantially better state of affairs is reached). For example, the OLG framework has a specially hard time reflecting the cyclical oscillations observed in real markets. The unwanted idleness in labor is captured by including a time varying profile of employment rates, but capital is assumed to be fully employed.²⁰ For an economy recovering from a deep recession, this leads to an excessively optimistic assessment of growth (and, consequently, of the state of the pension system) early in the simulation path. Other *substantial* modeling issues for the OLG framework include the (essentially) closed economy setting, the rather marginal role played by inflation and the abstraction from monetary policy. A particularly important avenue for future development is the incorporation of micro-simulation in this framework. Shifting from big modeling problems to more concrete difficulties of the current specification, we acknowledge that some elements of the economic environment could be better reproduced. The simplicity of the fiscal system, the rigidity of labor supply (with retirement age being left as the only margin of flexibility) and the need to complete some of the institutional details (eg. the survival pensions' entitlement rules) are indicative examples. We return to future improvements at the end of the paper in section 5.

3 The Calibration

The model proposed in the previous section only becomes operative once we have specific values assigned to each of its parameters and exogenous processes. This is addressed with a standard calibration strategy: we select a range of properties of the real economy and choose the model's parameters that deliver a close match. Roughly speaking, this involves two different procedures. For parameters with clear real-world counterparts, we simply impose the observed values exogenously. For unobservable preference and technological parameters we proceed with a proper calibration, solving the model with different parameter values and selecting those that fit the behavior of the Spanish economy in the pre-simulation interval (2001 to 2010) better.

We must also provide *future* trajectories for some key demographic, institutional and economic variables. Needless to say, these future trajectories are highly uncertain. Ideally, we would like to treat those future trajectories as stochastic processes in the solution of our general equilibrium model. Unfortunately, the technical challenges involved in such an exercise are still very important. Here we undertake a far more modest endeavor. We formulate a plausible *base* scenario, including particular specifications for all the relevant future exogenous paths. Then, we solve our model in that particular environment and use it to implement the policy

²⁰Furthermore, the relative price of capital and consumption goods is always 1. A "Tobin-Q" model could release this constraint, but reproducing the large fluctuations seen in eg. housing prices is still a challenge for stylized OLG equilibrium models.

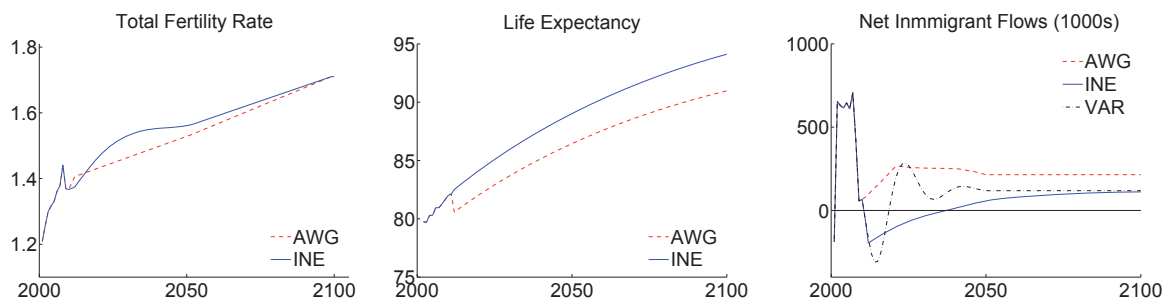


Figure 1: Fertility, mortality and immigration scenarios proposed by INE (2013 long term population projection), AWG (2012 European Commission projection) and the author’s own econometric projection (VAR) of future immigration flows.

experiment of interest (the impact of the 2013’s reform). Finally, we consider the robustness of our findings to changes in the key features of the proposed environment (ie, solving alternative eco/demographic settings). In this section we provide the details of the *base* calibration and the alternatives explored in our sensitivity analysis. The section is arranged as follows: demographics are discussed first (subsection 3.1), followed by the labor market and education distribution (3.2), the pension system (3.3), other public institutions and macro-aggregates (3.4). Additional calibration details are provided in Appendix B. Subsection 3.5 closes the section by summarizing the *base* case and the set of more extreme *alternative* futures that will be explored in the sensitivity analysis of the model.

3.1 Demographics

We implement a 1-year OLG model where people has a maximum lifespan of 100 years. The basic structure of our model is presented in section 2.2, while section A.1 in appendix A discuss our model of the population dynamics. This model generates our endogenous population predictions starting in the year 2013.²¹ The model fundamentals are (i) the age profiles of fertility by cohort; the (ii) survival probabilities by cohort, and (iii) the size and distribution of the flows of immigrants.

Fertility and mortality rates for 2001 to 2012 are constructed from *Instituto Nacional de Estadística* (INE) data on the number and distribution of births and deaths. For the values projected from 2013 to 2100 we consider two alternative scenarios. At the time of the execution of this project (middle of 2013) there were at least two sets of demographic projections applicable to Spain. First, the scenario underlying the long term projections by the Spanish’s Statistical Office, INE (2012). Second, the all-important budgetary projections in European-Commission (2012a), which included a set of population projections developed by EUROSTAT (referred thereafter as AWG, after the *Aging Working Group* that produced the simulations). Figure 1 illustrates the differences and similarities between these two set of simulations:

- INE’s projections are more updated on fertility and mortality. On the one hand, the AWG’s fertility assumption included a very rapid recovery from the downturn induced

²¹We use the 2001-Census data for the initial distribution of the population, by gender and origin (native vs migrants). For the inicial simulation period 2001/2013 we impose the additional constraint of reproducing the observed population distribution by age (as revealed by INE’s *Cifras de Población*). This is achieved by computing, during those years, the endogenous set of immigration flows compatible with the empirical profiles of fertility and mortality and with the aggregate population data. We check that those immigrant flows are a good approximation to the real figures (form INE’s 2002/2012 *Estadística de Migraciones*). .

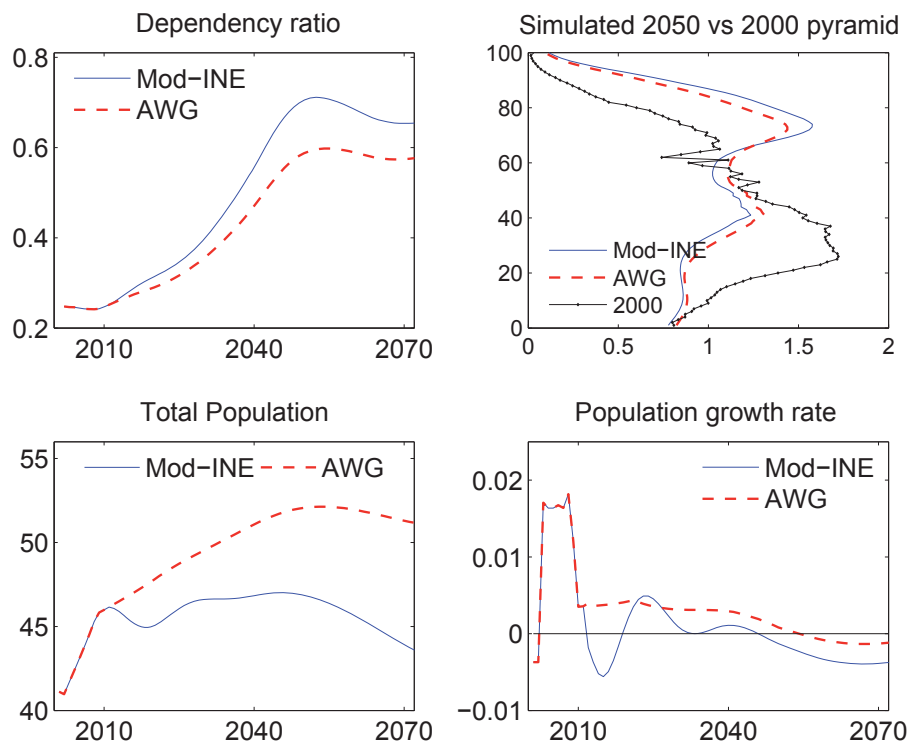


Figure 2: Basic statistics in the two demographic scenarios simulated: Mod-INE (modified INE including our own immigration assumptions) and AWG. For a visual assessment of the scope of expected aging, the top left panel includes the 2010's population distribution.

by the large recession of 2008/2012. INE more recent data show that the recovery has not yet started. Note that the long term targets of both simulations are similar. On the other hand, mortality rates have improved more rapidly than expected in 2010 (when AWG projections were first envisaged). Both simulations project similar *gains* in life expectancy, but the starting *level* in INE's exercise is more accurate.

- Differences are larger on the projected immigration flows. INE's proposal assumes a very slow recovery from the negative net inflows observed in 2012. In contrast, the AWG optimistically includes a brisk recovery from the small positive value still observed in 2010. Time has proved both projections wrong: the latest figures (displayed in the right panel of Figure 1) are worse than envisaged, even by INE. Under those circumstances, we decided to build our own future immigration figures. Rather than predicting immigration on an isolated basis (as INE) we linked it to the future performance of the economy in a bivariate VAR analysis. We modeled the joint performance of immigration and unemployment and predicted future flows accordingly. The resulting pattern is shown as the "VAR" projection in the leftmost panel of Figure 1.

In our simulations, we combined the information above in two alternative scenarios. On the one hand, we consider the full package of fertility, mortality and high immigration assumptions in the AWG projection. We will use this optimistic demographic scenario as our *base* background setting for simulation. We refer to this environment as the AWG or *High Imm.* setting. As an alternative we consider the scenario that combines INE's fertility and mortality assumptions with our own statistical analysis of immigration flows. It is referred in what follows as the

“Mod-INE” scenario (modified INE) or *Low Imm* environment (see Table 4).

Figure 2 displays some demographic patterns resulting from these alternative views of the future. In both cases the image that emerges is one of acute population aging, although with differences in the speed and intensity of the process:

1. **Population aging.** Both scenarios predict a marked aging of the Spanish population, as evidenced by a dramatic change in the shape of the Spanish population pyramid and a large increase in dependency ratios (top right and left panels of Figure 2, respectively).²² The quantitative differences across scenarios are, however, not trivial. The AWG dependency ratio is comparatively mild, falling short of 60 senior citizens per one hundred workers at its highest (around 2050). Our Mod-INE figures are larger, peaking at a value around 70 out of 100. Dependency ratios decrease a little in the second half of the century, but stay around values substantially larger than the ones currently observed.
2. **Population growth** rates and population levels are strikingly different. The AWG simulation only projects a decline in population after 2050 and from very high values (the turning point occurs when the population is well above the 50 million milestone. In contrast, our own Mod-INE figures portray an immediate decline followed by a long period of stagnation and, eventually, contraction. Population drops reverse themselves at the end of the current recession, but the long term picture is one of a clearly shrinking population.

3.2 Labor market and distribution by education

The educational attainment is a key determinant of labor market outcomes. Our model generates some of these outcomes endogenously (wages per efficiency unit of labor and retirement ages), but treat most of them as exogenous processes. This section describes how those exogenous outcomes are generated. Classification by **education** is the very first step. We consider four educational groups, corresponding to categories 1 to 4 in the (2 digits)-CNED classification (where higher numbers identify better performing individuals).²³ We group people in the several databases used according to this ranking. The left panel of Figure 15 in appendix B.1 displays the initial simulated distribution and the dynamics assumed during the simulation path. For the initial condition, we use the distribution by gender and age of birth in the 2004/2011 *Encuesta de Condiciones de Vida* (ECV), our most fundamental source of empirical information. We do not consider any further change in the educational attainment of future cohorts during our simulation interval. The distribution observed in 2011 for people aged 30/35 is, consequently, the distribution assumed for all future cohorts entering the model. Still, the average education level improves appreciably, thanks to generational replacement (eg, the proportion of those with only primary education goes down from almost 50% to around 10% by 2060).

The productive potential of individuals is captured with their life-cycle profiles of **efficiency labor units**, $\varepsilon_{j,g}$. We apply panel regression techniques to the ECV data to estimate quadratic, time-invariant profiles (conditional on gender and the worker’s educational attainment). Figure 16 in appendix B.1 provides a graphical illustration of the resulting profiles. The combination of these static profiles with labor-augmented productivity growth (which effectively shifts the

²²Dependency ratios at each year are defined as the ratio of the population aged 65 or more to the working population (16/64).

²³Category 1 (“primaria”) is used for High-School or less; 2 and 3 correspond to secondary education, split between basic and advanced degrees (“primera vs. segunda etapa de secundaria”); finally, category 4 applies to college graduates (“educación superior”).

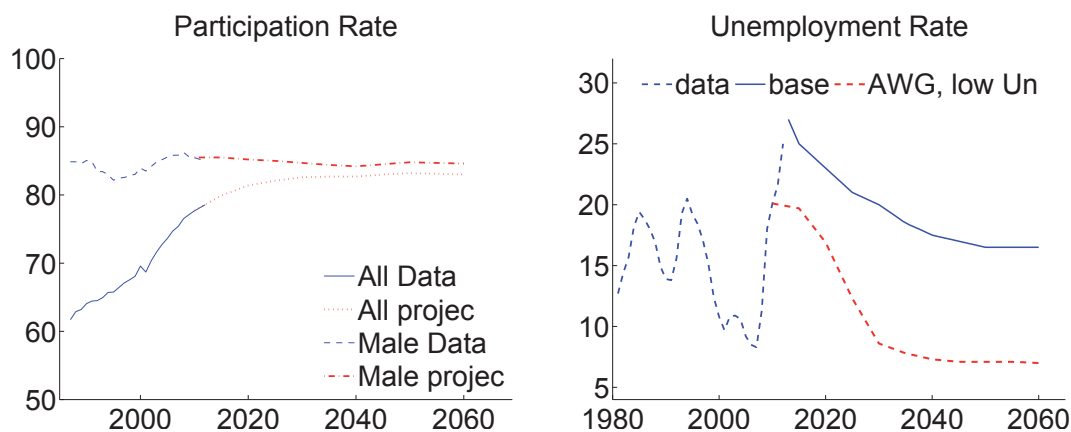


Figure 3: Historical and simulated aggregate participation rates of males and the total population (left panel) and historical and simulated unemployment rates in the *base* scenario (based on econometric projection) versus the AWG’s scenario (right panel).

profiles up for successive cohorts) is the main growth engine of the model. The other two growth-generating factors are the improvement in average education due to generational replacement and (early in the simulation) capital accumulation.²⁴

Regarding **labor participation**, we reproduce the aggregate performance by gender projected by the AWG in the interval (2010/2060) (left panel of Figure 3). We use the *Spanish Labor survey*, EPA, to complete the information needed for the simulation.²⁵ As an illustration, the right panel of Figure 15 in appendix B.1 displays the dramatic change by cohort in the proportion of households with just one wage-earner. Overall, we implement an optimistic scenario that, despite the initial drop created by the 2008-2012 *recession*, sees an increase in the long term aggregate participation rate from 77.7% to 83%.

For the **unemployment rates** we have considered two alternative paths in our simulations (right panel of Figure 3). The AWG path is that proposed by the European Commission in its 2012 budgetary simulations. It has two features that make us uncomfortable: (i) its starting point is already obsolete and (ii) it portrays a very rapid reduction in unemployment rates to figures around 12% by 2025 and 8% by 2035. Alternatively, we take as our *base* scenario a more pessimistic one: it starts from the rate observed in 2012 and proceeds with a slow and progressive reduction towards the long term value obtained in the eco/demographic VAR simulations discussed in the previous section (around 16.5%). Note that, although our base unemployment scenario is pessimistic, the overall long term employment rate of the economy is high (around 67%). The alternative *low Un* scenario (Table 4), constructed under the AWG assumptions, leads to an even more optimistic view of the total employment rate. Also note that, as with the participation rates, we disaggregate the unemployment aggregate values according to the age, gender and education of the cohorts considered.

Finally, we calibrate **retirement**, ie the age chosen by the *agents* for a complete withdrawal

²⁴In the interval 2015/2040, the average growth rate of gross labor income (deflated of exogenous productivity growth) is 0.45%. This mostly reflects educational change and higher employment rates, as the initial gains in capital accumulation tend to reverse after a couple of decades.

²⁵We need complete life-cycle profiles of labor participation by cohort, gender and education. To generate those complete profiles we proceed in two steps. First, we use EPA data to recover the time-varying participation rates of the cohorts in the model. Then, we estimate a set of distributional regularities in participation by gender, education and age (as observed in more recent EPAs). To complete all the needed profiles we simply assume that the estimated regularities remain unchanged in future cohorts.

	DATA		Model
	Absolute value	Ratio to Avmw(*)	Ratio to Avmw(*)
Maximum Retirement pension, bM	34.97	1.36	1.37
Minimum Retirement pension, bm	7.1/10.3	0.27/0.40	0.3
Minimum Survival pension, bm_v	6.3/9.6	0.24/0.33	0.2
Max. Contributive base, C_m	38.76	1.51	1.60
Min. Contributive base, C_M	8.9/12.3	0.35/0.48	0.52

Table 1: Calibration of the discretionary parameters of the pension system. Avmw= average male wage in *Encuesta de Estructura Salarial* 2011. All absolute values in thousands of euros of 2011.

from the labor force. For those already retired at the beginning of the simulation we simply match the average retirement ages (by gender, cohort and education) observed combining the information in the Social Security's *Muestra continua de Vidas Laborales* (MCVL) and INE's ECV. For younger cohorts retirement is endogenously determined by the optimal behaviour of our simulated households.²⁶ To handle the computational complexity of this choice we introduce two key modeling assumptions. First, the period utility function is separable in consumption and leisure. Second, the value of leisure, F_θ , is normally distributed across each cohort's population. Thanks to these assumptions, we can easily measure the proportion of households of each cohort that will retire at each possible age.²⁷ We calibrate the mean and variance of F_θ to match the average retirement age of workers born between 1940/1944 and its sample dispersion. The differences in retirement patterns by education are reasonably well captured by proceeding in this way. The complete time path of the average simulated retirement ages by cohort and education is shown in the left panel of Figure 7. It also includes the complete distribution of retirement ages for some selected cohorts.

3.3 Pension system

3.3.1 The system after 2011

We model the retirement and survival pensions of the *General Regime* of the Spanish pension system.²⁸ Our benchmark simulation corresponds to the structure in place after the 2011 reform. In particular, the Statutory Retirement age will be gradually increased from 65 to 67 (starting in 2013 and ending in 2027) and the Early Retirement age will follow a similar increase from 61 to 63.²⁹ The length of the averaging period in the pension formula will be increased from 15 to 25 years (one year per annum from 2013 to 2023) and the structure of the penalties for insufficient contributions $\alpha^H(h)$ will be linearized.³⁰

²⁶See Jiménez-Martín and Sánchez-Martín (2007) for a detailed explanation of the workings of (a continuous-time version of) the life-cycle retirement model implemented in this work.

²⁷We work with two additional assumptions: we limit the range of potential retirement ages to the interval 60/70; and consider a logarithmic functional form for the consumption component of the utility function.

²⁸The System is progressively converging to a dual structure featuring a *General Regime* (RGSS) for wage earners and an *Special Regime* (RETA) for the self-employed. In 2012, more than 70% of affiliated workers and 60% of pensions belong to RGSS.

²⁹The legislation about the early retirement age was clarified in the March 15th *Real Decreto-Ley* 5/2013. By 2027, 63 will be the new "legal" minimum in case of involuntary exit from the labor force (with an enrolment record of at least 33 years). In case of a voluntary transition, the new minimum is 65. In our simulations we implement the smaller of this two figures.

³⁰Section A.2 in appendix A reviews the details of the changes introduced in the structure of penalties.

	Number (mill)		Average (ths. Euros)	
	DATA	Model	DATA	Model
Total	7.9	7.75	11.6	12.5
Retirement	5.4	5.35	13.2	14.2
Survivors	2.5	2.23	8.1	8.2

Table 2: Simulated vs observed (2010) total number of pensions and average annual benefits (in thousands of euros of 2010).

Although the *permanent* parameters of the system typically attract most of the attention, the policy regarding its *discretionary* parameters can also be extremely consequential.³¹ Table 1 shows the 2012-values of the main parameters in this group (both in nominal terms and as a proportion of the average wage), and their simulated values in the benchmark model. Minimum pensions are specially important, representing slightly less than 6% of total expenditure on retirement pensions (13.7% for survival pensions) but affecting as many as 26.6% of all pensions in the system. Our stylized model does a reasonable job at reproducing these statistics, with 24% of simulated pensions affected, and with expenditure figures close to 5% for retirement pensions and 15.8% for survival pensions. The matching achieved for maximum pensions and bounds on contributions is also satisfactory. The future values of these parameters is, obviously, uncertain. Consequently, we have to take a stand in our simulation on the policy to be followed by future administrations. We conjecture that minimum and maximum pensions will stay essentially constant in real terms, while the maximum contribution will grow by half of the growth rate of labor productivity.³² This attempt by the government to use its discretionary power to extract some additional financing from workers has been named the “silent” or “hidden” reform (see Conde and González (2011)). The resulting time paths of the discretionary components is shown in the left panel of Figure 20 in appendix C.1. The alternative simulation where the ceilings (and floors) on both pensions and contributions stay constant in real terms is explored as environment *Neutral Max & Min* (see Table 4).

Replicating the observed *levels* and *distribution* of **initial pension benefits** is a critical and challenging task for the model. For the cohorts of already retired workers, this is accomplished by reproducing the exogenous values (by gender and cohort) obtained from HLSS, and using the ECV data to get a breakdown by education. For all other cohorts, pension payments are generated endogenously by the model described in section 2.4. Note that, on top of a good institutional model, getting a good match also demands a good reproduction of (i) the size of social contributions and, (ii) of the length of individuals’ contributive record. The contribution wedges described in footnote 15 are key to succeed with regard to (i). We assume that as much as 30% of total income of highly educated workers is not incorporated into pension rights. This proportion decays linearly with the educational attainment, reaching zero for the group with the lowest education. To approximate (ii) we construct a very stylized model of the number of contributed years.³³ This is a crucial input in the computation of the penalties for insufficient

³¹Discretionary parameters are set annually by the government in December’s budget law.

³²According to our assumption, the system’s administrators will try to increase the contributions from workers on the top end of the income distribution without increasing their pension rights. As discussed in section 4.1 (an illustrated in Figure 7) those affected will react by anticipating their retirement age.

³³We simply apply the existing individual rules to the simulated life-cycle profiles of employment of our representative *agents*. Appendix B.1 provides more information on this calibration procedure, including a graphical illustration of its results in Figure 17.

	Data	Model
Total aggregate pension expenditure (2010)	10.24	10.4
Retirement & survivors	8.8	9.0
Retirement	6.9	7.3
Survivors	1.9	1.7
Social contributions (2010)	13.2	13.1
% imputed to contributive pensions	71.0	71.0
Financial balance (contributive system)	1.1	0.9
Trust Fund Assets (2010)	6.14	6.1

Table 3: Summary statistics of the pension system: comparison of the model and aggregate data. All figures are expressed as percentage of GDP. (*) excludes minimum pensions.

contributions and to determine the proportion of workers that qualify for a retirement pension.

Table 2 summarizes the results obtained by our calibration procedure by comparing the average simulated number of pensions and their average value to their real-world counterparts in 2010.³⁴ Overall, simulated values seem reasonably closed to the real ones, given the complexity of the real world system. By aggregating the individual benefits and contributions of the agents of the model we can construct the simulated counterparts of aggregate pension income and expenditure. Table 3 displays both set of figures for the year 2010.³⁵ The adjustment is not perfect but, again, it seems reasonably successful.

When projecting future pension expenditure, we incorporate two additional modifications to the structure emerging from the 2011's reform. First, in 2013 all the expenditure associated with minimum pensions payments was transferred to the general budget. Consequently, this item is excluded of our measures of pension expenditure. Secondly, we incorporate in our *base* scenario the progressive elimination of survival pensions for pensioners endowed with a retirement pension of their own.³⁶ In our benchmark scenario, the elimination is complete for cohorts entering the labor market in 2010 (ie, it is not fully operative until the retirement of those cohorts around 2050). As an alternative, the current system of survival pensions is simulated as environment *S&ER Acum*, ie. a setting where survival and retirement pensions can be accumulated (see Table 4).

3.4 Public debt, public consumption and macro-aggregates

To complete the calibration of the public sector we specify the dynamics of public debt and public consumption throughout the simulation interval. For the ratio of **public debt** to GDP, we estimate a time-series regression model of its joint behavior with unemployment rates and

³⁴More detailed information is provided in appendix B.2. Figure 18 shows simulated pension-to-average-wage ratios by cohort, education and gender, while Table 16 compares the pension enjoyed by the cohorts born in 1940/1950 (according to ECV data) to the model-generated pensions of the cohort born in 1950.

³⁵Note that, for a meaningful comparison with the model predictions, we need to do some transformation of the real world pension statistics (as obtained from Seguridad-Social (2013)). For example, aggregates in the real world include disability and other pensions that should be excluded when compared with our model (which only reproduces retirement and survival pensions).

³⁶Under the current system, widows and widowers can combine the survival pension with any other source of income they enjoy. This generosity was designed to fight old-age poverty in a world with very low female labor participation. But recent cohorts of females have similar participation rates to those of men, and this disposition is unlikely to survive in a context of substantial reductions in real pension income. At the moment, legal changes in this direction are only under preliminary discussion in Spain.

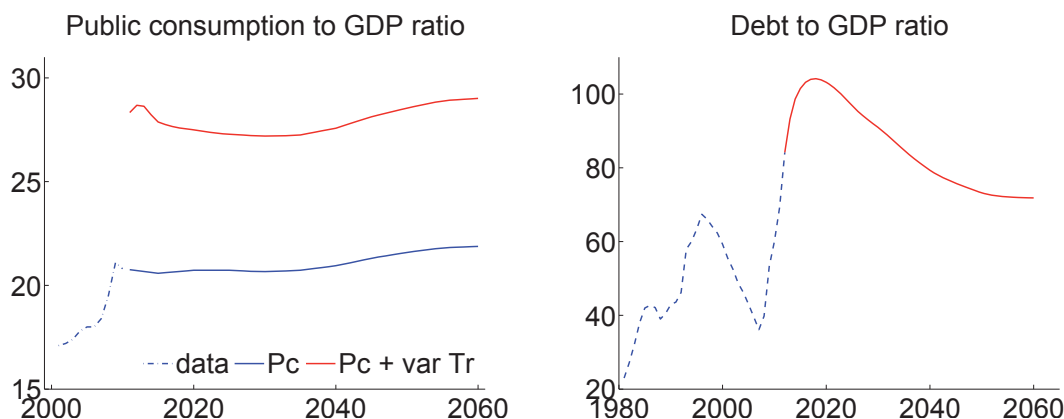


Figure 4: Exogenous paths of public consumption (left) and public debt (right) as a proportion of annual GDP. Public consumption enlarged with our simulation of non-pension transfers is denoted as “Pc + VAR TR”

the real interest rates paid by public debt. We then feed this model with the exogenous path of unemployment rates discussed above to generate a projection for the future path of the debt-to-GDP ratio. The result is the slowly decreasing ratio displayed in the right hand panel of Figure 4. **Public consumption** is a catch-all variable in our model. It includes (i) public expenditure in health, long term care and education, obtained (as percentage of the GDP) from the AWG projection; (ii) our own estimation of the other components of public consumption (eg. costs of running the government, providing justice, defence, etc) and (iii) transfers associated with unemployment insurance and other pensions. The left panel of Figure 4 shows the resulting time path. To keep the overall budget balanced (in the sense discussed in section 2.5) our simulated **income tax** must collect the equivalent of 21.9% of GDP. This is quite close to the real-world fiscal burden, where 19.8 % of GDP is raised from direct and indirect taxes and an additional 3.1 % is obtained from various other sources.

The calibration is completed with the specification of **preferences and technology**. For the former, we implement a utility function with separable consumption and leisure. The consumption component is logarithmic and we calibrate the annual β to reproduce the initial (2010) capital to output ratio. Our target K/Y is 2.8 and an annual discount factor of 1.2% ($\beta=0.988$) hits this target. The initial condition on the households’ accumulated assets is obtained from the Bank of Spain’s *Encuesta Financiera de las Familias* (EFF).³⁷ On technology, we generate aggregate output with a Cobb-Douglas production function, $Y = K^\zeta L^{1-\zeta}$. The supply side of the model is, then, completely specified by the capital share in aggregate income ζ , the rate of capital depreciation, δ , and the annual productivity growth rate, ρ . In our set of experiments we set ζ to 0.38, reflecting a recent increase in the capital income share of GDP. We assume a 6% depreciation rate, which generates an Investment-to-GDP ratio of 21% in 2010 (25% in the mid 2000’s). Finally, we consider three alternative time paths for the exogenous growth rate of productivity. In our *base* environment, we mimic the AWG projected increase in ρ^t from an initial 1.1% to a stationary 1.6% in the long run. In our alternative, more optimistic (pessimistic) scenarios we let ρ reaches 2% (1%) in the long run (environments *High* ρ and *Low* ρ respectively in Table 4).

³⁷We estimate smoothed life-cycle profiles of assets by education and age using EFF data. These profiles are uniformly re-scaled in the simulation to reproduce the targeted initial capital to output ratio.

	Base		Alternative economies	
		number	name	description
Demography				
Immigration flows	High Imm	1	<i>Low Imm</i>	Mod-INE immigration
Fert. & mortality	AWG			INE
Labor market				
Unemployment rate (employment rate e)	High Un (average e)	2	<i>Low Un</i> (high e)	AWG Low Unemploym.
Pension system				
Survival & retirement pension Accumulation	No accum. of surv. & ret.	3	<i>S&R Acum</i>	Accumulation of survival and retirement pensions
Annual discretionary adjustments	“Hidden Reform”	4	<i>Neutral</i> <i>Max&Min</i>	Constat real Max & Min pensions & contributions
Macroeconomy				
Productivity growth	1.6 % ρ	5	<i>Low ρ</i>	1 % productivity growth
		6	<i>High ρ</i>	2 % productivity growth
Annual inflation	2.5 % π	7	<i>Low π</i>	1 % inflation rate
		8	<i>High π</i>	4 % inflation rate

Table 4: *Base* and alternative eco/demographic scenarios: definition and enumeration.

Finally, we also consider three alternative inflation environments. Inflation has real effects in our model only after the 2013 reform, as the nominal indexation rules applied to pension updating generate a time-varying pattern of real pension expenditure. In the *base* simulation we assume a constant 2.5% inflation rate throughout the simulation (slightly above the ECB target). We also consider two possible deviations: the persistence of the current low inflation scenario (*Low π* setting in Table 4, characterized by a constant 1% inflation rate) and the return of higher inflation rates in the *High π* scenario (featuring a 4% rate).

3.5 Benchmark, alternative and extreme cases: an enumeration

In the previous paragraphs we have spelt the details of our *base* case scenario. This is the setting used in the next section to gauge the impact of the 2013 reform. Of course, the future eco-demographic background for the next decades is highly uncertain. Determining a “best probable” future case is too difficult at this point and we refrain from giving such status to our *base* case. More modestly, we just interpret the *base* scenario as a useful tool to highlight the main economic forces involved in the working of the pension system and its reform. But we also complete the analysis by performing a rather extensive sensitivity analysis. This is undertaken in section 4.3, where we explore how our findings in the *base* case change when some of the background assumptions (one at time) are modified. Table 4 enumerates all the different eco/demographic settings simulated. We also undertake a extreme case analysis, by including several simultaneous changes in the environment. Table 5 describes the two extreme alternatives considered. The *worst case* scenario combines several modifications of the *base* case assumptions resulting in a higher level of future pension expenditure. Conversely, the *best case* scenario combines modifications leading to lower pension expenditure. The perspective of this classification is, therefore, that of the manager of the pension system (and not necessarily that of pensioners or affiliated individuals).

Name	Immigration	Employment	S & R accum	“Hidden reform”	Productivity	inflation
Base	High	Avg	No	Yes	Avg	Avg
Best	High	High	No	Yes	High	High
Worst	Low	Avg	Yes	No	Low	Low

Table 5: Characterization of the *base* and *extreme* eco/demographic environments.

4 Results

This section is divided in three parts. First, section 4.1 deals with the exploration of the future financial condition of the pension system in place before the introduction of the ABM in December 2013. We refer to this institutional environment as the “R11 system”, reflecting that some of its basic features were informed by the immediately preceding pension reform in 2011. We focus in the *base* eco/demographic environment for this analysis. Section 4.2 studies the impact of three institutional changes: the inclusion of the ABM mechanism implemented in BOE (2013) and of two simplified versions of it based on constant indexation rules. For concreteness, the analysis is again confined to the *base* eco/demographic environment. Finally, section 4.3 checks the robustness of our findings to changes in the economic background. We explore the impact of the reform under the several alternative environments of section 3.5.

4.1 The future of the 2011’s pension system in the *base* environment

The R11 system is the result of the numerous parametric changes introduced in the Spanish pension system in 2011 (discussed in section 1 and reviewed in detail in section 3.3). Here we simulate its future economic performance under the *base* macroeconomic scenario defined in section 3.5. Recall that this particular set of assumptions included two hypothesis about the evolution of the pension system itself (the reform of survival pensions and a mild form of “hidden reform” of the system).

The aggregate evolution of pension expenditure and pension revenue as a proportion of GDP in our benchmark simulation is displayed in Figure 5. It clearly reveals that future pension expenditure will grow at a much faster rate than aggregate output until around 2050. In contrast, contributions will remain largely unchanged as a proportion of GDP. The result of these two simultaneous forces is a strong deterioration in the financial balance of the system. The *base* column of Table 12 (in section 4.3) shows the extension of the resulting financial imbalances. In our benchmark case they reach a figure close to 8% of GDP around 2050. In the process, the assets accumulated in the Trust Fund since 2002 will be progressively consumed and finally exhausted by year 2044 (right panel of Figure 22 in appendix C.2).³⁸

Figure 6 and Table 6 illustrate the dynamics of pension expenditure. The growth in the number of pensions peaks after 2050, while the average pension shows a steady upward trend. The speed of these changes, however, is far from constant. The increase in retirement pension payments is fairly moderate early in the simulation, thanks to the cost-cutting reforms implemented in 2011 (specially the heavier penalties associated with delayed legal retirement ages). The growth in the number of pensions accelerates markedly with the retirement of the generation

³⁸The relatively advanced exhaustion date for the Trust Fund’s assets reflects a policy of very smooth management of the Fund resources. A large proportion of the system deficits are transferred to the general budget well before the Fund’s assets are fully liquidated.

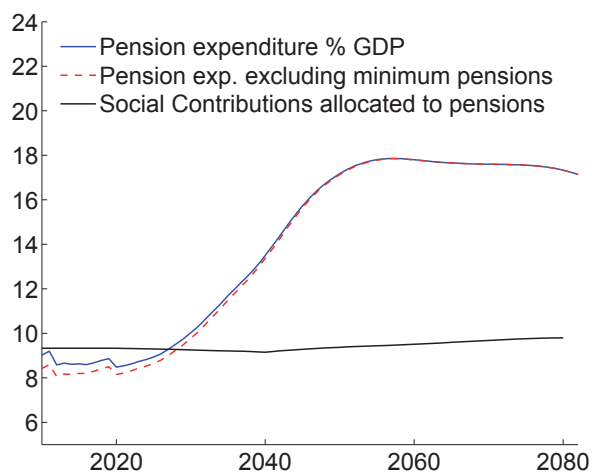


Figure 5: Benchmark Simulation (R11): Pension expenditure (inclusive and exclusive of minimum pensions) and aggregate contributions, expressed as ratios to GDP.

of Baby Boomers, starting around 2025. At its peak, the system will grant almost three times more pensions each year than the figures observed in the last decade. Note that these results include the endogenous reaction to the 2011-reform and to the on-going adjustment of the system (which we assume is done by increasing the income tax). Higher taxes reduce individual wealth from a life-cycle perspective, spurring households to increase their gross saving rates and to delay retirement (Figure 7). The trend towards later retirement is, however, broken for higher-income workers born after around 1980. Note how the incidence of early retirement goes systematically down for lower income workers (top right panel of Figure 7), while it rebounds for the younger cohorts of high-income workers (bottom right panel). This is a direct consequence of the policy of increasing the real value of the maximum contribution while keeping the maximum pension constant in real terms. The quantitative incidence of the legal floors and ceilings on pension payments is shown in Figure 21 in appendix C.2.

The moderating effects of the changes introduced in 2011 are more visible in the dynamics of the average pension. The right panel of Figure 6 shows a monotone increasing average pension level, reflecting the transmission of productivity growth to wages and pension rights and the effects of more complete working careers. However, average per capita income grows faster than pensions during the first part of the simulation. This can be appreciated with the following standard decomposition of the pension expenditure to GDP ratio:

$$\frac{PP^t}{Y^t} = \left(\frac{\bar{b}^t}{\bar{y}^t} \right) \left(\frac{J^t}{E^t} \right) = \left(\frac{\bar{b}^t}{\bar{y}^t} \right) \left(\frac{J^t}{P_{+65}^t} \right) \left(\frac{P_{+65}^t}{P_{20-64}^t} \right) \left(\frac{P_{20-64}^t}{E^t} \right) \quad (10)$$

The ratio is the product of the “replacement rate” (average pension per retiree, \bar{b}^t , divided by the average product per employee, \bar{y}^t) and the “coverage rate” (number of retirees, J^t , divided by the number of employees, E^t). In turn, the “coverage rate” is the product of the number of pensions per elderly citizen, the demographic dependency ratio and the inverse of the employment rate (in order, the three factors on the right hand side of eq (10)). The simulated time series of these four components are illustrated by the blue line in Figure 12. The bottom-right panel shows how the pension replacement rate *decreases* from around 20% to below 16%

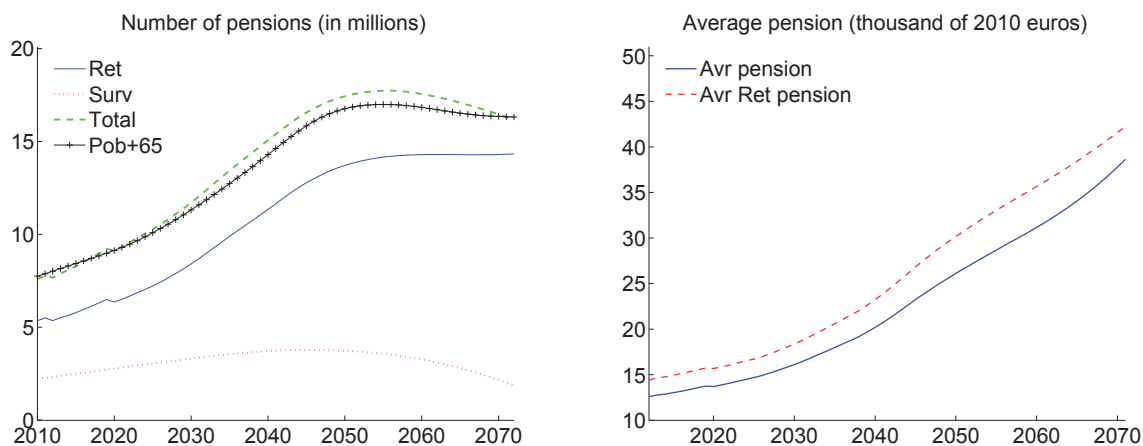


Figure 6: Simulated number of pensions (left panel) and average pension value (right panel) in the benchmark simulation (*base* environment and pre-reform, R11 pension system).

	g.avr B-ret	Δ N. BRet	Δ N. BSur	g.N BRet	g.N BSur
2004/2012	2.29	88.8	24.1	1.64	1.1
2010/2020	2.20	100.3	56.4	1.68	2.22
2020/2030	3.21	217.3	52.4	2.88	1.70
2030/2040	3.92	296.7	38.3	2.94	1.08
2040/2050	4.10	218.3	-2.9	1.72	-0.08
2050/2060	3.34	46.2	-52.3	0.33	-1.52

Table 6: Simulated growth rates of average pensions and increases in the number of pensions (in absolute value and in percentage). The top line reproduces real data. “g.avr” stands for the % average growth rate in real value in the indicated period; “g.N” is the average growth rate in the number of pensions; “ Δ N.” is the average increase in the number of pensions (in thousands). BRet refers to retirement pensions and BSur to survival pensions.

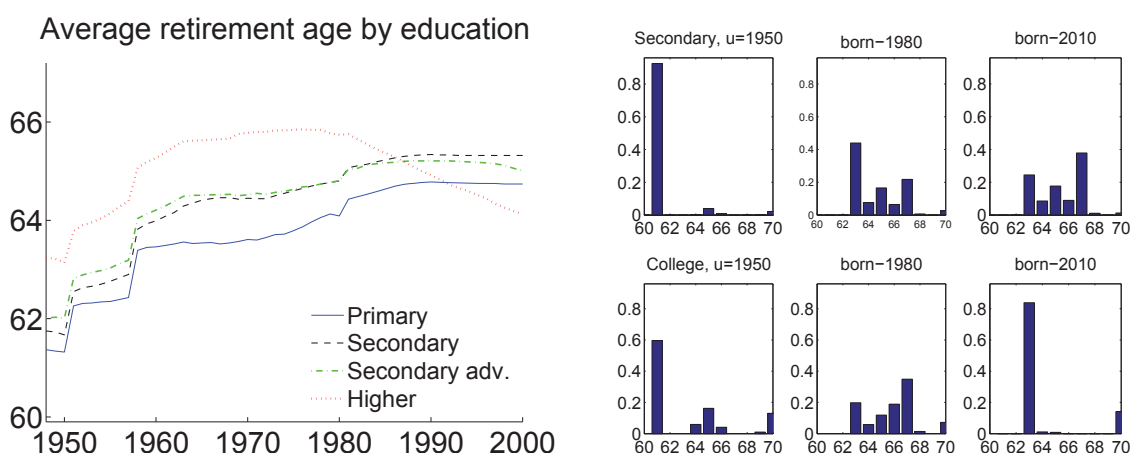


Figure 7: Average retirement age by age of birth and education (left panel) and distribution of retirement ages for low/high skill workers belonging to three particular cohorts (right panel).

before 2030 (only to subsequently recover all the lost ground).³⁹ The decomposition also reveals the causes of the increase in the “coverage rate”. It is not just population aging (the increase in the dependency ratio), but also, in the interval 2010/2035, the increase in pension coverage, ie. the number of pensions per elderly. This increase is mostly a delayed consequence of higher female labor participation, but it is exhausted by around 2040 and followed (in an scenario that places restrictions on new survival pensions) by a mild decline. Employment rates also play a role here (a mitigating one in this case, as this variable is increasing until around 2050).

In our model, the overall public budget is kept in balance each period by adjusting the income tax rate (section 2.5). Inevitably, the pension deficits lead to an increase in the fiscal burden, as the *base* column of Table 14 makes apparent. Aggregate tax collection as a % of GDP should increase from 22 % in 2010 to 32.4 % in 2050 and more than 34 % in 2070. The breakdown of these increases in taxes is, roughly, as follows: 8.5 points are due to the increased pensions expenditure; 2.5 points derive from additional health/long-term-care expenses and the rest comes from a drop in aggregate contributions.

4.2 Reform in the benchmark environment

4.2.1 The 2013’s reform

There are three main elements in the reform approved by the Spanish parliament in December 2013: (i) “Factor de sostenibilidad”, a straightforward indexation of the initial pension benefit to changes in life expectancy; (ii) “Índice de revalorización” (IR), an ABM that links the annual indexation of pension payments to the current state of the pension system; and (iii) the imposition of exogenous bounds on the workings of the IR mechanism in (ii). We review each of these components in turn.

- (i) Factor de sostenibilidad (FS). Starting in 2019, the initial pension benefit of retirees will be reduced according to the observed increases in life expectancy (evaluated on a quinquennial basis). The pension formula in eq (5) will include an additional multiplicative term, I_t^{FS} , calculated as follows⁴⁰:

$$I_t^{FS} = [ev_{67}^{t-7}/ev_{67}^{t-2}]^{1/5}$$

where ev_{67}^s stands for the observed life expectancy (according to the Social Security mortality tables) at the age of 67 at calendar year s . Figure 8 shows the evolution of the I_t^{FS} index in our simulation.

- (ii) Índice de Revalorización (IR): according to the new ABM mechanism, the anual growth rate at year t of the entire pool of old pensions (formed before t but remaining in effect at the beginning of the period), g_{t+1} , is no longer linked to realized inflation but to (a linearized version of) the following formula:

$$(1 + g_{t+1}) = \frac{1 + g_{t+1}^I}{(1 + g_{t+1}^P)(1 + g_{t+1}^S)} \frac{I_t}{G_t} \quad (11)$$

³⁹The right panel of Figure 19 in appendix C.1 shows the separate behavior of \bar{b}^t and \bar{y}^t . It clearly points towards a slowdown in the growth rate of output per worker (after around 2030) as a major factor after the increase in relative pension expenditure. In our model, this is a consequence of the dynamics of the capital/labor ratio, ie. of the relative scarcity of labor and capital. Both factors respond to both exogenous process (aging) and endogenous responses (savings and retirement). See appendix C.1 for a more complete discussion.

⁴⁰Given the lack of mortality uncertainty in our simulation, we implement a slightly simplified version of the official formula that uses contemporaneous information rather than that observed two years before the adjustment

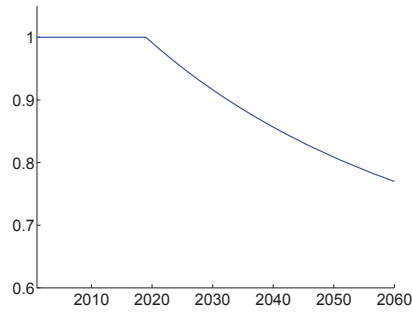


Figure 8: Simulated time path of the I_t^{FS} index: adjustment in the initial pension value induced by the expected gains in life expectancy according to “factor de sostenibilidad”.

where g_{t+1}^P is the growth rate in the number of pensions, g_{t+1}^s is the growth rate of the average pension due to the replacement of the old, smaller pensions of the deceased by the higher pensions of the newcomers, g_{t+1}^I is the growth rate in social contributions, and I, G represent the aggregate gross income and gross expenditure of the pension system.⁴¹ Roughly speaking, the first fraction captures the dynamics of the system’s financial state (growth component), while the second product reflects any current disequilibrium between the flows of revenue and expenditures (balance component). The actual application of (11) is smoothed over an entire business cycle in three ways: by applying 11-years moving averages of all growth rates; by applying a 11-years geometric MA to $\frac{I_t}{G_t}$ and by correcting only a fraction $1/4 \leq \alpha \leq 1/3$ of the current imbalance ($\frac{I_t}{G_t}$) on each particular year.

As an illustration of the workings of this mechanism, Figure 9 and Table 7 explore the effects of a pure IR mechanism in the *base* context. The impact of the state of the system, $\frac{I_t}{G_t}$, is shown in the top-left panel of the Figure. Revenue is insufficient to cover expenditure since the onset, pushing towards a negative adjustment in the level of pensions g_t . The contribution of the dynamics of revenue/expenses is shown in the bottom-left panel of the Figure. With the exception of a brief interval at the beginning, the increase in pension expenditure also pushes for a drop in the index (increase in the denominator of (11)), while the change in contributions has a small counterbalancing effect until around 2040.⁴² The simulation generates constant drops in the real value of pensions. If left unchecked, the BAA mechanism will produce really staggering drops in annual pensions. The maximum reductions will take place in the interval between 2035 and 2055, with cuts exceeding minus 4% per annum.

The cumulative effects of these cuts are quantified in Table 7. For those retiring in 2015, the annual pension payment 10 years later will be 8% smaller than the initial value and the deterioration continues in the subsequent years. For those alive 40 years after retirement, the real pension benefit will be slightly above 30% of the original value. And these figures get even worse for later cohorts. We have to wait until the cohorts retired in 2045 to see

⁴¹To rationalize expression (11), note that the one-period ahead financial balance at t , $G_{t+1} = I_{t+1}$, is granted if $G_t(1 + g_{t+1})(1 + g_{t+1}^P)(1 + g_{t+1}^s) = I_t(1 + g_{t+1}^I)$.

⁴²The early recovery in the the value of contributions reflects the rapid turnaround from the 2008/2013 recession assumed in the *base* environment. The negative (real) growth rate of pension expenditure is a result of averaging the effects of delays in retirement behavior over 11-year intervals. Note that, in the simulation, we have to introduce the 2011’s two-years delays in statutory pension ages at two particular years (rather than in the progressive way indicated in the law). The information available at the end of 2014 suggests that the initial dynamics predicted are excessively optimistic (at least in the short run), as the real update of pensions for 2014 is already in the lower bound of minimum 0.25% nominal growth (-2.25% real drop).

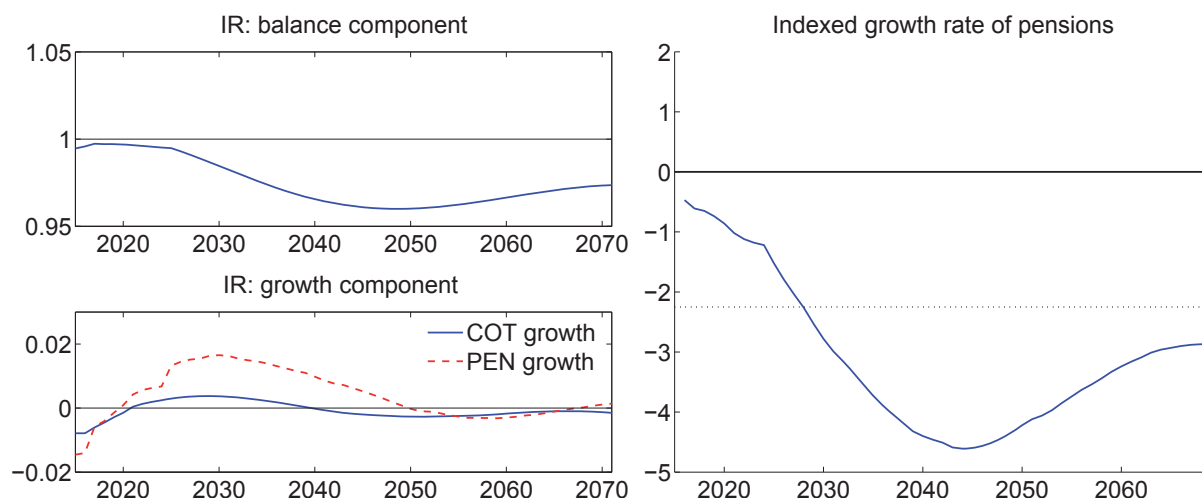


Figure 9: Unbounded IR mechanism in the *base* eco/demographic environment. Left panels: workings of the two components of the IR indexation mechanism (equation 11). Right panel: simulated growth rate of the pension index, g_t .

	10	20	30	40
2015	0.92	0.71	0.46	0.30
2025	0.78	0.50	0.33	0.23
2035	0.68	0.48	0.36	0.26
2045	0.74	0.55	0.40	0.30

Table 7: Accumulated effect of the application of an unbounded IR mechanism in the *base* environment. Ratio of the current pension payment (10 to 40 years after retirement) to the initial pension payment according to the year of retirement.

a turnaround in the trend towards a continuous reduction in the real value of pensions payments (in comparison to those of the previous cohorts).

- (iii) *Bounded IR mechanism*: Table 7 values make clear that the pension cuts needed to restore the financial balance of the system are very large. Unsurprisingly, current politicians were not prepared to endorse such harsh losses on their elderly constituencies and included lower (an upper) bounds on the indexation growth rates. The values effectively included in the 2013's law were a minimum nominal *increase* in current pensions of 0.25% and a maximum nominal increase of 0.5%. Assuming a 2.5% inflation rate, the real lower bound on g_{t+1} is a -2.25% annual drop in value.⁴³

⁴³The law also leaves open the possibility of discretionary changes in the α parameter, but always within the stated $[1/4, 1/3]$ bounds.

Combining factors (i) to (iii) above, we consider the following three simulation environments:

1. **MAX-I** or “Maximum pension indexation” environment, combines the status quo institutions (R11), the adjustment in life expectancy and the systematic indexation of pension payments according to the upper legal bound (+0.5% real).
2. **MIN-I** or “Minimum pension indexation” environment, is similar to **MAX-I** but indexes pensions by the minimum possible legal growth rate (-2.25% real).
3. **BAA** or the “Bounded Automatic Adjustment” environment, is our best approximation to the system finally put in place in 2013. Combines the Status-quo institutions (R11), the adjustment in life expectancy and the IR indexation mechanism (smoothed version of eq (11), constrained by legal upper and lower % limits on g ($-2.25 \leq g \leq +0.25$)).

4.2.2 Impact of the reforms on the system’s financial condition

The first step in the analysis of the BAA reform is to review the workings of the constraint IR mechanism. Figure 10 and Table 8 provide the results. Again, we find *real* pension contractions from the onset, but now the indexation rate hits the lower bound by around 2030 and stays there for more than 3 decades. Clearly, the operation of the floor imposed on the indexation growth rate blocks the correction of the financial imbalance in a significant way. This can be appreciated in the upper-left panel of Figure 10, where the income coverage of pension benefits is as low as 90% in the years around 2050 (compare to a 96% value in the unbounded simulation).

The performance of the system in terms of aggregate pension expenditure (as a % of GDP) and of the pension system’s balance is shown in Figure 11. For the automatic adjustment mechanism we also show the values in some selected years in Tables 10 and 12 (under the BAA column of the array displaying the *base* environment). The MAX-I and MIN-I rules have the advantage of simplicity (specially when compared to the intricacies of the BAA system’s eq. (11)). Both rules disconnect pension expenditure from the financial balance of the system as a whole. MAX-I is particularly interesting because it approximately measures the impact of the life-expectancy adjustment of the reform (the FS component). Significant reductions in pension expenditure are achieved, but the graphs clearly show a system in deep financial disequilibrium. The lower bound system MIN-I, featuring very aggressive pension drops from its inception, performs very well in financial terms until around 2025. But, eventually, it also becomes insufficient and aggregate expenditure exceeds that in a truly balanced system.⁴⁴

For the more complex BAA reform, the time path of pension expenditure stays in between that of the MAX-I and MIN-I systems, although it eventually becomes indistinguishable with the MIN-I system. This happens when the automatic adjustment in pension levels hits the maximum real drops that define the MIN-I environment (-2.25%). The BAA reform induces a large reduction in pension expenditure when compared to the R11 system: pension expenditure to GDP ratio peaks below 12%, implying “savings” equivalent to 5.5 percentage points of GDP in 2050. In this regard, the BAA system (ie, the joint work of the adjustment to life expectancy (FS) and to the pension system balance (IR)) does a remarkable job. Still, the legal bounds imposed on the growth rate of pension indexation prevent the system from reaching a full financial equilibrium: in the *base* environment, the system still incurs a deficit of more than 2% of GDP in 2050.

⁴⁴We have developed a Notional Defined Contribution system as a standard of financial soundness in our simulation. We do not show its performance due to space limitations, but the findings are available from the author upon request.

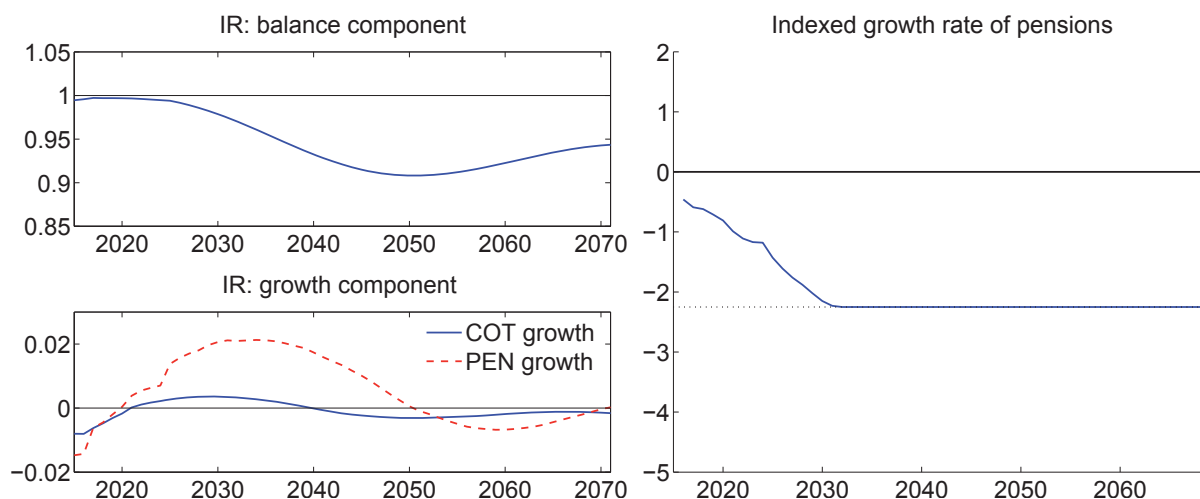


Figure 10: Bounded IR indexation in the *base* eco/demographic environment. Left panels: workings of the two components of the IR mechanism (equation (11)). Right panel: simulated growth rate of pension index g_t .

	10	20	30	40
2015	0.93	0.76	0.60	0.48
2025	0.83	0.66	0.53	0.42
2035	0.81	0.65	0.52	0.41
2045	0.81	0.65	0.52	0.41

Table 8: Accumulated effect of the application of the IR mechanism (in the *base* environment). Ratio of the current pension payment (10 to 40 years after retirement) to the initial pension payment according to the year of retirement.

How are these “pension savings” generated by the reform? Some important differences can be appreciated by looking into the working of the system more closely:

- The main driver of the result is the reduction in pension replacement rates (bottom-right panel of Figure 12). The reform has a negligible impact in the employment rate and a very small one in the pension coverage rate. Virtually all its effects derive from the reduction in the pension replacement rate.
- Consistently with the drop in individual pension payments, the incidence of minimum pensions increases appreciably after the reform, while the role of maximum pensions is diminished (Figure 21 in Appendix C.2).
- An immediate consequence of the more muted role played by maximum pensions is the disappearance of the downward sloping trend in average retirement observed in the R11 simulation (left panel of Figure 22 in Appendix C.2). The delay in retirement age, therefore, continues in a stepwise linear fashion after the reform.

As a corollary to the macro analysis, Table 14 reproduces the simulated fiscal burden in several environments. Focusing our attention on the *base* scenario we can appreciate the size of the tax hikes still needed to keep the public budget balanced after the reform. A 4 percentage

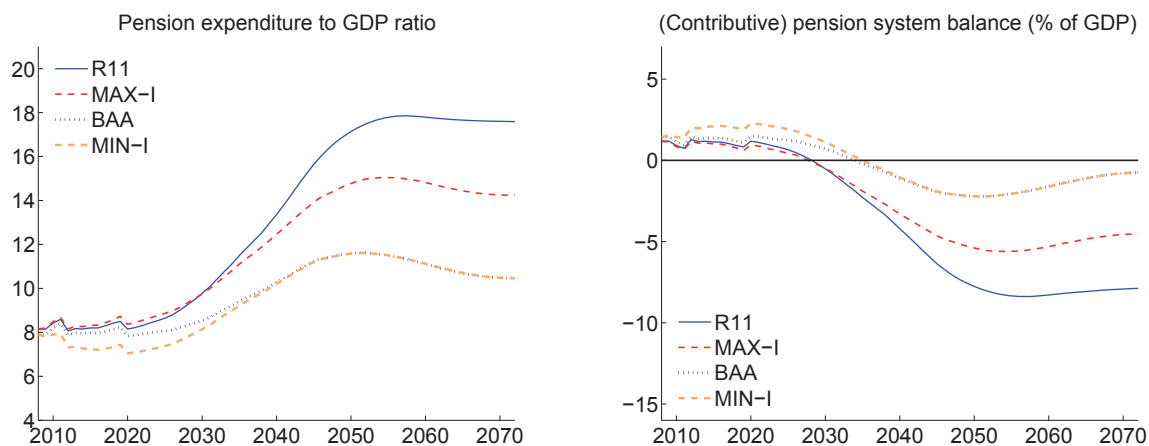


Figure 11: Aggregate effects of pension reform in the *base* environment. Pension expenditure and pension deficit as ratios to GDP in R11, BAA and under simple indexation rules MAX-I and MIN-I.

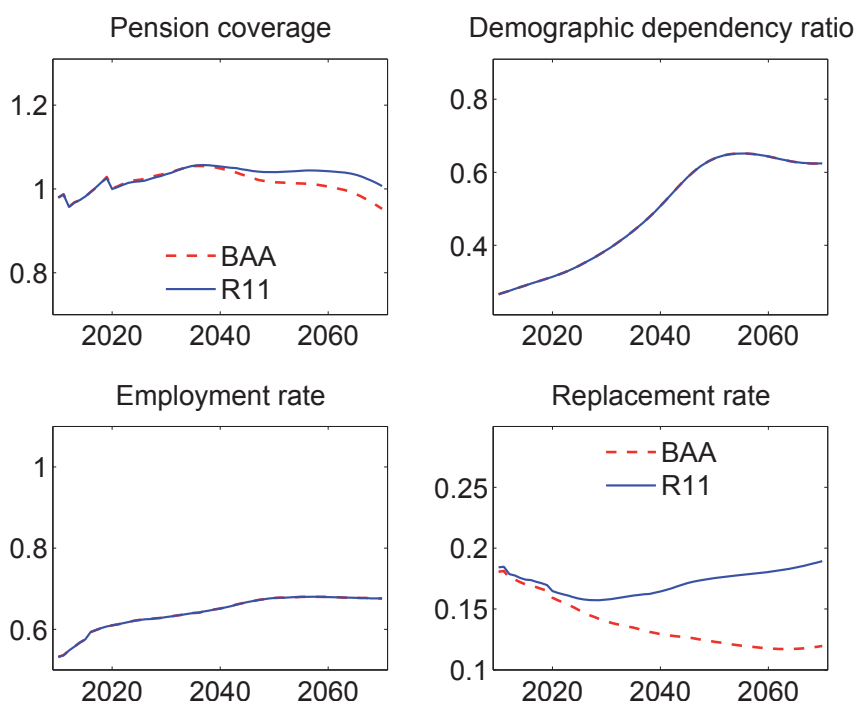


Figure 12: Accounting decomposition of pension expenditure according to equation (10), in the pre-reform (R11) and post reform (BAA) institutional settings.

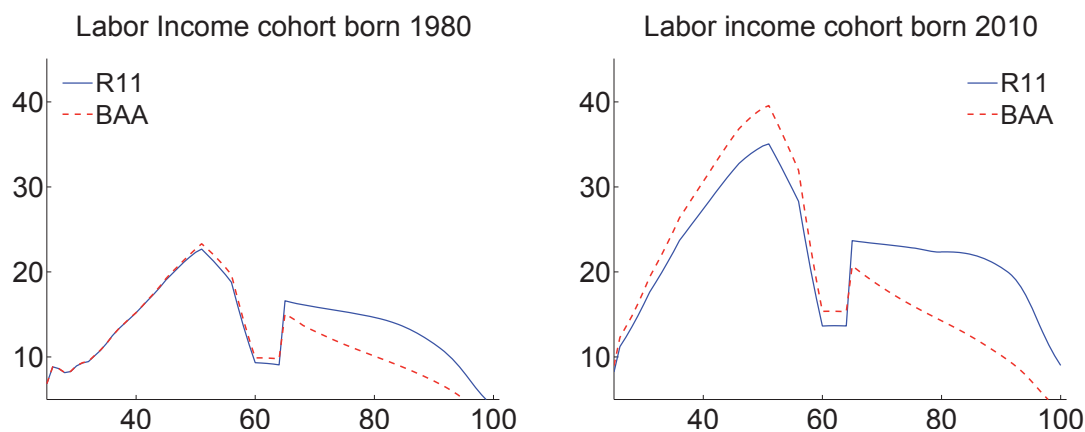


Figure 13: Simulated real labor income (net of taxes) of the representative households born in 1980 & 2010 (secondary education). All figures in thousands of 2010-Euros;

points increase in the overall tax burden is needed under the BAA system. This is far less than under the status quo, but also clearly larger than the value in a fully funded system.⁴⁵ The reform, then, alleviates a large part of the fiscal problems ahead, but fails to completely eliminate them.

4.2.3 Impact of the reform on life-cycle income and welfare

For those responsible of the public finances, the impact of the reform in aggregate expenditure is its most critical outcome. For economists, this should be combined with welfare analysis, ie. the inquire into who is benefiting from and who is being hit by the reform. As a first step in this analysis, we illustrate the effects of the BAA mechanism on the life-cycle profiles of labor income (Figure 13) and consumption (Figure 23 in appendix C.2) for the cohorts born in 1980 and 2010. The graphs illustrate the redistributive nature of the reforms: by reducing the pension payments granted to older generations (by the time the reforms are implemented), the net-of-tax labor income of future generations is enhanced. In absence of reform, the aging of the population would have been suffered mostly by future generations. The reforms, by reducing the generosity of current (and future) pensions, transfer part of those costs to the current generations of older workers.

Table 9 displays a quantitative evaluation of the welfare changes induced by the BAA reform. It shows the Equivalent Variation (EV) associated with that reform in our *base* eco-demographic environment.⁴⁶ An ubiquitous set of pattern emerges: cohorts of older workers pay a very big price in terms of foregone consumption as a result of the reforms. The losses peak at values around 4 % for the cohorts born around 1990. They become appreciably smaller as the education level improves. In contrast, younger cohorts of workers at the time the reform is implemented and future cohorts are better off under the new institutional setting. Educational heterogeneity becomes more important for future generations, as collage graduates emerge from losses earlier than their less educated counterparts and enjoy a steeper profile of gains by age of birth.

⁴⁵Note that some increases in taxation (adding up to around 2.5% of GDP) are needed even in absence of pension imbalances. This reflects the non-pension costs surrounding population ageing (health, long term care and diminished contributions).

⁴⁶The Equivalent Variation experienced by one particular agent is defined as the percentage shift in its life-cycle consumption profile (before the reform, ie under R11 institutions) that generates the same expected life-cycle utility as that observed under the reformed system.

cohort	Education			
	Primary	Secondary	Adv second	College
1930	-0.25	-0.29	-0.32	-0.31
1940	-0.87	-0.98	-1.04	-1.08
1950	-1.54	-1.64	-1.76	-1.82
1960	-2.46	-2.48	-2.88	-2.74
1970	-2.73	-3.37	-3.42	-3.19
1980	-3.23	-3.43	-3.22	-2.77
1990	-4.10	-3.33	-2.69	-1.37
2000	-2.77	-1.77	-0.97	2.19
2010	-0.96	0.12	1.07	6.33
2020	0.32	1.41	3.50	8.96

Table 9: Welfare changes induced by the BAA reform: Equivalent Variation by educational level for workers retiring at 65.

4.3 Sensitivity analysis

Are our findings of the impact of the 2013 reform in the previous section dependent of the eco/demographic environment? We address this question in two ways. First, we undertake a one-by-one exploration of the sensitivity of our findings to some of the key features of the eco/demographic environment (subsection 4.3.1). We also implement a extreme case analysis by assembling several simultaneous changes in the background environment in subsection 4.3.2.

4.3.1 Alternative eco/demographic scenarios

All our simulation results up to now are based on an unique set of eco/demographic assumptions (the *base* environment). As discussed in section 3, these assumptions are good educated guesses of the future performance of some key aspects of the Spanish economy. But they are by no means the only possible paths for the exogenous processes involved in our simulation. In this section we analyze the robustness of our findings by exploring some other possible trajectories for some of these eco-demographic processes. More precisely, we explore the set of alternative processes enumerated in Table 4 in section 3.5. Note that, in each case, we only modify one of the background elements, leaving the rest of the *base* environment unchanged. Simulation results are provided in Tables 10 and 11 (pension expenditure), 12 and 13 (pension imbalance), and 14 and 15 (overall fiscal effort). We find some clear cut common patterns across our set of simulations:

- There are very strong differences in the projected future of the pension system under the alternative underlying econ/demographic environments. Figure 24 in appendix C.3.1 visually illustrates these large differences.
- The 2013's reform universally reduces pension expenditure and helps to restore the financial imbalance of the system. This is mostly achieved through cuts in pensions levels. But the maximum level of pension cuts is reached earlier in the more unfavorable environments (see Figure 25 in Appendix C.3.1). This has two consequences: the reform is more effective in the more favorable settings while, in the more unfavorable cases, there are substantial

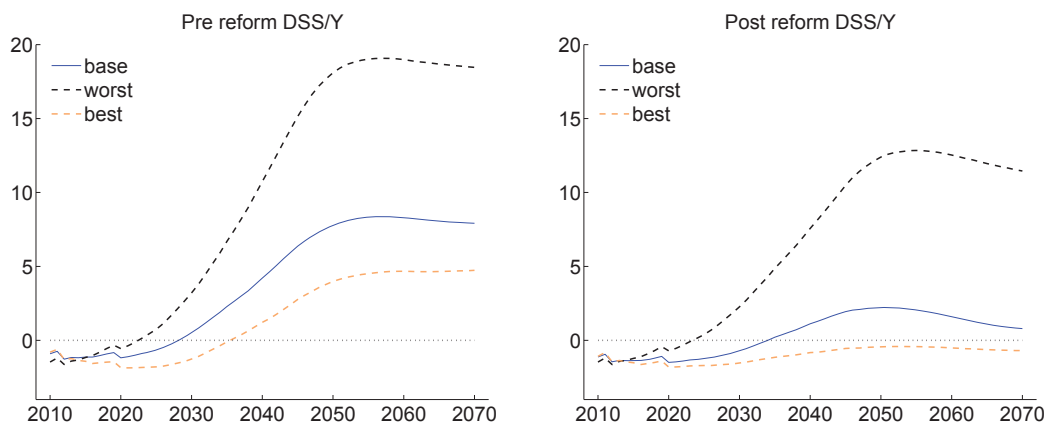


Figure 14: DSS/Y in the pre-reform (R11) and post-reform (BAA) institutional settings, in the eco/demographic environments: *base*, *best* and *worst* (see definition in Table 5)

imbalances still standing after the reform. The variance across environments is, therefore, reduced by the reform, but it is far from disappearing.

- The background environment does not modify the basic welfare impacts described in the *base* scenario (Table 17 in appendix C.3.1). The general patterns of welfare changes by age and education is similar across the simulations, with sizable (but not really very large) quantitative differences observed in the different environments.

Appendix C.3.1 provides a detailed revision of the performance of each alternative setting. Here we just summarize the findings by stressing the major risks threatening a “successful” development of the 2013’s reform. Our analysis confirms that low immigration flows and low productivity growth are major risk factors. Less attention is usually given to inflation and institutional factors. Our simulation indicates that a persistently low inflation could be (in the long term) as harmful for the success of the reform as poor immigration and productivity. The ability to extract extra financing from the discretionary year-by-year decisions of the system is also surprisingly important (full neutrality is *more* damaging for the balance of the system than low growth or inflation). The treatment of survival pensions is also remarkably influential. On the positive side, the findings can be more easily summarized: the reform will solve the financial problem of the system if unemployment or productivity surprise on the upside. High inflation also helps in financial terms, but its welfare consequences are stronger than in the *base* environment.

4.3.2 Extreme case analysis

To conclude the simulation analysis, we combine positive and negative alternative scenarios in the *best* and *worst* cases described in Table 5 (section 3.5). The performance of the resulting economies is depicted in Figure 14. The large differences showed are a good testimony of the uncertainty surrounding the future performance of the system (and, consequently, the effectiveness of the reform). Figures 26 and 27 in appendix C.3.2 delve more deeply into the forces driving such disparate performance by applying the classical 4-factor decomposition to pension expenditure and by showing the time path of pension indexation in each setting. A more detailed analysis is again confined to the appendix, but here we conclude by stating explicitly what is obvious from the graph: (i) that the reform is needed even if the best environment were to

year	base		Low Imm		Low Un		S&R accum		Neutral Max&Min	
	R11	BAA	R11	BAA	R11	BAA	R11	BAA	R11	BAA
2010	8.42	8.21	8.41	8.23	8.43	8.20	7.66	7.69	8.42	8.22
2030	9.77	8.54	10.85	9.21	8.17	7.77	9.71	8.56	9.77	8.37
2050	17.14	11.59	21.71	14.32	14.51	9.89	18.30	12.58	16.91	11.52
2070	17.60	10.48	21.55	12.61	15.58	9.34	20.00	12.29	16.14	9.53

Table 10: PP/Y: Pension expenditure to GDP ratio in several eco/demographic environments (see Table 4 for definition).

year	Low ρ		High ρ		Low π		High π		Best Case		Worst case	
	R11	BAA	R11	BAA	R11	BAA	R11	BAA	R11	BAA	R11	BAA
2010	8.67	8.39	8.53	8.33	8.42	8.34	8.42	8.19	8.54	8.25	7.86	7.86
2030	10.57	9.01	9.50	8.37	9.77	9.08	9.77	8.41	7.94	7.67	11.66	10.72
2050	19.76	13.26	15.72	10.69	17.14	13.27	17.14	10.25	13.28	8.86	25.52	19.82
2070	19.68	12.21	16.14	9.54	17.60	12.51	17.60	9.59	14.36	8.94	24.82	17.82

Table 11: PP/Y (continuation)

year	base		Low Imm		Low Un		S&R accum		Neutral Max&Min	
	R11	BAA	R11	BAA	R11	BAA	R11	BAA	R11	BAA
2010	-0.91	-1.12	-0.93	-1.11	-0.90	-1.13	-1.67	-1.64	-0.90	-1.11
2030	0.52	-0.71	1.60	-0.04	-1.04	-1.44	0.46	-0.69	1.32	-0.09
2050	7.76	2.21	12.35	4.95	5.21	0.59	8.92	3.20	9.48	4.08
2070	7.92	0.80	11.85	2.91	5.96	-0.29	10.33	2.61	9.79	3.18

Table 12: DSS/Y: Pension deficit (expenditure minus income) as a proportion of GDP, in several eco/demographic environments.

year	Low ρ		High ρ		Low π		High π		Best Case		Worst case	
	R11	BAA	R11	BAA	R11	BAA	R11	BAA	R11	BAA	R11	BAA
2010	-0.66	-0.94	-0.80	-1.00	-0.91	-0.99	-0.91	-1.15	-0.80	-1.08	-1.47	-1.47
2030	1.32	-0.24	0.25	-0.88	0.52	-0.17	0.52	-0.84	-1.26	-1.53	3.21	2.27
2050	10.39	3.88	6.35	1.31	7.76	3.89	7.76	0.87	3.98	-0.44	18.10	12.40
2070	10.00	2.52	6.46	-0.15	7.92	2.82	7.92	-0.10	4.73	-0.69	18.46	11.45

Table 13: DSS/Y (continuation)

year	base		Low Imm		Low Un		S&R accum		Neutral Max&Min	
	R11	BAA	R11	BAA	R11	BAA	R11	BAA	R11	BAA
2010	21.94	21.75	21.90	21.73	21.94	21.75	21.44	21.44	21.95	21.76
2030	23.14	22.55	24.79	23.49	21.68	21.78	23.11	22.58	24.18	23.10
2050	32.38	25.78	37.62	29.22	29.66	24.52	33.02	26.90	34.72	28.27
2070	34.25	26.61	39.01	29.59	32.62	25.19	36.77	28.08	36.84	29.68

Table 14: TAX/Y: Total tax collection as a percentage of GDP in several eco/demographic environments.

year	Low ρ		High ρ		Low π		High π		Best Case		Worst case	
	R11	BAA	R11	BAA	R11	BAA	R11	BAA	R11	BAA	R11	BAA
2010	22.10	21.86	21.90	21.72	21.94	21.86	21.94	21.73	21.91	21.68	21.55	21.53
2030	24.24	23.08	22.80	22.09	23.14	22.92	23.14	22.45	21.18	21.27	27.06	26.02
2050	35.34	27.72	30.71	24.44	32.38	27.70	32.38	24.34	27.85	24.04	44.34	37.92
2070	36.67	28.62	32.55	25.43	34.25	28.93	34.25	24.96	31.13	25.52	46.81	39.60

Table 15: TAX/Y (continuation)

materialize; (ii) that the reform solves the problem if the background setting is favorable; and (iii) that an alignment of unfavorable factors will make the reform hopelessly insufficient. The *worst* case scenario is so bad that, after the reform, the size of the unsolved implicit liabilities is *bigger* than that before the reform in the *base* environment. Even after the reform, the Spanish society still faces a large amount of pension risk.

5 Conclusions

The 2013 reform is the most ambitious effort to restore the financial sustainability of the pension system ever intended in Spain. Will it succeed? According to our simulations, it depends on the demographic and economic background. The most probable outcome is that it will fall short to some extent and some tax-increases will still be necessary. But, contemplating the problem from a life-cycle perspective, we can only conclude that the reform largely achieves what it is set to accomplish. It releases pressure from young and future cohorts of contributors by sharing the costs of aging more broadly with older generations. Still, the simulations make clear that there is scope for a more “egalitarian” distribution of the costs. By ignoring the balance sheet of the system (ie. the implicit liabilities that are already visible), the current reform let some cohorts (those retiring between 2030/2050) pay more than their fair share of the overall cost. Current generations of older workers and retirees may be compelled to help more by increasing the allowances to the Trust Fund, as in Sweden. This general conclusion is, however, contingent on the course followed by future governments when setting the annual discretionary elements of the system (minimum/maximum pensions and contributions) and on future changes in survival pensions.

Going beyond our particular simulation results, we close the manuscript with a couple of more general remarks. First, by discussing a few potential lines of improvement of our modeling strategy and implementation. Secondly, by highlighting the problems of resorting to money illusion as an apparently harmless “solution” to the “pension problem”. On the modeling front, we can only acknowledge the formidable difficulties involved in the eco/demographic simulations

attempted. It is quite clear that general equilibrium simulations of the type implemented here still need substantial improvement before considering their outcomes really “up to the task”. Future work must improve in at least three crucial dimensions:

1. Continue the move beyond the paradigm of representative households. We are still facing many non-linear situations where we use “functions of averages” as proxies for “averages of functions”. The use of the average contributed years in the pension formula is a good example. We need to use more micro-simulation to reproduce the real world heterogeneity in life-cycle profiles (of income, employment, health or family circumstances). Until that, we cannot really get trustworthy aggregate predictions from our models.
2. The cyclical behavior of the economy is another challenge. OLG models are naturally well designed to reproduce long term phenomena, but need to be improved to capture the higher frequency behaviour of the economy. This is important because the pension system makes part of the short-run fluctuations permanent (for example in systems that do some pre-funding in a Trust Fund or, more generally, by computing individual pensions according to long term labor records). Political risk is also clearly linked to the short term performance of the economy.
3. It is quite revealing of the state of the methodology that we cannot measure (in probabilistic terms) the variability of the future potential outcomes from the system. We need to move beyond *scenario analysis* and into a real probabilistic measurement of the future states of demographic, employment and productivity variables. The challenge is specially hard with respect to the simultaneous covariance of these factors.⁴⁷

Isolated improvements in some of these fronts have been already made in previous research papers, but we need to integrate them to develop a really trustworthy tool for policy analysis. We close with a reflection on the apparent use of “monetary illusion” to seek the endorsement of the reform from the general public. The nominal guarantee explicit in the ABM formula has been highlighted as one of the main aspects of the recent reform, probably to make the reform more politically appealing. However, it does not preclude potential real losses for current and future retirees. This is not a problem in our artificial world of rational utility maximizers with full information, but it is an important issue in the real world. We anticipate that a significant fraction of households may fail to appreciate the risk of systematic future losses in purchasing power. Consequently, they may fail to take protection by saving more, working longer careers or adjusting their portfolio choices. The downward path of real pension income may, consequently, translate into a similar downward path of consumption. This is an unsettling vision for many economists. According to the OECD’s recommendations⁴⁸:

*Automatic adjustment mechanisms are often complex, difficult to understand and create uncertainty over future benefits. In order for individuals to adjust to these new pension designs, there is a need for gradualism and transparency in their implementation. A **fair and predictable** burden-sharing across generations should help individuals to act pro-actively by adapting their saving and labor supply behavior.*

⁴⁷Under the new Solventia II framework, European governments demand a fairly comprehensive risk management from insurance companies assuming pension obligations. Adopting a similar approach by public pension would be an improvement.

⁴⁸Chapter 2 in OECD pension outlook (2012), page 45.

In our view, the current Spanish reform falls short on this recommendation.⁴⁹ The reform has been a large step forward in facing up to the problems of the pension system. But we think that further discussions (about the ABM design and, probably, about other fundamental features of the pension system as well) still lie ahead before we can claim some kind of victory over our demographic problems.

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⁴⁹In our view, a larger part of the drop in real pensions should be “front loaded” as a reduction in initial pension. And subsequent pension payments should be better protected. This may be achieved by making the ABM system contingent on the current *balance sheet* of the pension system (rather than on its state of flows). Furthermore, the system may benefit from the systematic monitoring of the future state of the system using standard risk management techniques. We share with the experts’ committee its emphasis on the importance of communication and openness to the public.

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A Model

In this section we complete the description of the model presented in the main text (section 2). We provide more details on the construction of our demographic simulations (subsection A.1), some institutional details of the pension system (subsection A.2) and the formal definition of the equilibrium of the economy (subsection A.3).

A.1 Demography

Individuals are classified according to their country of birth as “Natives”, N^t , or “Migrants”, M^t .⁵⁰ The number of people born at t is determined by the profile of age-specific fertility rates $\{\Theta_i^t\}$ (assumed to vary between the threshold ages f_0 and f_1):

$$N_1^t = \sum_{i=f_0}^{f_1} \Theta_i^t (N_i^{t-1} + M_i^{t-1}) \quad (12)$$

After-birth population dynamics is given by:

$$N_i^t = h s_i^{t-i+1} N_{i-1}^{t-1} \quad M_i^t = h s_i^{t-i+1} M_{i-1}^{t-1} + F_i^t \quad 1 < i \leq I \quad (13)$$

where F_i^t stands for immigrant flows and $\{h s_i^u\}_{i=1}^I$ for the cohort-u vector of age-conditional survival probabilities. Note that gender-conditional survival rates are used to compute the within-household distribution of the economic agents, $\pi_{i,g}^t$, in section 2.3. Equations (12) and (13) constitute the law of motion of the population during the *demographic transition* (in the interval $t \in (t_0, t_1)$). After t_1 we take simple assumptions that guarantee the convergence to a stable population: we assume that fertility and mortality patterns stay constant and immigration flows progressively die out.

A.2 Pension System

The structure of the penalties in the pension formula is as follows:

- Early retirement penalties are captured by the replacement rate, $\alpha^E(\tau)$. For each year that the individual anticipates retirement (from the Normal Retirement Age, τ_N), the final benefit is reduced by a $\Delta \alpha^E$ percent. There is also an annual bonus $\Delta \alpha_{\tau_N}^E$ for staying employed after τ_N . Formally:

$$\alpha^E(\tau) = \begin{cases} \alpha_0^E + \Delta \alpha^E (\tau - \tau_m) & \text{if } \tau \in \{\tau_m, \dots, \tau_N\} \\ 1.0 + \Delta \alpha_{\tau_N}^E (\tau - \tau_N) & \text{if } \tau > \tau_N \end{cases} \quad (14)$$

Before the 2011’s reform, $\Delta \alpha_{\tau_N}^E$ varied from 6 to 7.5% depending on the length of the working career. After the reform, a unique 7.5% penalty per year of early retirement will be applied (and only for those with at least 33 years of contributions).

⁵⁰The household formation process for migrants older than 20 years is assumed to reproduce the distribution in the population at large. That is to say, for each possible education level and year of birth of a newly arrived immigrant we assume the same distribution of single/biparental families in the corresponding representative household as in the entire population. Accumulated assets and labor market performance is also assimilated to that in the population at large. These assumptions are not realistic, but (we conjecture) have a small impact on our results.

- The replacement rate $\alpha^H(h)$ captures penalties associated with a record of social contributions shorter than 35 years (37 after 2011). In the system in place before the 2011 reform, the structure is stepwise, with more severe penalties for those with shorter records ($\Delta \alpha_1^H > \Delta \alpha_2^H$):

$$\alpha^H(h) = \begin{cases} \alpha_0^H + \Delta \alpha_1^H (h - 15) & \text{if } h \in \{15, \dots, 25\} \\ \alpha_1^H + \Delta \alpha_2^H (h - 25) & \text{if } h \in \{25, \dots, 35\} \\ 1.0 & \text{if } h \geq 35 \end{cases} \quad (15)$$

The parameter values were $\alpha_0^H=0.5$; $\alpha_1^H=0.8$, $\Delta \alpha_1^H=0.03$, $\Delta \alpha_2^H=0.02$. After the 2011 reform, there is a constant linear penalty, with α_0^H still 50% and 37 the age when the penalty finishes.

A.3 Equilibrium

The set of properties defining the equilibrium time path of the model are:

- Endogenous population dynamics. Population aggregates and distributions evolve according to the model in section A.1.
- Rational agents (with full information). All households solve their life-cycle problems taking the rest of the equilibrium environment as given.
- Capital and labor markets clear. The capital and labor effectively used in production coincide with the aggregation of the supply of savings and labor by households:

$$K^t = \sum_{j=1}^J \sum_{i=20}^{I-1} \sum_{\tau=\tau_m}^{\bar{\tau}} \mathcal{P}_{ij\tau}^t a_{ij\tau}^t \quad L^t = A^t H^t \quad H^t = \sum_{j=1}^J \sum_{i=20}^{\tau_j-1} \sum_{\tau=\tau_m}^{\bar{\tau}} \mathcal{P}_{ij\tau}^t l_{ij\tau}^t$$

We denote by $\mathcal{P}_{ij\tau}^t$ the number at time t of *agents* of age i , education j and an unobservable value of leisure leading to retirement at age τ ⁵¹. $l_{ij\tau}^t$ is the household supply of efficient labor units: $l_{ij\tau}^t = \sum_{g=1}^2 l_{ij\tau g}^t = \sum_{g=1}^2 \pi_{i,g}^u \varepsilon_{ijg}^t 1(i \leq \tau)$ (with π as defined in section 2.3, ε as defined in section 3.2 and $1(i \leq \tau)$ the indication function of the event $i \leq \tau$). $\bar{\tau}$ is the maximum working age (70 in the simulations).

- Competitive prices

$$r + \delta = \frac{\partial F}{\partial K}(K^t, L^t) \quad w^t = \frac{\partial F}{\partial H}(K^t, L^t)$$

- Balanced annual government budget: the income tax rate φ^t is set annually so:

$$RN^t(\varphi^t) = CP^t + r^d D^t - (D^{t+1} - D^t) - SST^t - BI^t$$

With

⁵¹With our assumptions on the modeling of life-cycle behavior, *agents* with different unobservable value of leisure will retire at different ages.

$$RN^t(\varphi^t) = \varphi^t \sum_{j=1}^J \sum_{i=\tau_j}^I \sum_{\tau=\tau_m}^{\bar{\tau}} \mathcal{P}_{ij\tau}^t inc_{ij\tau}^t \quad BI^t = \sum_{j=1}^J \sum_{i=20}^{I-1} \sum_{\tau=\tau_m}^{\bar{\tau}} (1 - hs_{i,j}^{t-i}) \mathcal{P}_{ij\tau}^{t-1} a_{i+1j\tau}^{t-1}$$

where inc stands for total household income ($inc_{ij\tau}^t = LI_{ij\tau}^t + r^t a_{i,j\tau}$).

SST^t is defined as in eq (9), the Social Security Transfers are as defined in eq (7), the Trust Fund dynamics are as stated in eq (8), contributions are split between retirement and other contributions as follows:

$$COT^t = \sum_{j=1}^J \sum_{i=1}^{\tau_j} \sum_{\tau=\tau_m}^{\bar{\tau}} \mathcal{P}_{ij\tau}^t cot_{ij\tau}^t \quad \text{with} \quad \begin{cases} COT_R^t = \xi_c^t COT^t \\ COT_o^t = (1 - \xi_c^t) COT^t \end{cases}$$

and contributive and non-contributive pension expenditure is computed:

$$PP_c^t = \sum_{j=1}^J \sum_{i=\tau_j}^I \sum_{\tau=\tau_m}^{\bar{\tau}} \mathcal{P}_{ij\tau}^t \bar{ib}_{ij\tau}^t \quad PP_m^t = \sum_{j=1}^J \sum_{i=\tau_j}^I \sum_{\tau=\tau_m}^{\bar{\tau}} \mathcal{P}_{ij\tau}^t ibm_{ij\tau}^t$$

where $\bar{ib}_{ij\tau}^t$ stands for total pension payments excluding minimum pensions and $ibm_{ij\tau}^t$ represents the part of pension payments originated from the minimum pensions program.

- Aggregate feasibility

$$Y^t + (1 - \delta) K^t + BI^t = K^{t+1} + BI^{t+1} + \sum_{i=20}^I \sum_{j=1}^J \sum_{\tau=\tau_m}^{\bar{\tau}} \mathcal{P}_{ij\tau}^t c_{ij\tau}^t + CP^t$$

The final steady state of the economy is defined by a stationary version of the same properties above.

B Calibration

This section completes the description of the alignment of the model economy and the target Spanish economy in the main text (section 3). It is divided in two subsections: B.1 centers on education, productivity, employment and the length of working records; B.2 deals with the formation of the initial pensions in the model.

B.1 Education, individual productivity and labor market behavior

The dynamics of the distribution by **education** in our simulations is displayed in the left panel of Figure 15. Virtually all the improvement in education achievement is due to generational replacement. Differences in education emerge with special intensity as differences in life-cycle productivity. These are captured by the different endowments of **efficient labor units** across agents, displayed in Figure 16. They are computed by regressing the annual growth rate of labor income (by education and sex and deflated of time-varying productivity growth) on calendar time and a quadratic function of age.

Educational attainment also results in large differences across agents is labor **participation** and employment. The right panel of Figure 15 shows those differences, along with the strong generational change created by the increased participation of females. This secular patten is

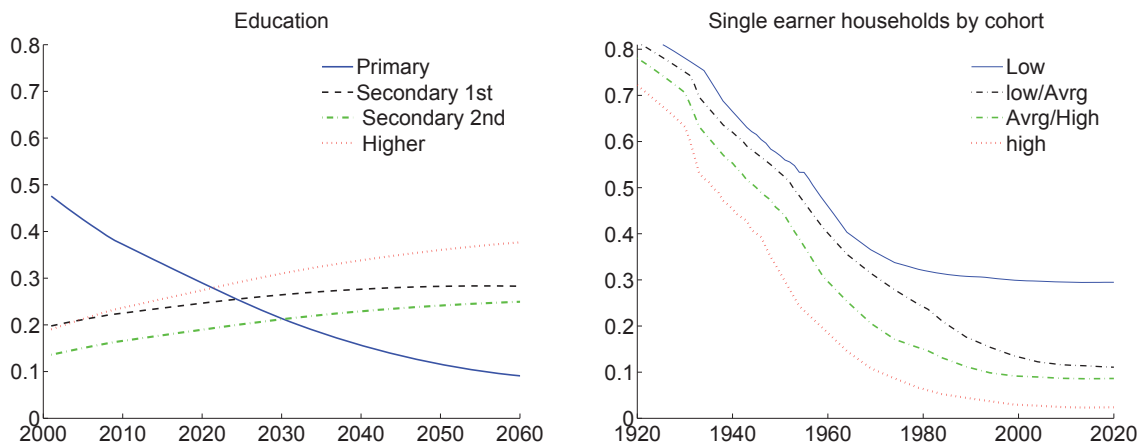


Figure 15: Left panel: Simulated educational distribution; Right panel: proportion of one-earner households by cohort and education

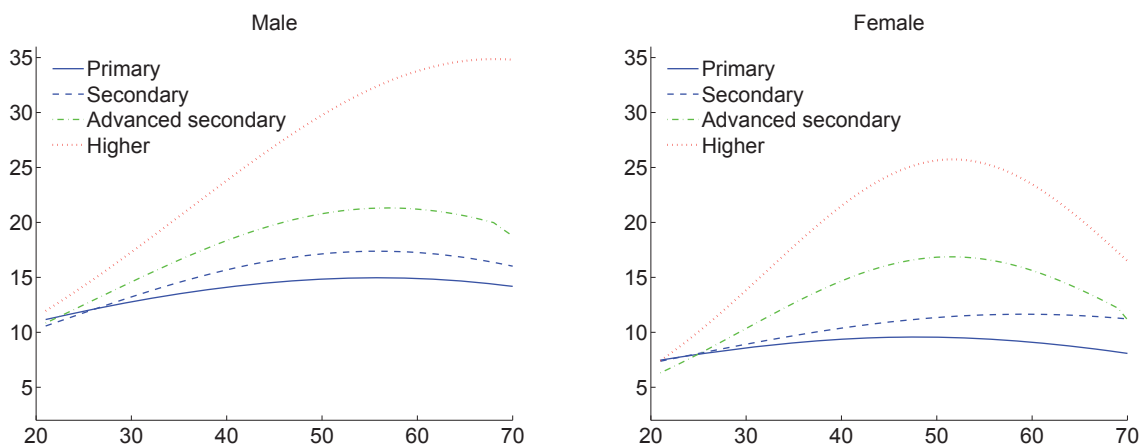


Figure 16: Life cycle profiles of efficiency labor units by gender and educational group.

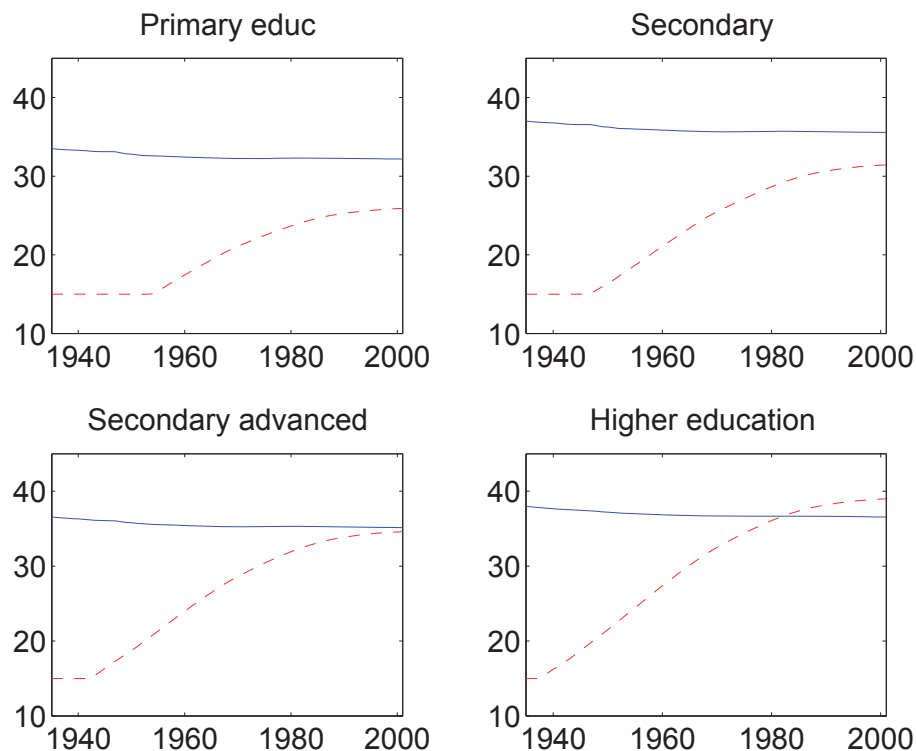


Figure 17: Simulated average number of contributed years by education and gender (male (-) and females (- -)).

specially important for the pension system, due to the link established between the initial pension and the length of contributed records. Figure 17 illustrates how the change in participation results in longer records as affiliated workers (and, consequently, leads to larger initial pensions). The proportion of individuals that qualify to enjoy a retirement pension also depends on this development (15 years of contributions are needed, with two of them in the years immediately preceding retirement). In the model, individual outcomes are approximated by using the participation profiles of the representative agents. This misses some qualifying individuals (those with erratic or discontinuous paths). On the other hand, we overstate the pension entitlement by using participation rather than employment rates. The rationale for this lies in the protection provided by the employment national agency to the unemployed age 52 and older (it pays their social contributions to the Social Security). For simplicity, we extend that privilege to earlier ages.

B.2 Pension system

The calibration of the initial pension payments is illustrated in Table 16. It compares the model-generated pensions for male and females born between 1940 and 1950 to their empirical counterparts in *Encuesta de Condiciones de Vida*. There seem to be a reasonably good match by education level and gender. The comparison is, however, only an approximation, as real data correspond to individual pension “payments” while the model simulation is of the “initial pension” of representative agents.

The subsequent dynamics of the initial pensions in our baseline simulation (under the pension system in place after the 2011 reform) is displayed in Figure 18. The figures are deflated of

Education group	u=1940/50, ECV		u=1950, model	
	male	fem	male	fem
1	11.69	-	11.00	2.86
2	16.32	-	13.80	3.89
3	19.57	4.00	15.83	6.16
4	26.31	11.35	24.18	10.73

Table 16: Estimated pension for workers born between 1940 and 1950 in ECV-2004/2011 (by education and gender), versus model predicted initial pensions (excluding minimum pensions) for the cohort born in 1951. Values in thousand of euros of 2010.

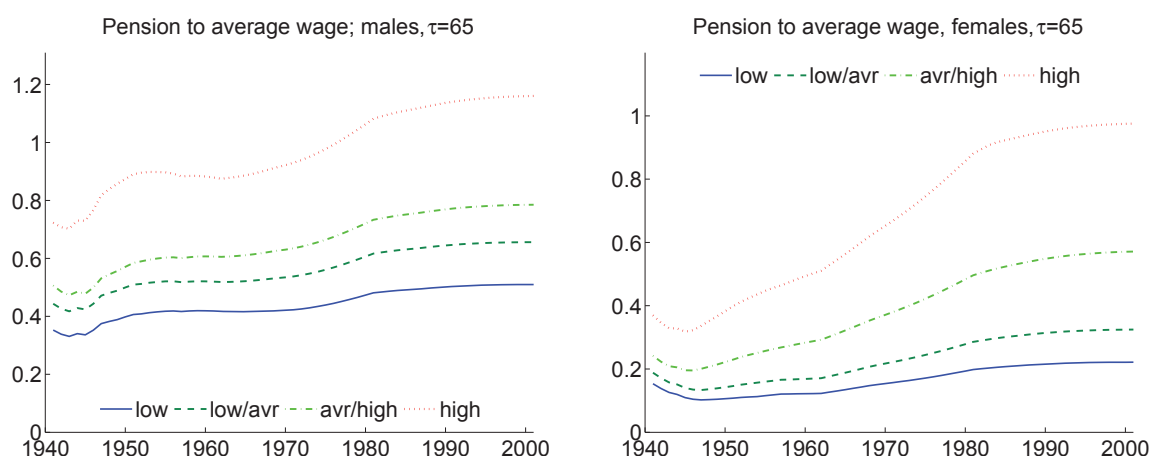


Figure 18: Simulated ratios of the initial pension to the average wage by cohort, education and gender, for workers retiring at 65.

exogenous productivity growth. They reveal gains derived from changes in employment (cyclical as well as secular) and changes induced by the parametric reform of 2011 (eg, the increase in the averaging period in the pension formula). Female gains are clearly larger, reflecting the strong changes in their life-cycle participation rates.

C Simulation results

This section completes the description of the simulation results in the main text (benchmark simulation in section 4.1, the 2013 reform in the *base* environment in section 4.2 and sensitivity analysis in section 4.3). They are mirrored by subsections C.1, C.2 and C.3 in this final appendix.

C.1 The 2011's pension system in the *base* environment

Figures 19 and 20 complements the revision of the baseline simulation path in section 4.1. In particular, we illustrate three important issues: the determinants of the pension-expenditure to GDP ratio; the behaviour of the discretionary elements of the pension system and the total fiscal burden during the simulated path. Top panels of Figure 19 deal with the decomposition of PP/Y. The left panel shows the growth rates of pension expenditure per capita, labor per capital and accumulated assets per capita. Note how, despite the cyclical downturn, the model predicts significant increases in effective labor supply until around 2025. This is due to higher

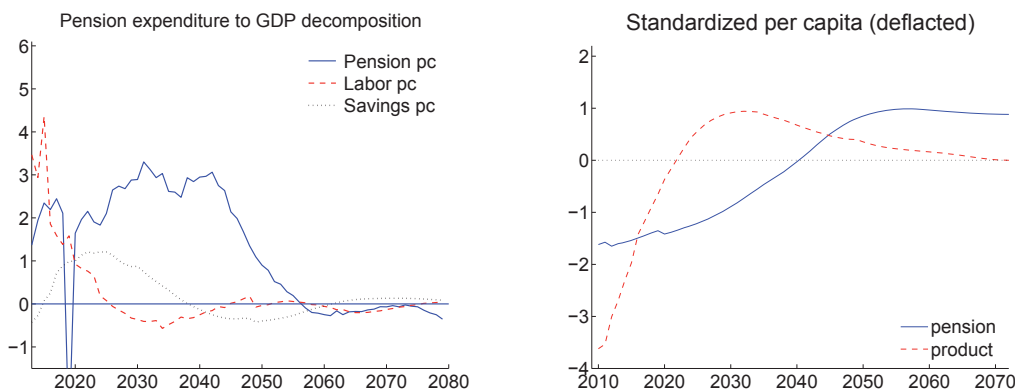


Figure 19: Left panel: growth rates of per capita pension, labor and accumulated assets (labeled savings). Right panel: Standardized per capita pension \bar{b}^t vs average per capita productivity \bar{y}^t in the BASE simulation (from pension expenditure decomposition in eq (10)).

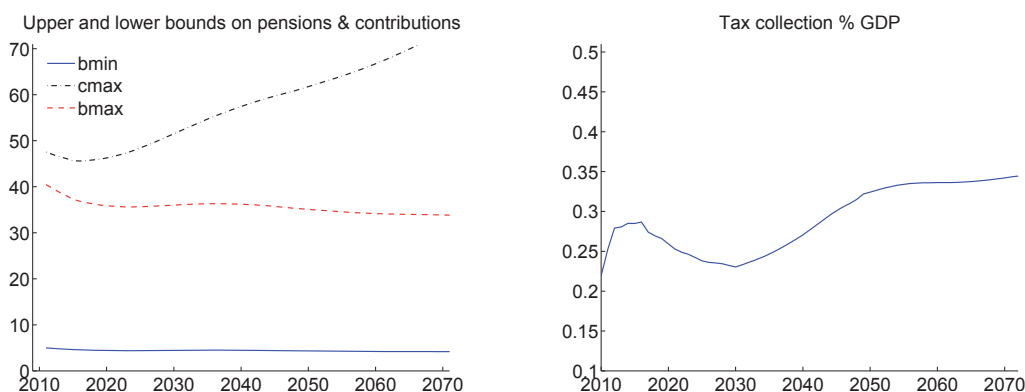


Figure 20: Left panel: simulated time paths of the discretionary components of the pension system. Right panel: fiscal revenue as % of GDP.

participation rates and better educational skills. Higher savings per capita until around 2040 also contribute to a brisk rebound in per capita income (right panel). Recall that we generate aggregate output by combining labor and capital according to a Cobb-Douglas function. Pension expenditure per capita initially picks up more slowly, as pension reform counteracts the early signs of population aging (the drop in expenditure in 2019 is associated to the second of the two 1-year delays in the normal retirement age legislated in 2011). All in all, we conclude that an important part of the jump in PP/Y in 2035/2050 is due to the deceleration in per capita income growth. These developments help to understand the time path of fiscal burden in the right panel of Figure 20: the increase in the tax rate is partly the result of drops in the tax base. Finally, the left panel of the same Figure displays our assumptions on the time path of minimum and maximum pensions and contributions. In an effort to extract more contributions, the maximum pensionable incomes (“bases contributivas”) are allowed to increase in real terms, while pension legal bounds are kept constant. This is a form of “hidden reform” of the system.

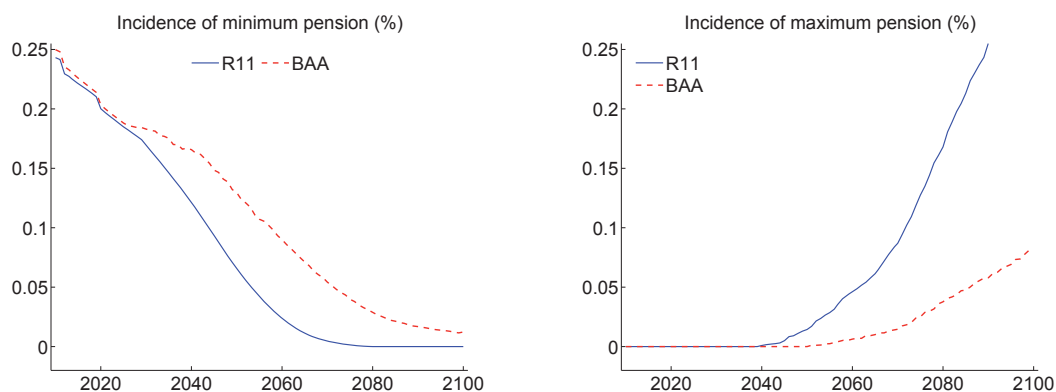


Figure 21: Incidence of minimum and maximum pensions in before (R11) and after the BAA reform (*base settings*).

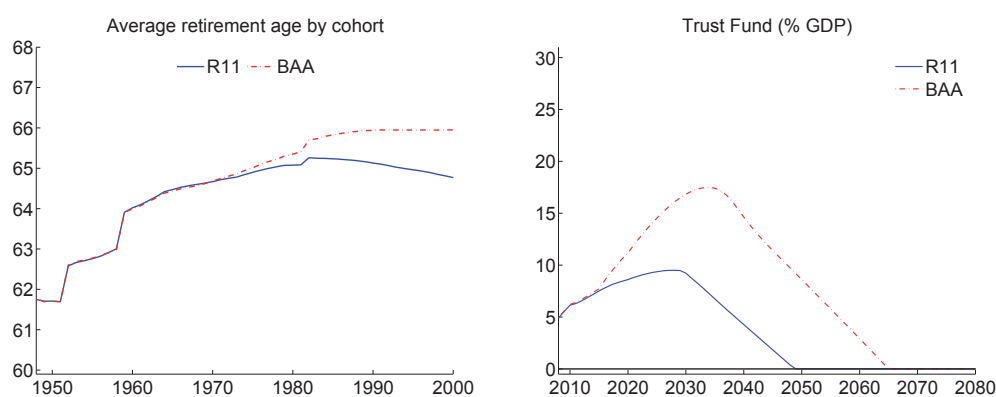


Figure 22: Left panel: average optimal retirement age before (R11) and after the BAA reform; Right panel: Assets accumulated in the Trust Fund as a % of GDP before (R11) and after the BAA reform.

C.2 Pension reforms

This section completes the information on the effects of the reforms studied in section 4.2. Figures 21 and 22 show several simulated time series in the pre-reform (R11) and post reform (BAA) institutional settings. Figure 21 display the impact of the reform on the incidence of minimum and maximum pensions. The left panel of Figure 22 shows the changes induced in the average retirement age. The right panel of that Figure displays the trajectories of the assets accumulated in the pension Trust Fund (as % of GDP) in both institutional environments.

The strong intergenerational consequences of the reforms are discussed in section 4.2.3 of the main text. Figure 23 completes that information by displaying the life-cycle consumption profiles of the representative households born in 1980 and 2010. They correspond to workers with secondary education, although the general patterns are similar across educational groups. Two remarkable observations stand out from these graphs. First, that consumption at advance ages goes down after the reforms for both younger and older cohorts. But younger cohort enjoys higher consumption levels early in their life-cycle. This is, arguably, a central objective of the reforms. Secondly (and more controversially) that, given our assumptions on exogenous productivity growth, the reforms redistribute from cohorts that enjoy smaller overall life-cycle consumption levels towards cohorts with higher overall life-cycle consumption levels.

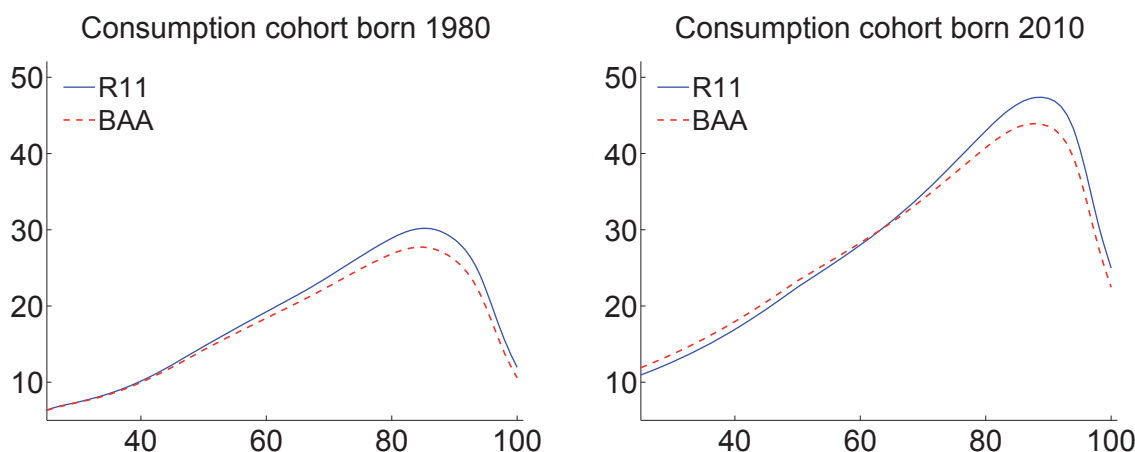


Figure 23: Simulated real life-cycle consumption of representative average-education households born in 1980 & 2010 (secondary education). All figures in thousands of 2010-Euros;

C.3 Sensitivity analysis

C.3.1 Alternative eco/demographic scenarios

In this section we review the results of each modification to the *base* environment explored in section 4.3.

- Low immigration setting (*Low imm*).** With the less intense immigration flows considered in the Mod-INE environment (vs the AWG demographic settings) the pre-reform behavior of the pension system is much less favorable. The demographic dependency ratio is bigger, resulting in a higher pension expenditure to GDP ratio (PP/Y), bigger imbalances between income and expenditure (DSS/Y) and the need of larger compensating tax efforts. The ABM mechanism would need deeper cuts in pension levels to deal with those larger initial imbalances. But this is not possible given the nominal floor set in the reform (top-left panel of Figure 25). Consequently, large imbalances of more than 5% of GDP per annum remain after the reform (Figure 24). This finding is important because, arguably, this setting is probably our “best estimate” of the future projection of the system. The patterns of welfare change induced by the reform (Table 17) are, in contrast, very close to those in the *base* setting. We observe a somewhat larger damage inflicted on older cohorts (born before 1990), but the differences are small.
- Low unemployment setting (*Low Un*).** The quick drops in unemployment rates implicit in the AWG economic projections create a much more benign environment for the pension system. Without the reform, PP/Y peaks at less than 16% and the DSS/Y deficits stay within the 5% threshold. The environment is so favorable that the BAA setting initially results in some small increases in pensions, although later cuts are unavoidable (top-left panel of Figure 25). The reform leaves manageable pension expenditure figures and practically eliminates future deficits. In other words: in this benign environment the BAA reform will be enough to restore financial sustainability. But this will still come at a price in welfare terms. The Equivalent Variation patterns are similar to those in the *base* case, although older cohorts are relatively better in this environment (cohorts born after 1970 are systematically worse in this setting).

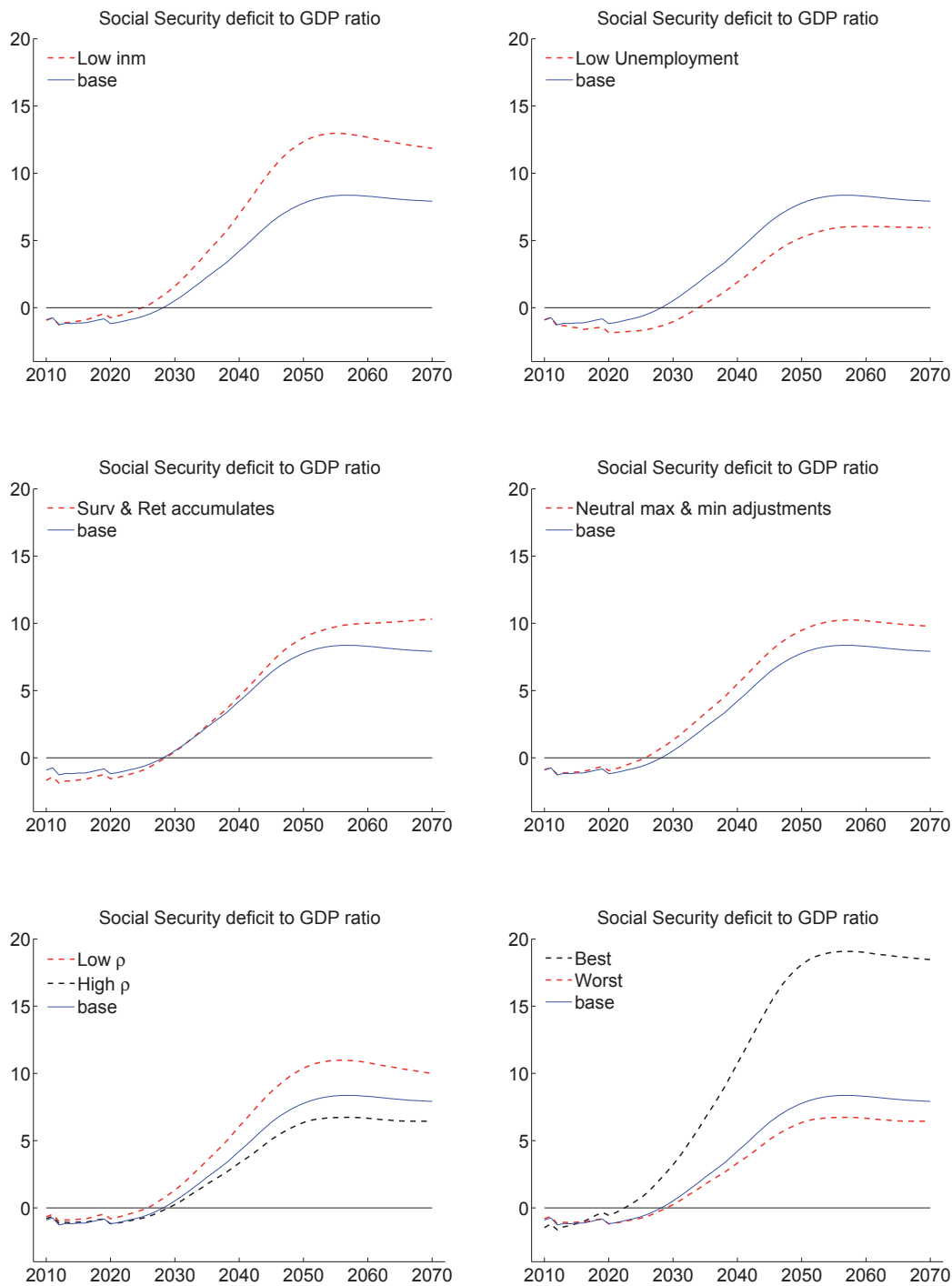


Figure 24: Sensitivity analysis. Pension deficit (expenditure minus income) as a proportion of GDP, DSS/Y , in the *base* and alternative eco/demographic environments.

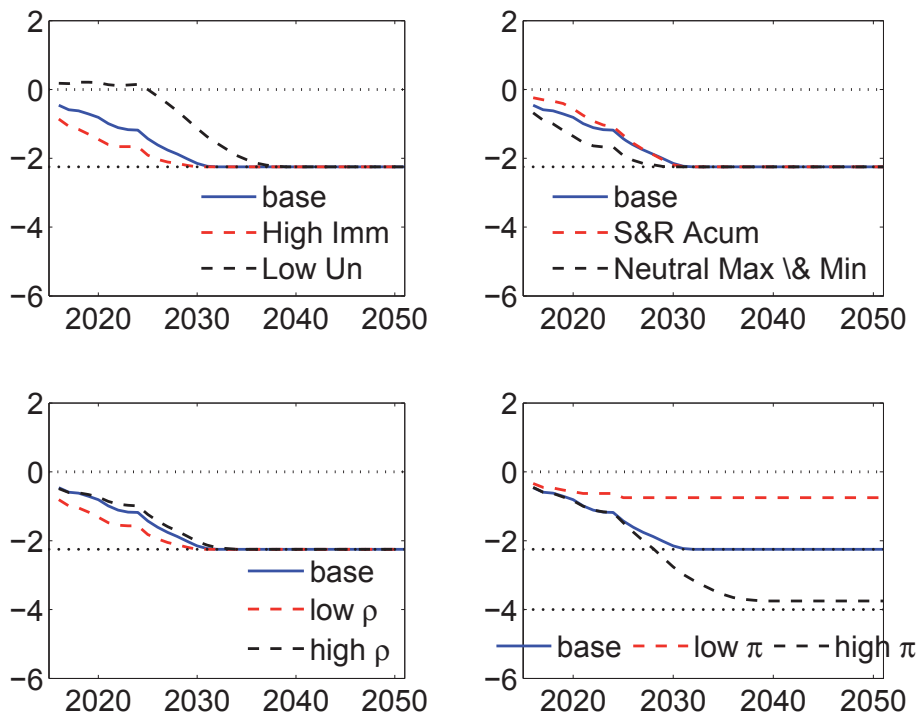


Figure 25: Growth rate of pension indexation g_t (defined in equation (11)) in the *base* and alternative eco/demographic environments defined in Table 4.

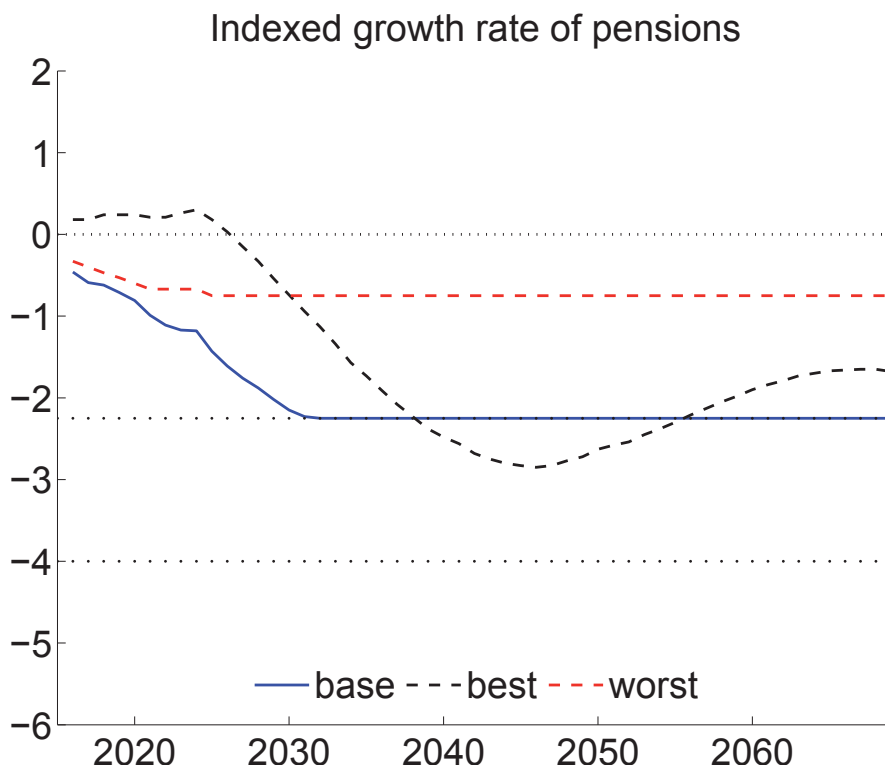


Figure 26: Growth rate of pension indexation g_t (defined in equation (11)) in the *base* and “extreme” eco/demographic environments.

- **Survival pensions “status quo” (*SE&R accum*).** In our *base* case scenario, widows and widowers that qualified for their own old-age pension are not entitled to survival pensions. If the current system (where survival and retirement pensions accumulate) were to be maintained, pensions cost would appreciably escalate. Total pension expenditure could approach 20 % by 2070 (implying more than a 10% deficit). The reform makes the overall picture better, but nominal limits to pension cuts undermine its ability to restore the financial balance (top-right panel of Figure 25). The working of this environment conforms to the general pattern: in more unfavorable environments, the reform leaves a substantial legacy of outstanding implicit liabilities.
- **No “hidden” reform (*Neutral Max & Min*)** In the *base* environment pension authorities use the annual update in the floors and ceilings of pensions and contributions to extract additional income from affiliates. If pension and contributions ceilings were updated in a neutral way (ie, if no form of ‘silent’ reform were attempted) the financial situation of the system would be more difficult. The system would acknowledge less pensionable income, cutting pension expenditure to some extent (just a bit in 2050; by 1.5 % of GDP in 2070). But the associated deficits due to the cuts in revenue would be bigger (approx. 1.7% larger in 2050 and surrounding years), resulting in a significantly bigger fiscal effort. With the reform, the imbalance leads to rapid pensions cuts until (once more) nominal threshold are hit (top-right panel of Figure 25). The legacy is, once again, one of large looming implicit liabilities and additional fiscal efforts.
- **Changes in productivity growth (*High/Low ρ*)** High exogenous ρ is sometimes hoped as a painless solution of the pension problem. In our simulations we test this hypothesis exploring a range of between 1 & 2% growth rates of productivity. The simulation results confirm the “a priori” that, with high (low) ρ , PP/Y is appreciably smaller (higher) creating a relatively easier (harder) environment for the reform to operate. But Figure 24 makes clear that high ρ alone is not a “cure” for the aging problem. The working of the reform and the welfare analysis are very similar to those in the *base* environment. Low ρ is associated with a somewhat more favorable treatment of cohorts of middle age, young and future workers (specially for better educated workers). The reform is relatively more painful with High ρ than with the more challenging environment of low productivity (probably, because the quantitative thresholds limit the full deployment of the reform).
- **Changes in inflation (*High/Low π*)** Inflation limits change the real thresholds imposed on the pensions cuts generated by the reform. A low inflation environment ($\pi=1\%$ in our *low π* scenario) will severely undermine the ability of the reform to reduce the real value of already granted pensions; Conversely, a higher inflation rate ($\pi=4\%$ in our *high π* scenario) will allow for much deeper drops in the purchasing power of outstanding pensions. The real pre-reform simulation results are not affected by inflation (money is a veil on real activity). But the reformed economies perform appreciably different. The reform is much less effective in the *low π* setting (with annual deficits bigger than in the *base* case by the equivalent of 2% of GDP), which have to be collected out of general taxation. Conversely, under the *high π* scenario pension expenditure hardly goes above 10%, the maximum deficit under the reform is less than 1% of GDP and the system is in surplus by 2070. The welfare impact conforms to the general pattern, with the exception than the cohorts that gain with the reform enjoy larger improvements in the best scenario (while we typically find the opposite in other settings).

cohort	base	low imm	low Un	S & R accum	Neutral Max&Min	Low ρ	high ρ	Low π	high π	best case	worst case
Primary											
1930	-0.25	-0.26	-0.19	-0.09	-0.26	-0.32	-0.22	-0.15	-0.27	-0.19	-0.08
1940	-0.87	-1.04	-0.54	-0.43	-0.95	-1.11	-0.82	-0.51	-0.95	-0.55	-0.29
1950	-1.54	-2.03	-0.71	-1.40	-1.81	-1.84	-1.45	-0.87	-1.81	-0.55	-0.83
1960	-2.46	-2.70	-2.11	-2.51	-2.49	-2.44	-2.39	-1.25	-3.12	-1.99	-1.23
1970	-2.73	-2.83	-3.16	-2.83	-2.68	-2.93	-2.75	-1.63	-3.67	-3.36	-2.16
1980	-3.23	-3.41	-3.63	-3.39	-3.25	-3.54	-3.08	-2.47	-3.96	-3.76	-2.98
1990	-4.10	-4.15	-4.38	-4.28	-4.17	-4.28	-3.91	-3.25	-4.53	-4.15	-3.67
2000	-2.77	-2.48	-3.24	-2.81	-2.98	-2.73	-2.62	-2.39	-2.44	-3.21	-2.76
2010	-0.96	-0.53	-1.46	-0.83	-1.54	-0.89	-0.96	-1.36	-0.27	-1.93	-1.76
Secondary											
1930	-0.29	-0.30	-0.21	-0.08	-0.30	-0.38	-0.25	-0.17	-0.31	-0.21	-0.09
1940	-0.98	-1.20	-0.58	-0.45	-1.09	-1.27	-0.93	-0.57	-1.07	-0.60	-0.33
1950	-1.64	-2.18	-0.73	-1.48	-1.94	-1.97	-1.54	-0.93	-1.92	-0.56	-0.89
1960	-2.48	-2.74	-2.13	-2.55	-2.51	-2.75	-2.42	-1.28	-3.18	-2.02	-1.55
1970	-3.37	-3.62	-3.71	-3.50	-3.31	-3.42	-3.28	-2.20	-4.34	-3.78	-2.34
1980	-3.43	-3.61	-3.93	-3.57	-3.42	-3.22	-3.37	-2.38	-4.22	-4.12	-2.56
1990	-3.33	-3.25	-4.07	-3.53	-3.41	-3.05	-3.31	-2.47	-3.78	-3.92	-2.74
2000	-1.77	-1.34	-2.80	-1.85	-2.03	-1.45	-1.78	-1.59	-1.45	-2.84	-1.81
2010	0.12	0.71	-0.95	0.19	-0.44	0.54	-0.01	-0.54	0.88	-1.51	-0.60
Advanced Secondary											
1930	-0.32	-0.33	-0.22	-0.11	-0.32	-0.40	-0.26	-0.18	-0.33	-0.22	-0.10
1940	-1.04	-1.26	-0.62	-0.45	-1.15	-1.42	-1.03	-0.61	-1.14	-0.86	-0.37
1950	-1.76	-2.29	-0.83	-1.57	-2.05	-2.18	-1.66	-1.04	-2.04	-0.66	-1.02
1960	-2.88	-3.26	-2.42	-2.94	-2.93	-2.91	-2.77	-1.51	-3.58	-2.26	-1.54
1970	-3.42	-3.70	-3.82	-3.55	-3.36	-3.20	-3.40	-2.06	-4.55	-3.96	-2.16
1980	-3.22	-3.33	-3.92	-3.37	-3.18	-2.89	-3.22	-2.19	-4.15	-4.15	-2.33
1990	-2.69	-2.52	-3.82	-2.92	-2.75	-2.34	-2.76	-2.06	-3.11	-3.68	-2.23
2000	-0.97	-0.42	-2.41	-1.09	-1.08	-0.35	-1.02	-1.05	-0.53	-2.49	-0.83
2010	1.07	1.77	0.08	1.15	0.85	2.69	0.83	0.10	2.00	-1.11	0.70
College education											
1930	-0.31	-0.32	-0.21	-0.11	-0.31	-0.38	-0.26	-0.17	-0.32	-0.21	-0.10
1940	-1.08	-1.33	-0.63	-0.55	-1.20	-1.37	-1.02	-0.62	-1.19	-0.65	-0.39
1950	-1.82	-2.43	-0.84	-1.65	-2.14	-2.17	-1.73	-1.03	-2.16	-0.68	-1.01
1960	-2.74	-3.10	-2.34	-2.82	-2.78	-2.72	-2.66	-1.44	-3.51	-2.20	-1.46
1970	-3.19	-3.40	-3.67	-3.33	-3.08	-2.94	-3.16	-1.93	-4.32	-3.81	-1.96
1980	-2.77	-2.75	-3.69	-2.91	-2.56	-2.18	-2.79	-1.90	-3.60	-3.90	-1.57
1990	-1.37	-0.78	-2.76	-1.57	-1.34	0.41	-1.89	-1.04	-1.58	-3.18	0.06
2000	2.19	3.48	0.69	2.03	1.01	4.76	1.01	1.71	2.86	-0.68	2.15
2010	6.33	7.93	4.87	6.18	3.41	8.59	4.84	4.84	7.54	2.84	3.52

Table 17: Welfare analysis: Equivalent Variation associated with the BAA reform by cohort and education attainment, in several alternative eco/demographic scenarios (defined in Table 4).

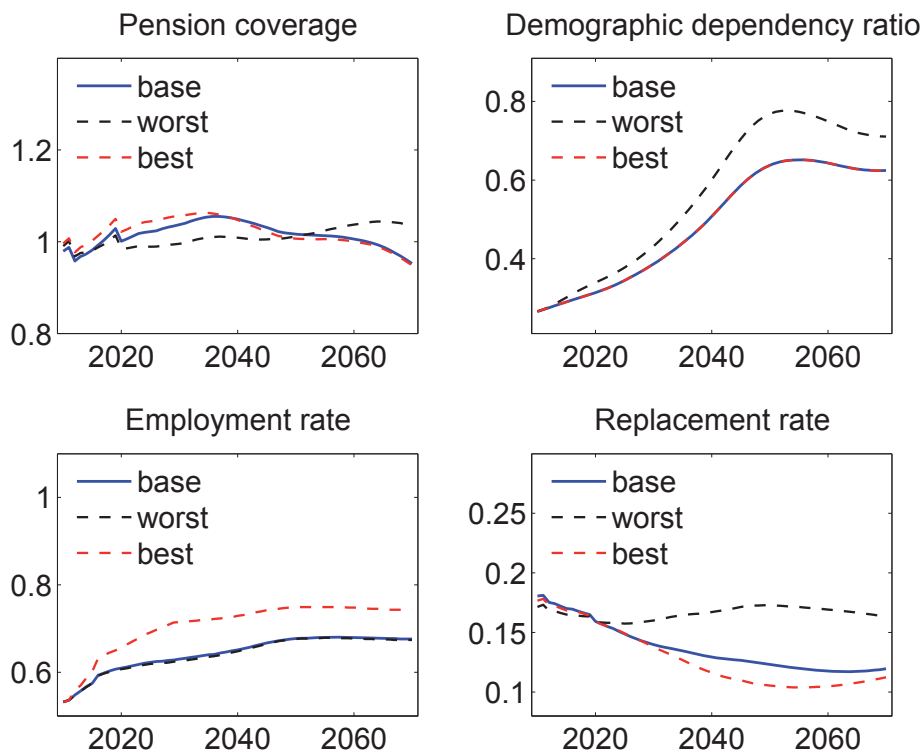


Figure 27: Decomposition of PP/Y (pension expenditure as a proportion of GDP) according to equation (10). The eco/demographic background is either *base* or some of the *extreme* environments defined in Table 5.

C.3.2 Extreme case analysis

In this section we combine the marginal changes explored in the previous section in two extreme cases. An enumeration of the components of each environment is provided in Table 5 in section 3.5. The *best* case scenario combines favorable developments in immigration, unemployment and productivity, together with cost-saving institutional changes (survival pensions and extra-financing obtained from annual discretionary choices) and the inflation environment most favorable for pension reduction. Despite all these advantages, the system is unsustainable without reform: PP/Y is well below the *base* case figures (13.3 vs 17.1 % by 2050), but it gains almost 5 % of GDP from 2010 to 2050 and 6 % to 2070. Income does not grow as much and annual deficits are close to 4% of GDP around 2050 (Figure 14 in the main text illustrate these developments). The system has to be reformed to restore the financial balance, and the 2013's changes deliver the needed stabilization. Figure 27 shows how: by increasing the employment rate and by inducing deeper cuts in pensions than in the *base* case. Note that the inferior threshold in the pension indexation scheme is *not* hit during the reform (Figure 26), although the base case's 2.5% threshold is clearly surpassed. After the reform a small surplus is sustained throughout the simulation interval, and the total extra tax collection needed by 2050 is only a little above 2% of GDP.

The *worst* case scenario is the mirror image of the *best* one. It combines unfavorable immigration, unemployment and productivity patterns, low inflation and the waiving of cost-saving institutional changes. The results are truly staggering: without reform, pension expenditure to GDP more than triples and the pension system deficit exceeds that in the *base* case by more

than 10 percentage points of GDP. 2013's changes can help with this daunting future, but its scope is reduced by the interaction of nominal thresholds and low inflation (Figure 26). Consequently, its welfare consequences are also less severe than in the *base* or *best* cases (Table 17). In the aggregate, the reform cuts pension expenditure by around 6% of GDP (a bit less than in the *base* case), leaving a very large unsolved problem of unfunded liabilities. The sources of the problem are displayed in Figure 27: more acute aging and relatively high pension replacement rates.

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