Social Security and Formal Labor Market Participation: A Dynamic Political Approach*

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Abstract

We study the effects on the social security tax rate, labor supply and capital accumulation, of making pension benefits contingent on, or independent of, formal labor market participation. We develop a recursive numerical approach that solves for the politico-economic equilibrium policy not only in steady state, but also as a function of time varying demographics. Due to its insurance properties, society always prefers universal pensions over a contributive pension system. Nevertheless, higher tax rates might lead to lower steady state welfare under a universal system. Calibrating the model to Argentina and Spain, we show that switching to a universal pension system leads to significant tax increases. This suggests that reducing the link between contributions and benefits may come at substantial costs, as this lowers private savings and reduces participation rates in the formal labor market.

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1 Introduction

More than a decade has passed since the start of the Great Recession. Although policy-makers around the world managed to avoid a collapse in output as deep as that seen in the Great Depression, the recovery has been very weak. In the 1930s, demographics allowed governments the possibility of introducing, or expanding, social security systems to redistribute towards those cohorts most affected by the crisis. Nowadays, population ageing creates a challenge for governments facing future retirement income shortfall of a larger fraction of workers that are unable to meet the requirements to access social security benefits, or whose benefits are depressed due to low contributions or low real returns.[1]

A policy proposal considered by several countries as a solution to the future expected income shortfall of current workers is to relax the requirements to receive pensions on retirement, or to increase minimum benefits. When evaluating the option of introducing or extending non-contributive benefits, developed economies can learn from developing countries. To tackle the problem that a large share of the population is set to retire without any pension coverage, several countries in Latin America have started to implement a universal pension system. In fact, one-third of pensions in the region is currently noncontributory, and preliminary evidence indicates this policy may come at a cost, e.g. in the form of crowding out of private savings.[2]

In this paper we build on a standard overlapping generations setup with capital formation a tractable model to analyze the effects of making social security universal on the equilibrium tax rate, labor supply, and capital accumulation. In their role as economic agents, households in the model take prices, taxes, and retirement benefits as given when choosing consumption, savings, and labor supply. In their role as voters, households choose among office motivated parties that offer policy platforms comprising labor income taxes, and retirement benefits. Since policy choices are of different concern to young and old voters, we model the resolution of the ensuing conflict under the assumption of probabilistic voting. The political process lacks commitment, and elections take place every period.

[1] Ageing reduces the scope for intergeneration redistribution from future generations as a policy tool. The political power of retirees also limits the ability of governments to redistribution from those currently retired to workers by reducing current benefits.

[2] See Cavallo and Serebrisky (2016).

Policy choices do not only affect economic outcomes. Absent commitment, they also affect, indirectly, future policy decisions. Voters internalize the indirect effects, reflected in the equilibrium relationship between future state variables and future policy choices. We focus on Markov perfect equilibria, and assume that only fundamental state variables enter this equilibrium relationship, excluding artificial state variables of the type sustaining trigger strategy equilibria.

We introduce endogenous labor supply by allowing households to supply labor to either the formal, or the informal labor sector.[3] To keep the model simple and tractable, we introduce a lottery mechanism to determine whether a retiree receives benefits or not under a contributive pension system. The probability of receiving benefits is positively correlated with labor market participation in the formal sector. On one hand, this assumption reflects the requirements on minimum number of years of contributions to receive benefits present in most real world social security systems. On the other hand it captures the stochastic nature of employment which makes some retirees unable to meet these requirements.

We find that society would always prefer a universal social security system over a contributive one, if offered such a choice in the political process. The reason for this is that, conditional on expectations on future pensions, the only difference between having in the current period a contributive or a universal system is on the welfare of retirees. And these prefer the universal system as it insures them against the risk of not receiving pensions. In contrast, in a comparison of steady states, capital accumulation is depressed in a universal system. Thus, from a Ramsey perspective a contributive system might dominate.

The model predicts some adverse effects of implementing noncontributory, or universal, coverage systems to solve the problem of inadequate pension coverage in Latin America. For instance, while a large degree of informality might have caused the low degree of pension coverage to begin with, a model calibration to Argentina predicts that universal coverage would further increase the degree of informality and crowd out savings in general. The model predicts that in a politico-economic equilibrium contribution rates tend to be approximately five percentage points higher under universal coverage, which further amplifies the problem of informality and crowding out of private savings. Lastly, where a comparison is feasible, model predictions on the effects of ageing

[3]The informal sector comprises both home production and a black labor market for the underground economy.

are in line with work in related dynamic political models on intergenerational transfers.[4]

Applied to Spain, the model can rationalize the persistence of minimum pension increases, and the fact that these tend to take place when unemployment is high: When participation in formal labor markets is low there is a higher pressure for pensions to be universal. This is achieved by topping up pension benefits for individuals whose pension is below the guaranteed minimum. These top-ups are then non-contributory pensions, and in Spain are financed entirely from general taxes since 2013.

We contribute to the existing literature on Markov Perfect voting equilibrium for social security (Forni (2005), Gonzalez-Eiras and Niepelt (2008, 2015), Song (2011)), in a number of ways. First, we develop a model that has endogenous labor supply, private savings and allows for different pension systems. Making labor supply endogenous by making workers allocate time in either the informal or formal sector, as in Song et al. (2012), allows us to capture the problem of informality that persists in most Latin American countries. It also introduces a mechanism explaining the inadequate coverage of contributive pension systems, as seen in some developed countries in the wake of the Great Recession. Second, when introducing contributive pension benefits the politico-economic equilibrium has to be solved numerically. It turns out that when pension benefits are contributive, the standard approach of iterating on the policy function over the relevant state space becomes infeasible when one is interested in the demographic transition. We circumvent this problem by developing a simple backwards recursive algorithm. By calibrating the model to Argentina, we show that introducing universal pension benefits is likely to exacerbate the existing problems of high informality rates and low private savings. Specifically we show that Argentina would experience a tax increase from around 25% to 30% when universal benefits are introduced, and that this difference increases in the future with an ageing population. We show that this tax increase significantly lowers private savings and formal labor supply, increasing informality.

The rest of the paper is organized as follows: Section 2 presents the economic environment and characterizes the economic equilibria under the different pension regimes. Section 3 presents the economic and the politico-economic concepts, and section 4 analysis politico-economic equilibria under the two pension systems, and shows that the universal system is always preferred to the contributive one if such a choice is offered on a popular vote. Section **??** outlines the numerical

[4]See e.g. Gonzalez-Eiras and Niepelt (2008, 2015) and Song (2011).

solution approach for the contributive equilibrium. In section 6 we calibrate the model to Argentina and Spain, and present the main results of a quantitative comparison of the two pension systems. Finally section 7 concludes.

2 The Model

2.1 Demographics and Institutions

We consider an economy populated by overlapping generations of workers and retirees. Workers supply labor to the formal and informal sectors, pay taxes, consume and save. In the subsequent period they retire, consume the return on their savings and social security benefits, if they receive them, and die. The ratio of workers to retirees in period t follows a deterministic process, and is given by $_t$.

The government runs a pay-as-you-go (PAYG) pension system with a balanced budget. Every period the government taxes labor supplied in the formal sector and transfers the sum directly to retirees. When the system is universal, every retired household receives the same pension benefit, independent of her participation in the formal sector when young. When the system is contributive, some workers receive pensions while others do not. The probability of receiving pensions is proportional to labor market participation in the formal sector when young. This assumption is made to capture workers' uncertainty on whether they will meet legal requirements to receive benefits.[5]

Policy decisions are taken by a government that acts in the interest of voters, but lacks commitment.

2.1.1 Technology

In the formal sector, a continuum of competitive firms transforms capital and labor into output. Capital is owned by retirees and fully depreciates after a period. The economy-wide capital stock per worker, k_t, therefore corresponds to the economy-wide per-capita savings of workers in the previous period, s_{t-1}, normalized by $_t$. We assume that production technology is Cobb-Douglas

[5] In most social security systems workers need to have a minimum number of years of contributions to receive benefits. Thus, if affected by long or repeated unemployment spells they might not qualify at the time of retirement.

with $\in (0,1)$ denoting the income share of capital. Furthermore, for tractability we assume productive externalities as in Romer (1986) such that firm i's output is given by

$$Y_t^i = A_t \left(K_t^i\right) \left(H_t^i\right)^{1-}, \qquad A_t \equiv Ag\left(\frac{k_t}{h_t}\right) = A\left(\frac{k_t}{h_t}\right)^{1-}. \tag{1}$$

Here K_t^i and H_t^i denotes the individual firm's use of capital and labor, while k_t and h_t are economy per-capita aggregates that the representative firm takes as given. The function $g\left(\frac{k_t}{h_t}\right) \equiv \left(\frac{k_t}{h_t}\right)^{1-}$ measures the strength of productive externalities (note $g' > 0$, and $g'' < 0$). In equilibrium this entails the following factor prices

$$R_t = A, \qquad w_t = (1 -)A\left(\frac{k_t}{h_t}\right). \tag{2}$$

Production in the informal sector is given by the technology

$$y_t = w_t^* F(h_t) = w_t^* \frac{}{1+} X\left(1 - h_t^{1+\frac{1}{}}\right), \tag{3}$$

where w_t^* denotes the labor sector wage rate *if* labor taxes were zero, and note that $F(1) = 0$, $F' < 0$, $F'' \leq 0$, $F''' \leq 0$.[6] Thus, informal production technology only uses labor $(1 - h)$ and has weakly decreasing returns to scale.

2.2 Preferences and Household Choices

Workers and retirees in period t value consumption, $c_{1,t}^i$ and $c_{2,t}^i$ respectively. Workers discount the future at factor $\in (0,1)$, and are endowed with a unit of time, supplying h_t in the formal sector and $1 - h_t$ in the informal sector. For analytical tractability, we assume that period utility functions are logarithmic. Welfare of a worker who chooses savings, s_t^i, and labor supply in the formal market, h_t^i, is given by

$$\begin{aligned} & \ln(c_{1,t}^i) + \ln(c_{2,t+1}^i) \\ \text{s.t.} \quad & c_{1,t}^i = w_t\left[(1 - {}_t)\, h_t^i + \frac{w_t^*}{w_t} F\left(h_t^i\right)\right] - s_t^i \equiv \mathcal{I}_t - s_t, \\ & c_{2,t+1}^i = s_t^i R_{t+1} + E_t[b_{t+1}^i]. \end{aligned}$$

Where ${}_t$ is the social security tax rate, and the expectation for retirement benefits reflects that these are stochastic when the social security system is contributive. Total labor income is denoted by $\mathcal{I}_t$.

[6] In appendix A.3 we discuss why this assumption is important.

We assume optimal savings and labor supply decisions are characterized by

$$s_t^i = s(w_t, w_t^*, \ _t, \ _{t+1}), \tag{4}$$

$$h_t^i = h(w_t, w_t^*, \ _t, \ _{t+1}). \tag{5}$$

2.3 Social Security System

The government runs a pay-as-you-go pension systems with a balanced budget. Every period the government taxes labor supplied in the formal sector and transfers the sum directly to the current retired generation. We consider two polar types of systems. First, a contributive one such that workers need to satisfy a requirement on contributions to receive pension benefits. This makes pension benefits to be stochastic as a worker with long or repeated unemployment spells might fail to meet contribution requirements when they retire. To keep the model simple, we postulate that the probability that a worker receives pension benefits is given by the share of her time endowment supplied in the formal sector, h_t.[7] Since the budget is balanced, pension benefits are then given by

$$b_t^c = \frac{\ _t h_t w_t \ _t}{h_{t-1}}, \tag{6}$$

where the superscript c denotes that the system is contributive. Note that pension benefits are affected by past labor supply decisions.

The second pension system that we analyze is a universal one in which all retirees receive benefits, independently of contributions made. In this case we have that benefits are given by

$$b_t^u = \ _t h_t w_t \ _t, \tag{7}$$

where the superscript u denotes that the system is universal. It is immediate that, for given tax rates, current labor supply, wage rate, and demographics, $b_t^u \leq b_t^c$.

2.4 Elections

Elections take place at the beginning of each period. We assume that preferences are aggregated through probabilistic voting.[8] Thus, policy maximizes a convex combination of the objective func-

[7] In this way we introduce the contributive principle of making pension benefits contingent on sufficient participation in the formal labor sector, while maintaining tractability by making all workers identical.

[8] See Lindbeck and Weibull (1987). In appendix **??** we offer a formal discussion of probabilistic voting.

tions of all groups of voters, where the weights reflect the groups' sizes and their responsiveness to policy changes. We allow for age related variation in responsiveness, reflected in a per capita political influence weight of unity for young voters and a per capita weight of $\omega \geq 0$ for retired voters. Furthermore, we assume that the political weight of a retiree is independent of whether she receives benefits or not.

3 Equilibrium

3.1 Competitive Equilibrium

The state is given by z_t, which includes exogenous demographics as well as savings per capita, s_{t-1}, and past labor supply in the formal sector, h_{t-1}. Conditional on z_t, the production function as well as competition among firms determine factor prices, w_t and R_t. Policy, $\ _t$, and the type of pension system, then determines capital accumulation, s_t, labor supply, h_t, and thus z_{t+1}. Conditional on z_t, a policy sequence $\{\ _s\}_{s\geq t}$ thus fully determines an allocation and price system.

A *competitive equilibrium* conditional on z_0 and a policy sequence $\{\ _t\}_{t\geq 0}$ is given by an allocation and price system such that

i. households optimize: (4) and (5) hold for all i, t;

ii. capital evolves according to $k_t = s_{t-1}/\ _t$, labor markets clear, and factor prices are determined according to (2) for all t; and

iii. the government budget constraints (6) or (7) are satisfied for all t;

Appendix A derives the competitive equilibria when pension benefits are universal or contributive. The following proposition summarizes the comparison of economic equilibria across regimes.

Proposition 1. *Consider the economic equilibria .*

i. For a given policy the propensity to save out of labor income $(\ )$ and formal labor supply (h) are unambiguously larger when pension benefits are contributive.

ii. The economic equilibrium functions are decreasing in the current tax rate under both type of pension benefits. When pension benefits are contributive the economic equilibrium function is increasing in future taxes.

iii. When taking the path of future policies as exogenous, the relative labor response to a change in the current labor tax is numerically larger when pension benefits are universal.

Proposition 1 asserts that when we take policies as given, introducing universal benefits unambiguously leads to crowding out of private savings and lower formal labor supply. The economic mechanisms at play here can both be explained as a self-insurance behavior against the potential bad state of not receiving pension benefits when old. The household provides this self-insurance by (1) increasing the formal labor supply to lower the probability of ending in that state and (2) increases its private savings as a buffer in the light of the added old age consumption risk. This also explains why economic labor equilibrium responses are smaller when benefits are contributive: A change in the current tax rate affects the profitability of supplying labor to the formal sector. However when benefits are contributive, optimal labor supply weights the profitability of the formal sector against the risk of losing out on pension benefits. In the economic equilibrium we take future policies as given ($_{t+1}$ is exogenous) the incentive from losing out on pension benefits are not affected, which anchors the labor response compared to when pension benefits are universal.

3.2 Politico-Economic Equilibrium

In politico-economic equilibrium political decision makers optimally choose tax rates, taking all implications of their actions into account and forming rational expectations about future policy choices. We assume that these choices are Markov, i.e. they are functions of the fundamental state variables. The decision maker at date t takes s_{t-1} and h_{t-1} as well as $^{t+1}(\cdot)$ as given. Furthermore, given the continuation tax function the policymaker takes as given the following law of motion for the state variables as a function of current policy choices[9]

$$z_{t+1} = \;_t(z_t, \;_t, \;^{t+1}(\cdot)). \tag{8}$$

The policymaker maximizes

$$\mathcal{W}_t(z_t, \;_t; \;^{t+1}(z_{t+1})) \equiv \; ! \, \mathcal{O}(z_t, \;_t) + \;_t \mathcal{Y}(z_t, \;_t; \;^{t+1}(z_{t+1})) \tag{9}$$

s.t. (2), (6) or (7), (8),

[9]These laws of motion formally follow from (4) and (5) when we replace future policy by the continuation policy function.

where the objective function is the weighted sum of the indirect utility functions of workers, $\mathcal{Y}(z_t, \ _t; \ ^{t+1}(z_{t+1}))$, and retirees, $\mathcal{O}(z_t, \ _t)$. We denote argmax $\mathcal{W}_t$ the *political aggregator* that maps individual preferences into an equilibrium policy choice.

A *politico-economic equilibrium* as of period t conditional on z_t consists of a sequence of tax functions, $f \ (\cdot)g_{\ \geq t}$; a sequence of continuation tax functions, $f \ ^{+1}(\cdot)g_{\ \geq t}$; a sequence of laws of motion for the state variables, $f \ (\cdot)g_{\ \geq t}$; policy choices, $f \ ^{\star}g_{\ \geq t}$; and a competitive equilibrium allocation such that

i. tax functions are optimal subject to continuation tax functions:

$$(z \ ) \in \arg\max \mathcal{W} \ (z \ ; \ ^{+1}(\cdot)) \text{ for all } z \ , \ \geq t;$$

ii. continuation tax functions are consistent with tax functions:[10]

$$(z \ ) = \ (z \ ) \text{ for all } z \ , \ \geq t;$$

iii. laws of motion are consistent with the policy and continuation policy functions according to (8);

iv. equilibrium tax choices are generated by the continuation tax function,

$$f \ ^{\star}g_{\ \geq t} = f \ (z \ )g_{\ \geq t},$$

and $f \ ^{\star}g_{\ \geq t}$ implements a competitive equilibrium allocation.

Note that for infinite horizon and a recursive time-autonomous structure, the policy and continuation policy functions are time-autonomous functions of the state as well, and conditions i. and ii. above are combined in a fixed point requirement.

4 Analysis

4.1 Universal pensions

When the system is universal every retired household receives the same pension rate, characterized by (7), independent of its participation in the formal labor sector when young. Households behavior

[10] Note that we do not need to track policy choices in the future beyond one period since current voters, at most, live for two periods. Otherwise this consistency requirement should be written as $(z \ ) = (\ (z \ ), \ ^{+1}(z_{\ +1}(\cdot)))$.

is characterized by:

$$h_t^{u,j} = \left(\frac{1 - \ \ _t}{X}\frac{w_t}{w_t^*}\right) \ , \qquad s_t^{u,j} = \frac{}{1 + }\mathcal{I}_t^u - \frac{b_{t+1}^u}{(1 + \ \ )R_{t+1}},$$

where the u superscript refers to social security being universal. Recall that w_t^* was defined as the equilibrium wage rate if taxes were zero. Using this in the households' first order condition, and the factor price equation for w_t, (2), we define $(w_t^*/w_t) = (h_t^u/h_t^*)$ where $h_t^* = (1/X)$. Combining households and firms' first order conditions and equilibrium conditions, we solve for the economic equilibrium:

$$\begin{aligned} h_t^u &= \left(\frac{1 - \ \ _t}{X^{1+}}\right)^{\overline{1+}}, \\ s_t^u &= {}^u(\ _{t+1})\mathcal{I}_t^u, \\ c_{1,t}^u &= {}^u(\ _{t+1})\mathcal{I}_t^u, \\ c_{2,t+1}^u &= A \ {}^u(\ _{t+1}) \ {}^u(\ _{t+1})\mathcal{I}_t^u, \end{aligned} \qquad (10)$$

where the functions ^{u}, ^{u}, ^{u} are defined by

$$^u(\ _{t+1}) \equiv \left(1 + \frac{1 - }{} \ \ _{t+1}\right), \quad ^u(\ _{t+1}) \equiv \frac{}{ + \ ^u(\ _{t+1})}, \quad ^u(\ _{t+1}) \equiv 1 - \ ^u(\ _{t+1}). \quad (11)$$

Note that the labor income function is given by

$$\mathcal{I}_t^u = (1 - \ \ )A\frac{s_{t-1}^u}{t}\left[1 - \ \ _t + X \ F(h_t^u)\right],$$

which is independent of future policy choices and log-separable in state variables s_{t-1}^u, and $_t$.

When pensions are universal, the political aggregator function is given by

$$\mathcal{W}^u(z_t) = \ ! \ u\left(c_{2,t}^u\right) + \ \ _t\left[u\left(c_{1,t}^u\right) + \ \ u\left(c_{2,t+1}^u\right)\right]. \qquad (12)$$

The political process maximizes (12), subject to the constraints that the economy is in a competitive equilibrium, and taking the future policy function, $_{t+1}(z_t)$, as given. Since the labor income function, the economic equilibrium, and the objective function do not depend on h_{t-1}, then only savings per capita might be a relevant endogenous state variable when pensions are universal.

The main results of the politico-economic equilibrium with universal pensions are summarized in the following proposition.

Proposition 2. *Consider a universal pensions system. There is a unique Markov perfect equilibrium in the limit of the finite horizon. The equilibrium policy function is given by:*

$$^{u}(\ _{t}) = \min\left\{1,\ \max\left\{0,\ \frac{1}{! +\ _{t}(1+\ )}\left[!\ \left(1+\ X^{1+}\right) - \frac{}{1-\ }\ _{t}(1+\ )\right]\right\}\right\}.$$

Proof. See appendix B.1. □

We note here that as the policy function does not depend on any endogenous states, future taxes $_{t+1}$ become independent of $_{t}$ as well. Notwithstanding this orthogonality, the trade-offs underlying the equilibrium tax rates are dynamic in nature as they relate contemporaneous tax revenue and benefits to future factor prices and tax revenue. The tractability of the model comes from specifying functional forms that render the factor price elasticities and the derivatives of the indirect utility functions orthogonal to the capital stock.[11] As we will see shortly, when pensions are contributive we lose the ability to generate closed form solutions since, although the capital stock remains orthogonal to the derivatives of the indirect utility functions, lagged labor supply affects political trade-offs.

Note that the equilibrium policy is increasing in $!$ and decreasing in $_{t}$. To gain intuition for this, consider the marginal effect of a tax increase on a worker and a retiree. For a retired household a marginal tax increase simply translates directly into higher benefits. Indirectly however, the higher tax on labor also crowds out the formal labor supply of workers, which lowers pension benefits for the retired. The direct effect always dominates, such that retirees prefer higher tax rates in equilibrium.[12] For the working household consumption is linear in labor income and thus political support can be summed up by how $\mathcal{I}_t^u$ is affected. The direct effect from a tax increase is a drop in labor income. The indirect effect is that formal labor supply in equilibrium drops, which drives up the wage rate, due to the classic congestion externality on the labor market. The direct effect always dominates.[13] Thus young and working households will generally prefer lower taxes. In this respect the model with universal pension benefits confirms the finding in related literature

[11] As shown elsewhere, these functional form restrictions tend to be of minor importance for the quantitative predictions of the model. See Gonzalez-Eiras and Niepelt (2005) for an analysis in a related context.

[12] The assumption of productive externalities implies that the direct effect always dominates. However, even without this assumption the direct effect would at least always dominate locally around the equilibrium. While the assumption simplifies the solution structure a lot, it still renders our specification more prone to corner solutions in general.

[13] Appendix A.3 deals with the assumptions of the labor income function in more detail .

that an ageing population (decrease in $_t$), and a larger political power of retirees, (higher !), result in higher equilibrium taxes.

4.2 Contributive pensions

With contributive pensions some retirees do not receive pensions, as they fail to meet eligibility criteria for receiving them due to long or repeated spells of unemployment. We assume that with probability $h_t^{c,j}$ retired household j receives pension benefits b_{t+1}^c given by (6), and with probability $(1 - h_t^{c,j})$ she receives nothing.[14] Note that the probability of receiving pension benefits depends on *individual* household's formal labor supply. In this way we introduce the contributive principle of making pension benefits contingent on sufficient participation in the formal labor sector, while keeping the model tractable by having workers identical. The economic equilibrium is given by:

$$
\begin{aligned}
h_t^c &= \frac{1}{X}\quad 1 - \quad _t + \quad \ln[\ ^c(h_t^c,\ \ _{t+1})]\ \ ^c(h_t^c,\ \ _{t+1})\,\frac{\mathcal{I}_t^c}{w_t}\quad ^{\overline{1+\ \ }} \\
s_t^c &= \ ^c(h_t^c,\ \ _{t+1})\,\mathcal{I}_t^c, \\
c_{1,t}^c &= \ ^c(h_t^c,\ \ _{t+1})\,\mathcal{I}_t^c, \qquad\qquad (\mathrm{EE_c}1) \\
c_{2,t+1}^{c,0} &= A\ ^c(h_t^c,\ \ _{t+1})\,\mathcal{I}_t^c, \\
c_{2,t+1}^{c,1} &= A\ ^c(h_t^c,\ \ _{t+1})\ \ ^c(h_t^c,\ \ _{t+1})\,\mathcal{I}_t^c,
\end{aligned}
$$

where the superscript c refers to the contributive system, and for second period consumption superscript 1 denotes a retiree that receives benefits, while superscript 0 denotes a retiree that does not receive benefits. Functions ^{c}, ^{c}, ^{c} are defined by

$$
^c \equiv 1 + \frac{1 - \quad}{\quad}\frac{_{t+1}}{h_t^c}, \qquad ^c \equiv \frac{1 + (\ ^c - 1)(1 - h_t^c)}{1 + \quad + (\ ^c - 1)\,(1 + \quad (1 - h_t^c))}, \qquad ^c \equiv 1 - \ ^c. \qquad (\mathrm{EE_c}2)
$$

We note that while equilibrium consumption and savings are still linear in the labor-income function, and thus the capital stock is not a relevant state variable for the political process, two complications arise: (1) The equilibrium labor supply function is an implicit function of both current and future taxes. (2) Functions ^{c}, ^{c}, ^{c} are non-linear functions of state variables and future taxes.

[14] In reality, some social security systems still pay a pension to workers that do not meet eligibility criteria, but this is usually a minimum benefit.

When pension benefits are contributive, the political aggregator function is given by

$$\mathcal{W}^c(z_t) = ! \left[h^c_{t-1}\ln\left(c^{c,f}_{2,t}\right) + (1-h^c_{t-1})\ln\left(c^{c,if}_{2,t}\right)\right] + {}_t\left[\ln\left(c^c_{1,t}\right) + \quad \left(h^c_t \ln\left(c^{c,f}_{2,t+1}\right) + (1-h^c_t)\ln\left(c^{c,if}_{2,t+1}\right.\right.\right.$$

and the political process seeks taxes to maximize it, subject to the constraints that the economy is in a competitive equilibrium (EE_c1)-(EE_c2), and taking relevant states, z_t, as given. As mentioned above, the capital stock does not affect the derivatives of the indirect utility functions. Compared to the case of universal benefits, h^c_{t-1} becomes a potentially relevant state variable. This makes the economic equilibrium labor supply function to depend explicitly on both $_t$ and $_{t+1}$.

Given the policy function $\tilde{}^c_{t+1}(\cdot)$, we define a *politico-economic equilibrium* labor function by:

$$\tilde{h}^c_t = \frac{1-\ {}_t}{X^{1+}} + \ \ln\left({}^c\left[\tilde{h}^c_t, \tilde{}^c_{t+1}\left(\tilde{h}^c_t, \ {}_{t+1}\right)\right]\right) \ {}^c\left[\tilde{h}^c_t, \tilde{}^c_{t+1}\left(\tilde{h}^c_t, \ {}_{t+1}\right)\right]\frac{\mathcal{I}^c_t}{w_t}^{\ \frac{}{1+}} . \qquad (13)$$

Before proceeding we impose some structure on this function.

Assumption 1. *In the politico-economic equilibrium, labor supply and income are always strictly decreasing in the current tax rate* $_t$.

The main analytical results of the contributive politico-economic equilibrium are summarized in the following proposition.

Proposition 3. *Consider a contributive pensions system under assumption 1. In the finite horizon economy ending at time T, the terminal equilibrium policy function is unique and given by:*

$${}^c_T\left(h^c_{T-1}, \ {}_T\right) = \min \ \ 1, \ \max \ \ 0, \ \frac{1}{! + \ {}_T/h^c_{T-1}}\left[!\left(1+\ X^{1+}\right) - \frac{}{1-}\ {}_T\right] \ \ .$$

(PEE_c)

For t<T the politico-economic equilibrium has to be solved numerically. Some analytical results are: (i) The policy function is increasing in ! and decreasing in $_t$*, (ii) the policy function is increasing in* h^c_{t-1}*, and (iii) retirees' support for taxes is unambiguously lower compared to under universal benefits.*

Proof. See Appendix B.2. □

The basic intuition for why the equilibrium tax must be increasing in ! and decreasing in $_t$ is the same as in the universal case: Retirees (workers) generally prefer higher (lower) taxes. Shifts in

! and $_t$ move the relative weights the political process puts on the two groups of households and thus the equilibrium tax. Compared to the universal case however, there are a number of additional effects.

When retirees evaluate an increase in the tax rate, only a share of them receive benefits. When this share (h^c_{t-1}) is large, more retired households benefits from higher taxes, thus ^c_t is increasing in h^c_{t-1}. Since, for a given tax rate, households that receive benefits have lower marginal utility, there will be lower support for taxation from the retired, relative to the universal pension system.

Finally the effect of making pension benefits contributive on political support from workers is analytically ambiguous. When benefits are contributive, a rise in taxation has two effects on workers' welfare: A *labor income channel* and a *consumption smoothing channel*. In comparison, taxes only affect workers through a similar labor income channel, when benefits are universal.

As seen in (EE_c1), all economic equilibrium consumption functions are linear in labor income $\mathcal{I}^c_t$. As in the case of universal benefits, taxation produces a direct loss of income from working in the formal sector, and a positive congestion externality effect on wages. In the universal case, the assumed constant labor supply elasticity is sufficient to ensure that the direct effect always dominates. In the contributive case we need to add assumption 2 to ensure this. It is ambiguous whether the marginal effect of taxation due to changes in labor income is higher or lower than when pension benefits are universal.

When pension benefits are contributive, the pension system induces old-age consumption risk. The working households self-insures against this state by increasing private savings and formal labor supply, see proposition 1. This increases the marginal utility of consumption (given labor income) and thus amplifies the marginal effect of a tax change on workers' indirect utility functions, thus reducing the political support for taxes.

4.3 Dominance of Universal System

We now show that if a vote were to take place on the type of pension system to use in the current period, a universal system would *always* be preferred. For this we start by conjecturing that the future choice of social security system is unaffected by the current choice, such that, for a given tax rate, workers' savings decisions would only be determined by the future type of social security system. If the pension system is contributive or universal today, the political objective functions, for given current and future taxes, are respectively given by:

$$\mathcal{W}_t^C = \,!\, h_{t-1} \log(\;^c(h_{t-1},\;_t)) + \;_t\mathcal{Y}_t(\;_t,\;_{t+1}),$$
$$\mathcal{W}_t^U = \,!\, \log(\;^u(\;_t)) + \;_t\mathcal{Y}_t(\;_t,\;_{t+1}),$$

where $\mathcal{Y}_t$ is the indirect utility of workers. Crucially, for given tax rates, this is the *same* regardless of which pension system is in place today, as workers only care about what pension system will be in place when they retire when making their saving decisions.

It can be shown that $h_{t-1}\log(\;^c(h_{t-1},\;_t)) \leq \log(\;^u(\;_t))$.[15] Thus, retirees are always better off with universal pensions as they benefit from the risk sharing this provides. Therefore,

$$\mathcal{W}_t^U(\;_t^{u,*}) \geq \mathcal{W}_t^U(\;_t^{c,*}) \geq \mathcal{W}_t^C(\;_t^{c,*}),$$

and a universal system would always be preferred. Note that this verifies our conjecture that the current choice of pension system would not affect future pension system choice.

If a universal pension would always defeat a contributive system in a vote, why do we not see more universal systems across the world? One possible explanation is that our modelling assumption that workers are homogenous and they are "surprised" by failure to meet retirement requirements is too blunt a description of behavior along the life cycle. But even if workers can foresee their retirement situation in advance and adjust accordingly, there will be a benefit from the universal system as this redistributes benefits towards the poor.

Instead, we can compare steady state welfare under the different social security systems. This can serve as an approximation of the preferences of a Ramsey planner with dynastic weights. To do this, we must assume that production has no externalities, as otherwise changes in savings would lead to divergence in GDP growth rates.[16] In this case the universal system will have the advantage of redistributing pension funds among all retirees. But, it will also have a cost as the tax rate will be higher and thus, capital accumulation will be depressed. Which of these two effects dominates depends on parameters. In appendix C we show that for our calibrations it is the case that a contributive system has higher steady state welfare than a universal system.

[15]This follows since $\frac{d h_{t-1}\log(\;^c(h_{t-1},\;_t))}{d h_{t-1}} \geq \frac{\log(\;^u(\;_t))}{d h_{t-1}} = 0$, and $h_{t-1}\log(\;^c(h_{t-1},\;_t))|_{h_{t-1}=1} = \log(\;^u(\;_t))|_{h_{t-1}=1}$.

[16]Production externalities were assumed for tractability reasons, not because we cared about the effects of policies on output growth rate.

5 The Numerical Solution with Contributive Pensions

When pension benefits are contributive the politico-economic equilibrium has to be solved numerically. Nevertheless, our modelling assumptions allow us to numerically solve for each period's continuation policy function, when we assume the economy has a finite horizon. More precisely, given that the labor supply function in (EE_c1) is a closed-form relation between $_t$, h_t, and $_{t+1}$ that does not depend on h_{t-1}, we solve for the policy function using an endogenous gridpoint method (EGM) following Carroll (2006).

In the terminal period we construct a grid of the endogenous state h_{T-1}. The bounds are found by evaluating the labor supply function at $(_{T-1}, _T) = (0,1)$ and $(_{T-1}, _T) = (1,0)$ respectively. For each node on the grid we solve for the equilibrium terminal policy as given by (PEE_c). We approximate this policy function by interpolation over the solution grid. For each pair $(h_{T-1}, _T)$ we use the labor supply function to define the implied tax rate $_{T-1}$. With the terminal policy given we solve for all policies $t < T$ recursively following the outline:

i. *Update bounds on grid of h.*[17]

ii. *For each node on the grid define the equilibrium tax from*

$$^c_t = \underset{_t \in [0,1]}{\text{argmax}}\, \mathcal{W}^c_t\Big(h_{t-1}, \ _t; \ ^{t+1}_I(h_t)\Big),$$

where $^{t+1}_I(h_t)$ *is the interpolation approximation of the future policy function.*

iii. *Compute the implied tax rate* $_{t-1}$ *for each pair* $(h_{t-1}, _t)$ *from economic labor supply function.*

Given parameter values and an initial value h_0 we can simulate a model realization using the identified policy functions. As with the EGM solution in general, this approach naturally takes corner solutions into account.[18] Furthermore, the policy at time t may depend on the entire future

[17] To increase accuracy we update the bounds of the grid in each iteration. Given the solution grid at time t, the bounds of h_{t-1} are updated to reflect what levels the solution at time t lies in. Bounds are thus updated with $\bar{h}_{t-1} = h^c(0, \max(_t))$, and $\underline{h}_t = h^c(1, \min(_t))$. This ensures that all gridpoints evaluate the policy function in a range of h_{t-1} that is feasible in the politico-economic equilibrium.

[18] We naturally allow for corner solutions in our approach, as the constrained maximization of the $\mathcal{W}^c_t(\cdot)$ function simply would be $0/1$ for 2 subsequent grid-points.

path of the exogenous state $\{\ _h\}_{h\geq t}$, in a way that is parsimoniously captured by the continuation policy function $\ ^{t+1}(z_{t+1})$.

5.1 Time Dependent versus Steady State Policy Functions

In our numerical approach, policy functions are time dependent, as the entire trajectory for the demographic transition is taken into account. In infinite horizon models of politico-economic equilibrium, the policy function is usually defined as a time autonomous function of the endogenous states. We can make our model time-autonomous by restricting our attention to steady states.

When the policymaker searches for the optimal tax rate today, she internalizes the effect this has on future policy choices. With a steady state approximation this effect is evaluated as if the demographic structure were to stay the same. Intuitively a time dependent identification - as the one we study - can capture, if the political incentives to increase pension benefits are larger or smaller due to further future demographic challenges. To compare the two approaches note that the time-dependent policy function depends on the entire path $\{\ _t\}_{t=0}^{T}$: While the steady state approximation can naturally be plotted against $(h_{t-1},\ _t)$, there are many potential time dependent policy functions to compare this to. We find it a natural benchmark in our context, to consider the policy function with an ageing population. Figure 5.1 compares the time dependent policy function and the steady state approximation, where $\ _1 = 2$ and decreases by around 9.33% per period to reach 1 after exactly 10 periods.[19] In general the steady state approximation seems to capture the overall shape quite well. Furthermore, the result seems robust to changes in the rate of convergence.

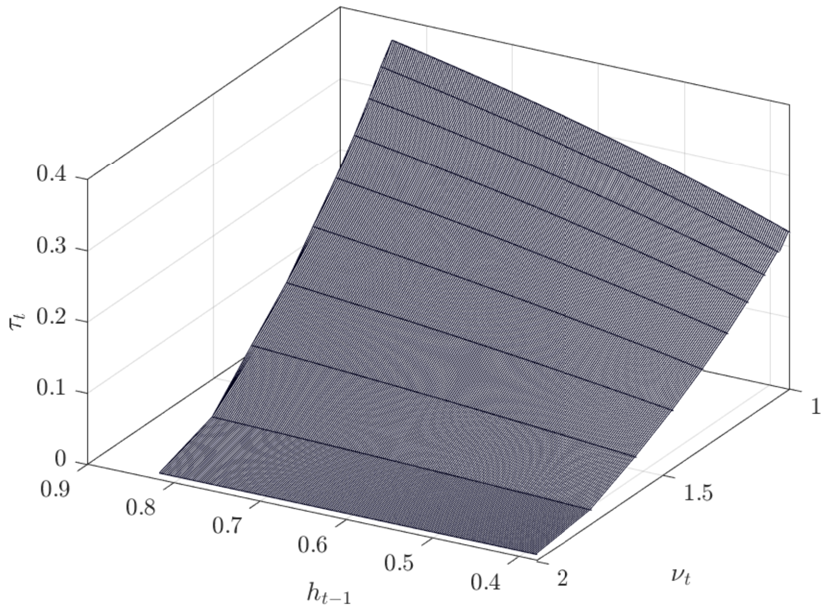
To get a closer look at exactly how the two functions actually differ, we consider the level of a single tax rate, say $\ _1$. We let $\ _1 = 1.2$ and consider $\ _2 \in [1, 1.5]$ to gauge how the time dependent policy function is affected by different sizes of jumps in $\ _{t+1}$. Figure 5.2 plots the results. While the policy function varies with $\ _2$, the variation is negligible with an effect on the tax rate of at

[19] Specifically $\ _t$ is defined as

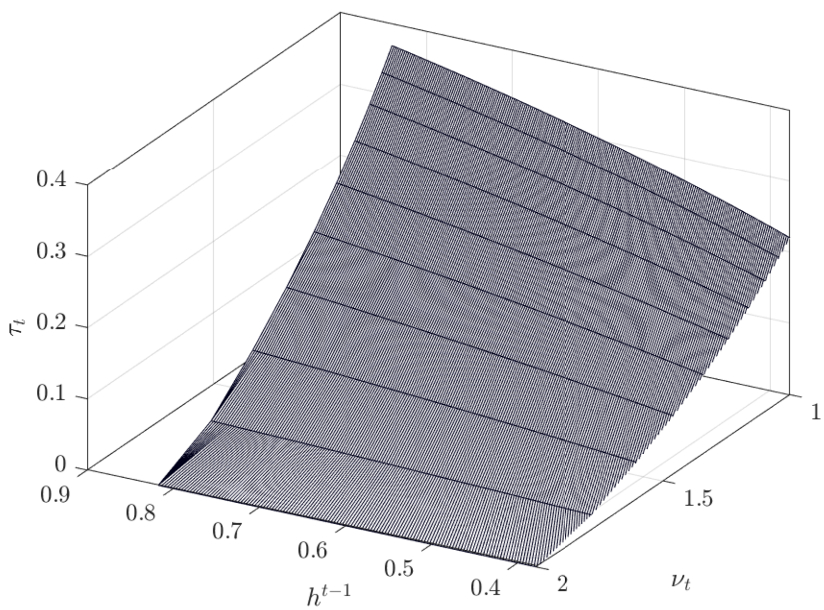
$$\tilde{\ }(\ ) = \{\ _t\}_{t=0}^{T}, \qquad \ _t = \begin{cases} \bar{\ }, & \text{for } t = 1 \\ \ _{t-1}(1-\ ) + \underline{\ }, & \text{for } 1 < t \leq T_1(\ ) \\ \underline{\ } + k, & \text{for } t \geq T_1(\ ) \end{cases},$$

and defined by fixing $T_1(\ ) = 10$ in this case. Varying $T_1(\ )$ we control the speed of convergence in $\ _t$, keeping the initial condition and steady state levels the same across paths.

Figure 5.1: Time Dependent Policy function and its Steady State Approximation



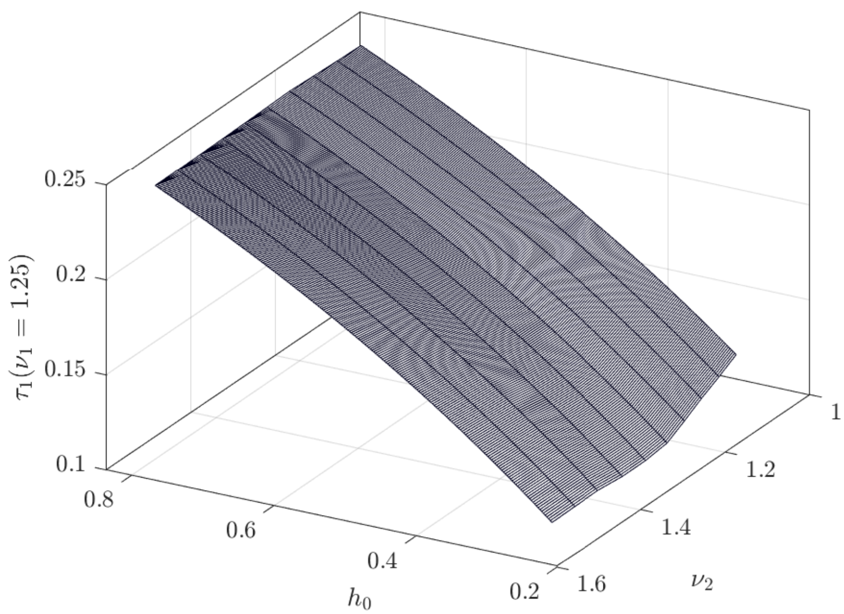
(a) Time Dependent Policy Function



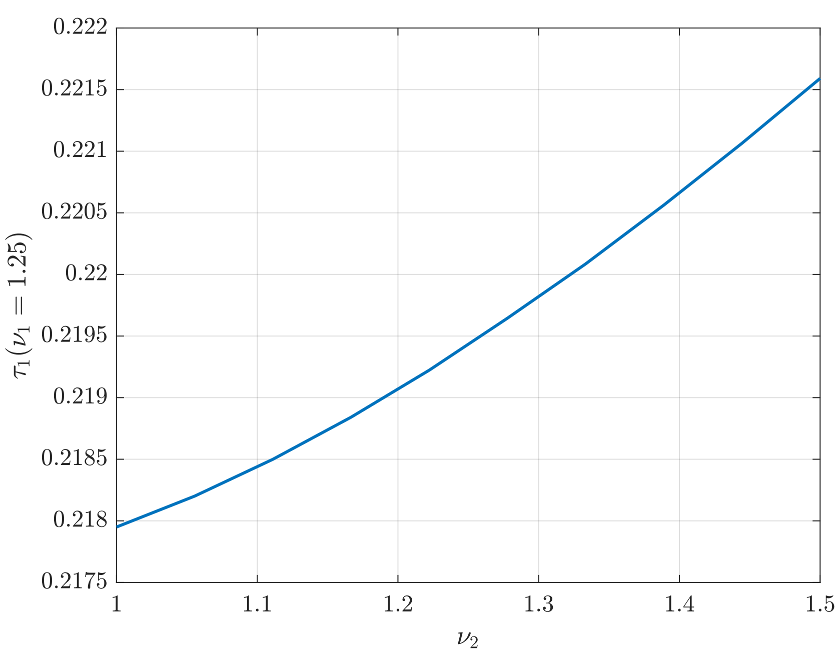
(b) Steady State Approximation

most 0.45%, c.f. figure 5.2 part (b).

Figure 5.2: The policy function varying 2



(a) On grid of h_0



(b) For h_0 = 0.72

6 Quantitative Analysis

We now want to evaluate the model's quantitative performance. For this, we calibrate the model both to Argentina, a developing country with a high level of informality in the labor market, and to Spain, a developed country that has experienced two spells of high unemployment since the return of democracy in the 1970s.

6.1 Universal pensions in Argentina

In an attempt to solve persistent funding problems, Argentina introduced a fully-funded pillar to its social security system in 1994. High levels of unemployment and informality, coupled with strict requirements to receive benefits, led to more than one third of those of retirement age to be without benefits, even when the country had fully recovered from the deep crisis of 1999-2002 that reduced GDP by 18.4%. In december 2008 the fully-funded pension funds were nationalized, and its beneficiaries were transferred to the pay-as-you-go system.

Since 2005 a number of reforms were introduced to increase pension coverage. In particular, a tax amnesty allowed workers that had less than the required 30 years of contributions to receive a pension. This policy increased the number of beneficiaries by 2.7 million between 2005 and 2011, representing approximately 40% of current pension beneficiaries. This increased coverage of the elderly from 68% to 91%.[20] Furthermore, prior to the moratorium, minimum pensions had been raised significantly more than other pensions, such that by 2005 60% of beneficiaries were receiving minimum pensions. Thus, in less than a decade, Argentina experienced a significant increase in non-contributive pensions: While in 2005 pensions represented 4.3% of GDP, by 2013 they accounted for 8.1% (6.8% in 2011). Of this increase, 2.1% of GDP was due to the tax amnesty.

To estimate the effects of switching from a contributive to a universal social security system on taxes, informality and savings—and how these are affected by ageing—we calibrate the model to Argentina in 2010. We assume the economy is in a steady state, pensions are contributive, and we take a period to be 30 years. The capital income share, $= 0.50$, comes from Frankema (2010) (see also Restrepo-Echevarría (2017)). In the baseline we take the elasticity of labor supply,

[20] See Bertranou et al. (2012) and Rofman and Oliveri (2012) for details on recent pension reforms in Argentina, and Gonzalez-Rozada and Ruffo (2015) for an estimate of the tax amnesty on savings.

$= 0.35$, and explore values between 0.2 and 0.5 as robustness (see). The savings rate is used to calibrate , and in 2010 is 20.6%, from World Bank national accounts data. The informality rate in 2010 is 48.1%, taken from International Labor Organization's ILOSTAT database, and pins down parameter X. To construct the time series for $_t$ we follow Gonzalez-Eiras and Niepelt (2008) and use 30-year gross population growth rate from census data. Finally, we use the social security tax rate in 2010 of $_{2010} = 0.27$ to calibrate $!$.[21]

Table 1: Calibration

Parameter	Value	Calibration target
	0.50	Factor income shares
$_t$	$[1.45, 1.06]$	30-year gross population growth rates
	0.35	Elasticity of labor supply
	0.32	Private savings rate of 20.6%
X	1.76	Ratio of informal-to-formal activity of 48.1%
$!$	1.48	Social security tax of 27%

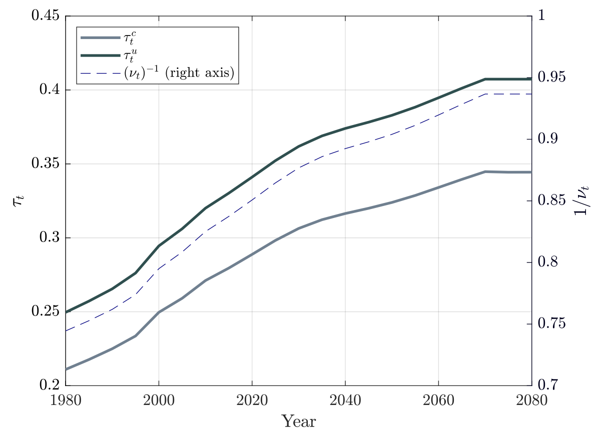
As figure 6.1 illustrates, the model indicates that as $_t$ decreases from 1.45 to around 1.06, the equilibrium tax rates and informality increase, whereas private savings and formal labor supply decrease. What is more interesting, is that the model generally predicts significantly higher tax- and informality rates under a universal system, and lower private savings and formal labor supply. Furthermore, this difference between pension systems seems to be increasing with the ageing population. In the calibration year the model predicts that a shift to a universal pension system increases tax rates from 27.1% to 32.0%.[22] By the end of the demographic transition this difference is widened by 1.3 percentage points to respectively 34.5% and 40.7%. Furthermore, this pattern

[21] We do this by following the general outline of the nested fixed point algorithm, cf. Rust (1987): Given parameter values an inner loop solves the model and calculates the difference from target values $_t$. An outer hill-climbing algorithm searches the parameter space to minimize this difference.

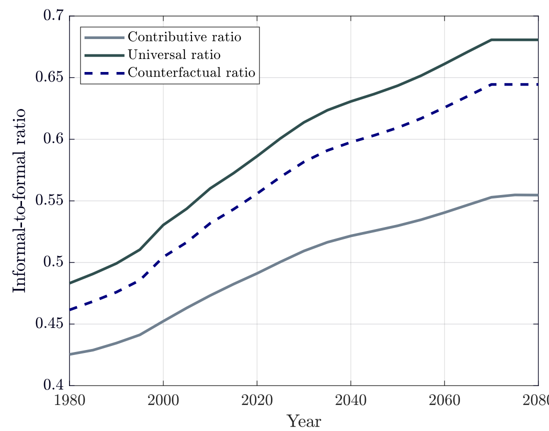
[22] Recall that the PEE tax rate under the universal system is independent of endogenous states. Thus our model (probably unrealistically) predicts no transition period between the contributive- and universal path of tax rates, but simply a jump to the new equilibrium path.

is even more apparent when it comes to rate of informality, the private savings and formal labor supply. Finally, parts (b)-(d) include time series for outcomes under the counterfactual with taxes chosen as under the universal pension system, but with the economic equilibrium features of the contributive system.

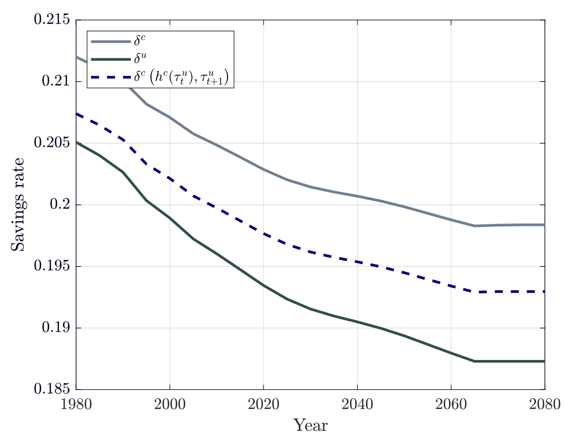
Figure 6.1: Comparing the universal- and contributive pension system in PEE



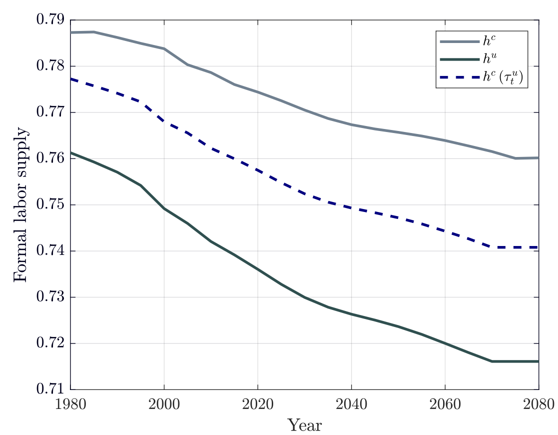
(a) PEE tax rates



(b) Informality-to-formality ratio



(c) PEE private saving rates



(d) PEE formal labor supply

Taken together the figures in 6.1 tell an interesting story: Firstly, recall that the universal pension system is considered a potential solution to the problem of an increasingly ageing population set to retire with insufficient private savings and attachment to the contributive pension system. However, while the implementation of a universal pension system treats the symptom of poverty of retirees, the adverse effect of such a treatment seems to be an exacerbation of the underlying decease of high informality and low private savings. Secondly, figure 6.1 indicates that these adverse effects are both due the economic- and political equilibrium features.

Thus by ignoring the endogenous political process we would neglect the effect that retirees and workers generally both prefer lower tax rates under the contributive system. From proposition 3 we know that retirees always prefer lower taxes when pension benefits are contributive, while it is analytically ambiguous for workers. Figure 6.2 decomposes the determinants of the equilibrium tax rate into three effects for each pension system: The effect on retirees ($\mathcal{E}^{j}_{2,t}$), the effect on workers ($\mathcal{E}^{j}_{1,t}$) working through the labor income channel ($\mathcal{E}^{j,l}_{1,t}$) and the consumption smoothing channel ($\mathcal{E}^{j,r}_{1,t}$).[23]

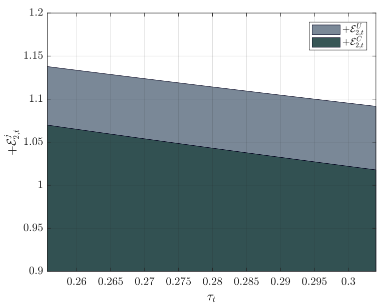
In general figure 6.2 confirms analytical results from proposition 2 and 3: (i) In equilibrium retirees generally prefer higher tax rates and workers lower tax rates and (ii) when pension benefits are contributive, retirees prefer lower tax rates. Furthermore part (b) of figure 6.2 shows that in the calibrated model workers generally also prefer lower taxes when pension benefits are contributive as opposed to universal. The *labor income channel*, measuring the utility loss from a loss of income induced by a marginal tax increase, is strongest under the universal system, but the difference is more than offset by the *consumption smoothing channel*.

6.2 The Rise of Minimum Pensions in Spain

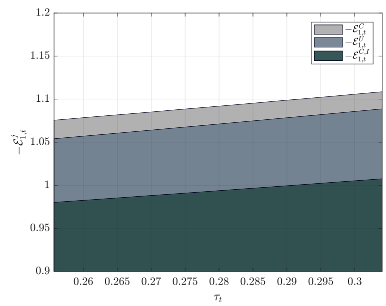
TO BE DONE

[23] Appendix B.1-B.2 derives decomposition in more detail.

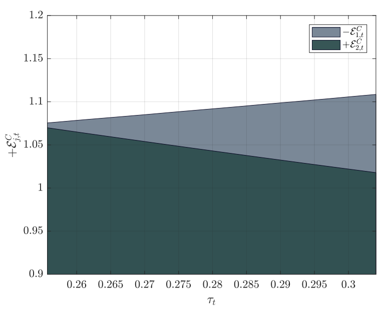
Figure 6.2: Comparing the marginal effect of tax changes on political support



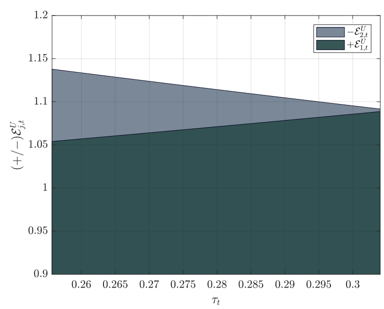
(a) Marginal effect on support from retirees



(b) Marginal effect on support from workers



(c) Marginal effect in contributive system



(d) Marginal effect in universal system

Note: The figure uses benchmark calibrated values from table 1. It measures the marginal effects of a change of the labor income tax on the political support for higher taxes (when indicated with (+)) / lower taxes (when indicated with (-)). It evaluates the marginal effects in 2015 by varying the tax between the contributive PEE tax rate and the universal PEE tax rate.

7 Conclusion

We have presented a dynamic political general equilibrium model suited for assessing the effects of making social security benefits universal as opposed to contingent on participation in the formal labor sector. Our simplifying assumptions lead to analytical solutions under the universal system, and allowed us to find numerical solutions under the contributive pension system for the full demographic transition and not just for steady states. For this purpose we have developed a simple backwards induction algorithm that identifies how the politico-economic equilibrium evolves over time when the endogenous state-variable is forward-looking.

Under both contributive and universal pension benefits predictions are generally in line with similar earlier work in political economy and social security. For example, the model predicts that as a response to an ageing population, contribution rates of workers are generally increased and thus formal labor supply is discouraged. The novel and main results of the paper however, are uncovered when the model is calibrated to Argentina. It then predicts that introducing universal pension benefits will increase tax and informality rates by about five percentage points, and significantly lower private savings rates. This suggests that the introduction of universal benefits might come at the cost of amplifying existing problems. Furthermore, we have shown that these costs can be attributed to both features of the economic- and the political equilibrium features. Thus analyses neglecting to account for endogenous policy choice may severely underestimate the actual costs of introducing universal pension benefits.

Applied to Spain our analysis rationalizes the observed increase in minimum pension benefits in times of high unemployment since the restitution of democracy in the late 1970s. Increased unemployment raises the likelihood that workers do not meet the minimum number of years of contributions to qualify for pensions, or that their pensions fall short. Pension top-ups and non-contributory pensions (introduced in 1990) financed from general revenue are the political response. That universal pensions are politically preferred to a contibutive system explains why these changes have been persistent and have not been undone in periods of low unemployment.

Finally, our results are subject to a number of caveats. Most importantly, we simplify the model by assuming that young households are all ex-ante identical and all employed. Thus we are not able to capture involuntary unemployment. Retirees that do not receive pension benefits because of unemployment would then not be able to engage in precautionary savings when young and generally not be ex-ante identical to retirees receiving those benefits. As Song (2011) argues this distributional concern might make the universal pension system even more desirable.

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Appendices

A The Economic Equilibria

A.1 Deriving the contributive equilibrium

The representative young household solves (**??**) subject to the budgets in (**??**). The first order condition for this problem under assumption 1 is then given by:

$$\left(\frac{h_t^c R_{t+1}}{c_{2,t+1}^c} + \frac{(1-h_t^c)R_{t+1}}{c_{2,t+1}^{c,if}}\right) = \frac{1}{c_{1,t}}$$

$$\ln\left(\frac{c_{2,t+1}^{c,f}}{c_{2,t+1}^{c,if}}\right) = -\frac{w_t\left[(1-{}_t)+\frac{w_t^*}{w_t}F'(h_t^c)\right]}{c_{1,t}^c}.$$

Deriving the savings rate:

Plug in budgets and rewrite the first order condition for savings:

$$w_t\left[(1-{}_t)h_t^c+\frac{w_t^*}{w_t}F(h_t^c)\right]-s_t=\frac{s_t}{\frac{s_tR_{t+1}+(1-h_t^c)b_{t+1}^c}{b_{t+1}^c+s_t^cR_{t+1}}}.$$

Note that using the equilibrium constraints on R_{t+1} and pension benefits we can rewrite the denominator of the right hand side as:

$$\frac{s_tR_{t+1}+(1-h_t^c)b_{t+1}^c}{b_{t+1}^c+s_t^cR_{t+1}}=\frac{1+\frac{1-}{}\frac{{}_{t+1}}{h_t^c}(1-h_t^c)}{1+\frac{1-}{}\frac{{}_{t+1}}{h_t^c}}.$$

Using this we can derive the savings function as

$$s_t^c = {}^c(h_t^c, {}_{t+1})w_th_t^c\left[(1-{}_t)+X\ F(h_t^c)\right],$$

where the savings rate out of labor income is given by

$${}^c(h_t^c, {}_{t+1}) = \frac{1+\frac{1-}{}\frac{{}_{t+1}}{h_t^c}(1-h_t^c)}{1+\ +\frac{1-}{}\frac{{}_{t+1}}{h_t^c}(1+\ (1-h_t^c))}.$$

The consumption functions are then simply defined by plugging in the savings function into budgets.

The intertemporal labor supply decision:

From the first order condition wrt. labor start by plugging in budgets on the left-hand side (LHS) and use equilibrium conditions for b^c_{t+1} and w^*_t/w_t to get:

$$\ln\left(1+\frac{1-\quad_{t+1}}{h^c_t}\right) = -\frac{w_t\left[(1-\quad_t)+h^c_t X\ F'(h^c_t)\right]}{c^c_{1,t}}.$$

Next we plug in budgets for $c^c_{1,t}$, use the functional form of $F(h)$ and rearrange as:

$$h^c_t = \frac{1-\quad_t}{X^{1+}} + \ln\left(1+\frac{1-\quad_{t+1}}{h^c_t}\right)\ ^c(h^c_t,\ _{t+1})h^c_t\frac{1-\quad_t + X\ F(h^c_t)}{X^{1+}}\ ^{\overline{1+}}.$$

Given the value of h^c_t and $_{t+1}$, the tax rate $_t$ can be found from

$$h^{\overline{1+}} = \frac{1-\quad_t}{X^{1+}} + \ln(\ ^c)\ ^c h\left[\frac{1-\quad_t}{X^{1+}}+\frac{F(h)}{X}\right].$$

$$h^{\overline{1+}} - \ln(\ ^c)\ ^c h\frac{F(h)}{X} = \frac{1-\quad_t}{X^{1+}}[1+\ \ln(\ ^c)\ ^c h]$$

$$_t = 1-\frac{X^{1+}}{1+\ \ln\ ^c)\ ^c h}\left[h^{\overline{1+}} - \ln(\ ^c)\ ^c h\frac{F(h)}{X}\right].$$

A.1.1 Proof of proposition 1, first part: Comparing savings rate and formal labor supply

Comparing the private savings rates ^{c}, ^{u} is straightforward. One way to see that $^c \geq\ ^u$ is to note that the economic equilibria in general coincide when we impose $_{t+1} = 0$ in the contributive solution. It is straightforward to show that $@\ ^c/@\ _{t+1} \geq 0$, which proofs that $^c \geq\ ^u$.

A similar argument shows that $h^c_t \geq h^u_t$ (we show that $@h^c_t/@\ _{t+1} \geq 0$ below).

A.1.2 Proof of proposition 2, second part: Economic equilibrium labor responses

The algebra from this part is quite tedious and thus relegated to an online appendix. It is howevfer basically just an application of the implicit function theorem. It confirms that h^c_t is decreasing in $_t$, increasing in $_{t+1}$ and more interestingly that the relative labor response of a tax-change (semi-elasticity) is larger under the universal system.

A.2 A note the equilibrium labor income function

A problem in an earlier version of this paper was that with a labor income function of the form

$$\mathcal{I}_t = w_t \left[(1 - {}_t)h_t + F(h_t)\right],$$

where the productivity (measured by w) was inherited by the informal sector, was not well behaved.[24] Specifically we noted that for $F(0) > 0$ and a wage-function where $\lim_{h \to 0} w_t(h_t | s_{t-1}) = 1$, young households would *always* prefer as large taxes on labor income as possible as $\lim_{\ \to 1} I_t = 1$ in this case.

To alleviate this problem we argue that while the general productivity in the informal sector should not be completely decoupled from the formal, it should not fluctuate with contemporaneous wage decisions. Thus we alter our assumption to informal production being proportional to some general productivity measure w^* that is not affected by contemporaneous taxes as opposed to w_t. With the assumptions applied here we have the equilibrium labor income functions:

$$\begin{aligned} \mathcal{I}_t^j &= (1 - \ )A \frac{s_{t-1}^j}{{}_t h_t^j} \left[(1 - {}_t)h_t^j + h_t^j X\ F(h_t^j)\right] \\ &= (1 - \ )A \frac{s_{t-1}^j}{{}_t} \left[1 - {}_t + X\ F(h_t^j)\right], \end{aligned}$$

with $j = \{u, c\}$. Note that in this case the effect of a tax change is given by

$$\frac{\partial \mathcal{I}_t^j}{\partial \ {}_t} = (1 - \ )A \frac{s_{t-1}^j}{{}_t} \left[X\ F'(h_t^j) \frac{\partial h_t^j}{\partial \ {}_t} - 1\right].$$

Note that we still have opposing effects on $\mathcal{I}_t^j$ from a tax change. The reason is that in the economic equilibrium we have a classic congestion effect lowering wages when h is raised. Thus suppressing the overall formal labor supply increases the per-unit wage rate. In an economy without an informal sector this congestion effect would be present, but under fairly general assumptions $\mathcal{I}_t^j$ would still be decreasing in ${}_t$.[25] To ensure that the presence of our informal sector does not make it optimal for young households to impose a large labor tax on themselves we need to ensure that

$$1 > X\ F'(h_t^j) \frac{\partial h_t^j}{\partial \ {}_t}. \tag{14}$$

[24]This assumption was adopted from Song, Storesletten and Zilibotti (2012).

[25]For instance, in our model without an informal sector the effect would simply include the -1 part in the derivative.

Furthermore we prefer to have $\partial \mathcal{I}_t^j / \partial \ _t$ be numerically increasing in $_t$. As we move further away from the efficient point of taxation the losses should at least weakly increase. With the universal system the condition (14) implies

$$1 > \frac{\ }{1 + \ },$$

which is the case for $\ \geq 0$. Note that while the effect is constant in $_t$ the relative effect $\partial \ln(I_t^u) / \partial \ _t$ is numerically increasing in $_t$: $\partial I_t^u / \partial \ _t$ is constant, but the level I_t^u decreases with $_t$. Consequently, the universal system can have corner solutions in the politico-economic equilibrium, but the policy-platform objective function will at least be concave in . For the contributive case we do not have the same guarantee automatically. This is dealt with explicitly by assumption 2.

B The Politico-Economic Equilibrium

B.1 Universal social security system

We start by conjecturing that the policy function $^u(\cdot)$ is independent of all endogenous states (in this case s_{t-1}^u). Under this conjecture, we can substitute the economic equilibrium consumption functions into the political candidate's problem and rewrite as follows:

$$^u(\ _t) = \underset{t \in [0,1]}{\text{argmax}} \ ! \ln\left(1 + \frac{1 - \ }{\ } \ _t\right) + \ _t(1 + \ ) \ln(I_t^u) + e_t,$$

where e_t contains all the terms that under our conjecture is independent of the choice of $_t$. Note that the conjecture that the policy function does not depend on any endogenous states, implies that $_{t+1}$ becomes independent of $_t$ as well. This is not to say that the assumption breaks the dynamic ties of the model: Agents in the economy still internalizes **how** policy is made and takes future policy decisions into account when voting today. However, under our conjecture, it is not rational to believe that $_{t+1}$ is affected by $_t$. This yields the FOC for equilibrium tax

$$\frac{!(1 - \ )}{\ + (1 - \ ) \ _t} + \ _t(1 + \ ) \frac{\partial I_t^u / \partial \ _t}{I_t^u} = 0, \tag{15}$$

We note that

$$\frac{\partial \ln(I_t^u)}{\partial \ _t} = -\frac{1}{1 - \ _t + \ X^{1+ \ }},$$

such that we can derive the equilibrium tax rate as:

$$^{*}_{t} = \frac{1}{! + \ _{t}(1 + \ )} \left[! \left(1 + \ X^{1+} \ \right) - \frac{}{1 - } \ _{t}(1 + \ ) \right]. \tag{16}$$

Note that (as discussed in appendix A.3) if $^{*}_{t} > 1$ then the solution is in the corner of $_{t} = 1$ and if $^{*}_{t} < 0$ then we have the corner solution $_{t} = 0$. Note furthermore that this confirms our conjecture that the policy function is indeed independent of endogenous states (s^{u}_{t-1}). It is straightforward to verify that this function is increasing in $!$ and decreasing in $_{t}$. If there is a terminal date, say T, the political objective at such date is derived in a similar manner, but with workers not retiring. This is given by:

$$^{u}(\ _{T}) = \max_{_{T} \in [0,1]} ! \ln \left(c^{u}_{2,T}\right) + \ _{T} \ln \left(c^{u}_{1,T}\right),$$

where $c^{u}_{2,T}$ follows the usual household solution formula and $c^{u}_{1,T} = \mathcal{I}^{u}_{T}$ from imposing $s_{T} = 0$ in the budget. This yields the same problem as for $t < T$ where $\ = 0$ is imposed.

To show that the policy function $^{u}(\cdot)$ is the unique Markov perfect equilibrium we argue by backwards recursion. Let us now allow for ^{u} to depend on the endogenous state s^{u}_{t-1}. In this case we can write the policy function in the terminal state as:

$$^{u}(\ _{T}) = \max_{_{T} \in [0,1]} ! \ln \left(\ ^{u}(\ _{T}) \mathcal{I}^{u}_{T-1}\right) + \ _{T} \ln \left(\mathcal{I}^{u}_{T}\right).$$

Here $\mathcal{I}^{u}_{T}$ contains terms regarding s^{u}_{T-1}. However, as these are log-separable from terms regarding $_{T}$, the first order condition for equilibrium policy does not depend on s^{u}_{T-1} and thus policy is independent from this as well. Thus policy changes at time $T - 1$ does not have any effects on $_{T}$. Knowing this the policy function at $T - 1$ is defined as

$$^{u}(\ _{T-1}) = \max_{_{T-1} \in [0,1]} ! \ln \left(\ ^{u}(\ _{T-1}) \mathcal{I}^{u}_{T-2}\right) + \ _{T-1} \ \ln \left(\ (\ _{T}) \mathcal{I}^{u}_{T-1}\right) + \ \ln \left(\ ^{u}(\ _{T}) \mathcal{I}^{u}_{T-1}\right) \ .$$

Once again the policy function at $T - 1$ could only potentially depend on terms in $\mathcal{I}^{u}_{T-1}$. However, these are log-separable from terms regarding s^{u}_{T-2} and thus the equilibrium policy at $T - 1$ is independent of s^{u}_{T-2}. This argument goes for all t and thus the policy function is unique.

B.2 Contributive social security system

Substituting in the economic equilibrium constraints in the political program and omitting all terms independent of the choice of policy, we can write an equivalent objective function for the policy choice at time t as:

$$W_t^c = ! \quad h_{t-1}^c \ln\left(\ {}_{t-1}^c \right) \quad + \ {}_t \quad \ln\left(I_t^c\right)\left(1 + \quad\right) + \ln\left(\ {}_t^c\right) + \quad \ln\left(1 - \ {}_t^c\right) + \quad h_t^c \ln\left(\ {}_t\right) \quad ,$$

where the labor-income function can be written as

$$\mathcal{I}_t^c = (1 - \quad) A \frac{s_{t-1}^c}{{}_t} \left[1 - \ {}_t + X \ F(h_t^c)\right],$$

and the maximization of W_t^c is subject to the constraint that future policies are defined by continuation policies consistent with the current maximization, i.e. ${}_{t+1} = \ {}_{t+1}^c(h_t^c, \ {}_{t+1})$. Before we proceed to the characterization of the equilibrium policy, we define the **politico-economic equilibrium labor function** as the labor function that internalizes the effect through the continuation tax function, i.e. the $\mathbf{h}_t^c$ implicitly determined from:

$$\mathbf{h}_t^c \equiv h^c\left(\ {}_t, \ {}^{t+1}(z_{t+1})\right), \qquad\qquad h_t^c \in z_{t+1}.$$

Assumption 2 in the main text defines the labor response of this function to be in the domain

$$\frac{-1}{X^{1+} \ (h_t^c)^{1/}} < \frac{\partial \mathbf{h}_t^c}{\partial \ {}_t} \equiv \frac{\partial h_t^c}{\partial \ {}_t} + \frac{\partial h_t^c}{\partial \ {}_{t+1}} \frac{d \ {}^{t+1}}{d \ {}_t} < 0, \qquad \frac{d \ {}^{t+1}}{d \ {}_t} \equiv \frac{\partial \ {}^{t+1}}{\partial h_t^c} \frac{\partial h_t^c}{\partial \ {}_t}. \tag{A2}$$

The marginal effect on political support from a marginal change in ${}_t$ can be summed up by the following:

- The marginal effect on retirees' political support from a marginal tax increase ($\mathcal{E}_{2,t}^c$):

$$\mathcal{E}_{2,t}^c = \frac{!\,(1 - \quad)}{+ (1 - \quad) \frac{{}_t}{h_{t-1}^c}}.$$

  This is always positive, but smaller than the corresponding term with universal pension benefits (they are equivalent when we impose $h_{t-1}^c = 0$).

- The marginal effect on workers' political support from labor-income changes induced by a marginal tax increase ($\mathcal{E}_{1,t}^{c,l}$)

$$\mathcal{E}_{1,t}^{c,l} = \ {}_t (1 + \quad) \frac{X \ F'(h_t^c) \frac{\partial \mathbf{h}_t^c}{\partial \ {}_t} - 1}{1 - \ {}_t + X \ F(h_t^c)}.$$

This marginal effect may be smaller/larger than the universal marginal effect depending on parameter values. For comparison we restate the effect from pension system U:

$$\mathcal{E}^{u,l}_{1,t} = \quad {}_t(1+ \quad) \frac{X\ F'(h^c_t)\frac{@h^u_t}{@ \ _t} - 1}{1 - \ _t + X\ F(h^u_t)}.$$

The problem with comparing the two analytically is that $\mathcal{E}^{c,l}_{1,t}$ depends on the politico-economic equilibrium function $@ \ ^c_{t+1}/@ \ _t$, which has to be solved for numerically.

- Finally, we collect the residual marginal effects on workers' political support from a marginal increase in $\ _t$ as

$$\mathcal{E}^{c,r}_{1,t} = \quad _t \left[\frac{@\mathbf{h}^c_t}{@ \ _t} (\ln(\ ^c_t) - \quad _h) + (\ ^c_t - 1) \frac{@ \ ^c_{t+1}/@ \ _t}{ \ _{t+1}} \quad \right],$$

where coefficients $\ _h, \quad \geq 0$ are relatively complicated functions defined as

$$\ln(\ ^c_t) \geq \quad _h \equiv \frac{ \ ^c_t(1+ \quad h^c_t) + \ ^2 \ ^c_t(1 - h^c_t) - (1+ \quad) \ ^c_t \ ^c_t(1+ \quad (1 - h^c_t))}{ \ ^c_t(\ ^c_t)}$$
$$\equiv \frac{ \ ^c_t(\ ^c_t - 1)^2 h^c_t}{(\ ^c_t)^2(1 + (\ ^c_t - 1)(1 - h^c_t))}.$$

Under assumption 2 we can further verify that $\mathcal{E}^{c,r}_{1,t} \leq 0$.

With the marginal effects of a tax-change outlined showing proposition 3 is straightforward:

Proof of proposition 3:

Consider first the terminal policy function in (PEE$_c$). To show this we proceed as in appendix B.1 and set up the terminal period political objective function:

$$\ ^c_T \left(h^c_{T-1}, \ _T\right) = \max_{ \ _T \in [0,1]} ! \quad h^c_{T-1} \ln\left(c^{c,f}_{2,T}\right) + \left(1 - h^c_{T-1}\right) \ln\left(c^{c,if}_{2,T}\right) \quad + \quad _T \ln\left(c^c_{1,T}\right),$$

where $c^c_{1,T}$ is simply defined from the budget when young. Plugging in the economic equilibrium functions and omitting terms not relevant for the choice of $\ _T$ we can equivalently present the political objective function as:

$$\ ^c_T \left(h^c_{T-1}, \ _T\right) = \max_{ \ _T \in [0,1]} ! \ln\left(\ ^c_{T-1}\right) h^c_{T-1} + \quad _T \ln\left(\mathcal{I}^c_T\right),$$

where the terminal period's choice of labor supply is equivalent to that of the universal pension system's such that $\mathcal{I}^c_T = \mathcal{I}^u_T$. Maximizing this yields ($\mathsf{PEE_c}$). It is straightforward to verify that the terminal policy is increasing in h^c_{T-1}.

For $t < T$ we can characterize the equilibrium policy by use of the marginal effect terms $\mathcal{E}$. Firstly, note that if the equilibrium policy is not in the corner then it must be the case that

$$\mathcal{E}^c_{2,t} + \mathcal{E}^{c,l}_{1,t} + \mathcal{E}^{c,r}_{1,t} = 0.$$

If the equilibrium tax rate is in the corner, the marginal effect of changing ! , $_t$ or h^c_{t-1} is zero per construction. Thus we concentrate on the interior case where the equality above holds. Firstly note that for us to have an interior solution at $^*_t$, we know that at least in a local region around *, $\sum \mathcal{E}^c_t$ must be positive and decreasing towards the crossing of zero around $^*_t$ and negative and decreasing in a region thereafter. Note furthermore that $\mathcal{E}^c_{2,t}$ is always positive, implying that in an interior equilibrium we conversely have that $\mathcal{E}^{c,l}_{1,t} + \mathcal{E}^{c,r}_{1,t} \leq 0$. Finally, note that a marginal change in h^c_{t-1} or ! simply shifts $\sum \mathcal{E}^c_t$ upwards implying an increase in equilibrium tax rate. Conversely, $_t$ simply enters as a proportional factor in $\mathcal{E}^{c,l}_{1,t} + \mathcal{E}^{c,r}_{1,t} \leq 0$. Thus an increase in $_t$ shifts $\sum \mathcal{E}^c_t$ downwards implying a lower equilibrium tax rate.

C Contributive Versus Universal System Steady States

C.1 Terminal period policy

For completeness we can show that in the last period the universal system is preferred over the contributive one. Take the path of policies before terminal period T as given. Furthermore, when voting for a contributive/universal pension system, note that variables such as s_{t-1} and h_{t-1} is considered constant. In the terminal period the objective function for the policymaker is then given by (under system C):

$$\mathcal{W}^c_T = ! \left[h_{T-1}\log(c^f_{2,T}) + (1 - h_{T-1})\log(c^{if}_{2,T})\right] + \ _T\log(c_{1,T}).$$

Recall that consumption functions (w. contributive system) are given by:

$$
\begin{aligned}
c^{f}_{2,T} &= \ As_{T-1}\left(1+\frac{1-}{}\frac{T}{h_{T-1}}\right),\\
c^{if}_{2,T} &= \ As_{T-1},\\
c_{1,T} &= (1-\ )A\frac{s_{T-1}}{T}\left[1-\ _T + X\ F(h_T(\ _T))\right],\\
h_T(\ _T) &\equiv \left(\frac{1-\ _T}{X^{1+}}\right)^{\overline{1+}}.
\end{aligned}
$$

With commitment to policy, both retirees and current workers would benefit from retirees promising when young to vote contributive system, C, when old. This would imply that s_{T-1} and h_{T-1} were larger under system C than system U. However, without commitment to policy, the objective function we compare to has to be one where levels of s_{T-1}, h_{T-1} are the same:

$$
\begin{aligned}
\mathcal{W}^{u}_{T} &= \ !\log(c_{2,T}) + \ _T\log(c_{1,T}),\\
c_{2,T} &\equiv \ As_{T-1}\left(1+\frac{1-}{}\ _T\right),\\
c_{1,T} &\equiv (1-\ )A\frac{s_{T-1}}{T}\left[1-\ _T + X\ F(h_T(\ _T))\right],\\
h_T(\ _T) &\equiv \left(\frac{1-\ _T}{X^{1+}}\right)^{\overline{1+}}.
\end{aligned}
$$

It is straightforward that the objective function $\mathcal{W}^{u}_{T} \geq \mathcal{W}^{c}_{T}$ for a given tax rate. It follows directly therefore that

$$
\mathcal{W}^{u}_{T}(\ ^{u,*}_{T}) \geq \mathcal{W}^{u}_{T}(\ ^{c,*}_{T}) \geq \mathcal{W}^{c}_{T}(\ ^{c*}_{T}).
$$

If $\ ^{u,*}_{T} \neq \ ^{c,*}_{T}$ the first inequality holds strictly (only coincides with $h_{T-1} = 1$).

C.2 A comparison of political objective under the two systems

As discussed above a model including a discrete choice of type of pension system in each period will (absent any type of commitment) always choose the universal system. To get a sense of whether an ageing population leads to a larger support for a universal system compared to a contributive one, we consider alternative comparisons than the discrete choice one above. This appendix compares the welfare in a steady state under the two pension systems. Before going to the welfare comparisons, we note that with the productive externalities the model features endogenous growth with a growth rate of

$$\left(\frac{k_{t+1}}{k_t}\right)_j^{BGP} = \frac{(1- \ )A}{} \ ^j \left[1- \ ^j + X \ F(h^j)\right], \qquad j \in fu, cg.$$

Given different levels of saving rates, tax levels and labor supply with the two pension systems the balanced growth paths diverge in the long run. To get a better comparison we present the results without these externalities.

C.2.1 The Economic Equilibrium without productive externalities

The results are somewhat similar to the ones attained with the externalities. In the universal case we have:

$$\begin{aligned}
h_t^u &= \left(\frac{1- \ _t}{X^{1+}}\right)^{\overline{1+}}, \\
s_t^u &= \ ^u(\ _{t+1})\mathcal{I}_t \\
c_{1,t}^u &= \ ^u(\ _{t+1})\mathcal{I}_t \\
c_{2,t+1}^u &= A \ ^u(\ _{t+1})\,[s_t] \ (\ _{t+1}h_{t+1})^{1-} \\
\mathcal{I}_t &= (1- \ )A\left(\frac{s_{t-1}}{t}\right) \ \left[(h_t)^{1-} \ (1- \ _t) + X \ F(h_t)\right],
\end{aligned}$$

where the functions ^{u}, ^{u}, ^{u} are the same as in the main part. In the contributive case the result is similar: Formal labor supply is the same, savings rate and consumption when young is the same (except for $\mathcal{I}_t$ part which is identical to the part above) and $c_{2,t+1}^c$ is modified in the same manner as the universal part:

$$\begin{aligned}
h_t^c &= \ \frac{1- \ _t}{X^{1+}} + \ \ln\left(1 + \frac{1-}{} \ \frac{t+1}{h_t^c}\right) \ ^c(h_t^c, \ _{t+1})h_t^c\frac{1- \ _t + X \ F(h_t^c)}{X^{1+}} \ \ ^{\overline{1+}}, \\
s_t^c &= \ ^c(h_t^c, \ _{t+1})\mathcal{I}_t \\
c_{1,t}^c &= \ ^c(h_t^c, \ _{t+1})\mathcal{I}_t \\
c_{2,t+1}^{c,0} &= \ A[\ ^c(h_t^c, \ _{t+1})\mathcal{I}_t] \ \left(\ _{t+1}h_{t+1}^c\right)^{1-} \\
c_{2,t+1}^{c,1} &= \ A \ ^c(h_t^c, \ _{t+1})\,[\ ^c(h_t^c, \ _{t+1})\mathcal{I}_t] \ \left(\ _{t+1}h_{t+1}^c\right)^{1-} \ .
\end{aligned}$$

Imposing steady state implies the savings rates

$$s^j = \left(\ ^j(1- \ )A \ ^- \ \left[(h^j)^{1-} \ (1- \ ^j) + X \ F(h^j)\right]\right)^{\frac{1}{1-}}, \qquad j \in fu, cg.$$

C.2.2 Steady State welfare without productive externalities

The steady state welfares are given by

$$\mathcal{U}^{u} = ! \ln(c_2^u) + \sum_t \mathcal{B}_t \left[\ln(c_1^u) + \quad \ln(c_2^u)\right]$$

$$\mathcal{U}^{c} = ! \left[h^c \ln\left(c_2^{c,1}\right) + (1 - h^c)\ln\left(c_2^{c,0}\right)\right] + \sum_t \mathcal{B}_t \left[\ln(c_1^c) + \quad \left[h^c \ln\left(c_2^{c,1}\right) + (1 - h^c)\ln\left(c_2^{c,0}\right)\right]\right]$$

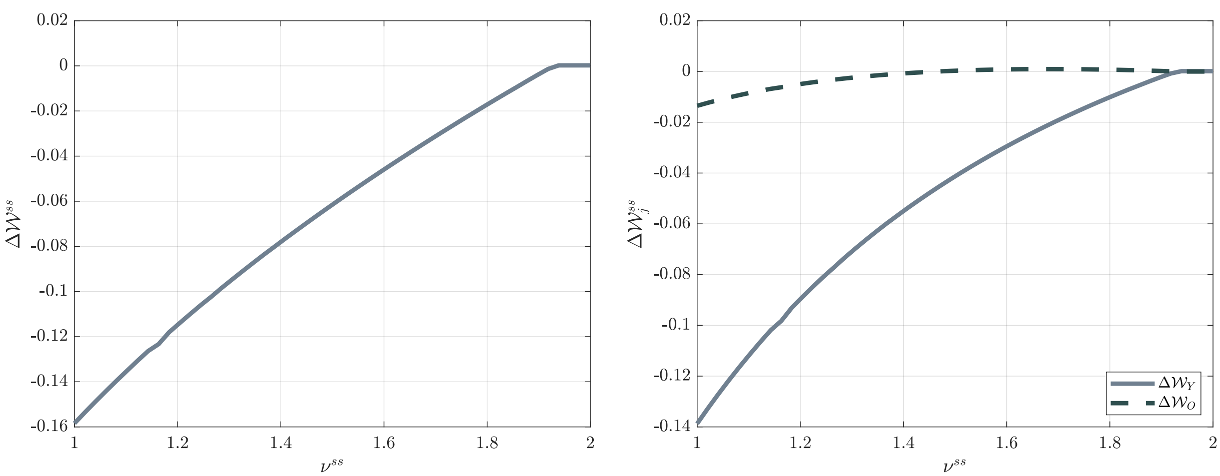
where we have normalized the weight on the current old generation at $!$ and $\mathcal{B}_t$ are weights on generation young at time t. We note that $\mathcal{U}^j$ coincides with political welfare functions $\mathcal{W}^j$ when $\mathcal{B}_1 = \quad$ and $\mathcal{B}_t = 0$, for $t > 1$. For the political welfare case the steady state difference can be reduced to

$$\mathcal{W} = \quad \ln(\ ) + \frac{}{1 - } \quad \ln(\ ) + \frac{1}{1 - } \quad \ln\left[h^{1-} \quad (1 - \quad) + X \quad F(h)\right]$$

$$+ (! + \quad) \quad (1 - \quad) \quad \ln(h) + \ln(\ ^u) - h^c \ln(\ ^c) + \frac{}{1 - }\left[\quad \ln(\ ) + \quad \ln\left[h^{1-} \quad (1 - \quad) + X \quad F(h)\right]\right],$$

where we have used the notation $\quad f(x) = f(x^u) - f(x^c)$. For our calibration we show below that for all $\quad \in [1, 2]$ the contributive system offers higher welfare in steady state.

Figure C.1: Difference in steady state (political) welfare



The figure C.1 shows that $\quad \mathcal{W} \leq 0$ and increasing in $\quad$. The second part shows how the difference in political support is for 'one unit' of young (Y) and old (O) households.

Figure C.2: Steady state labor supply and tax rates

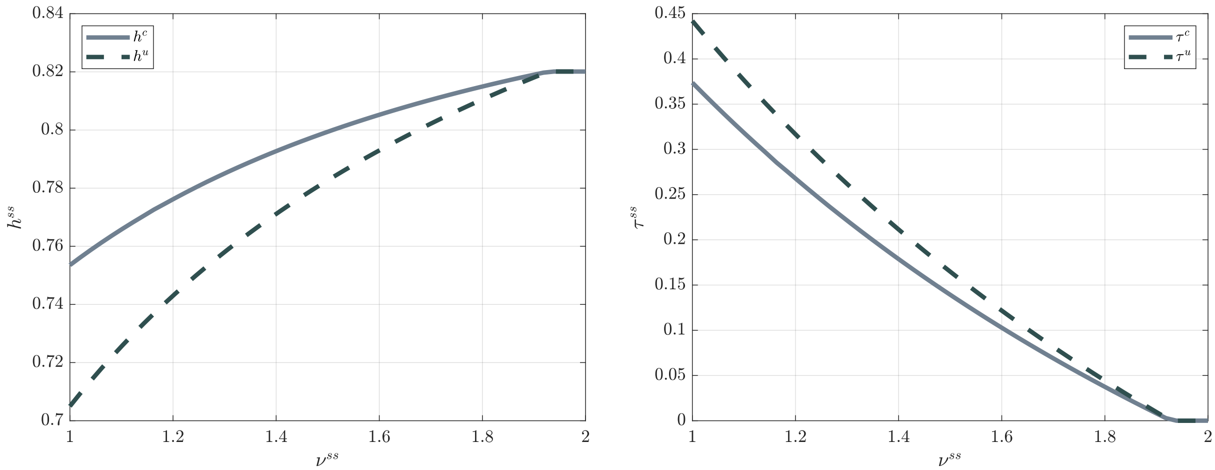


Figure C.2 illustrates how the PEE labor supply and tax rates change with . The two systems coincide when taxes are zero, which occurs around $= 1.92$.

D The model without productive externalities

As a robustness check we run the model without the productive externalities. Appendix C derives the economic equilibrium relations in the current setting without productive externalities. Thus we go directly to the political layer of the model here.

D.1 The political objective without productive externalities

In the universal case the policy function will still be independent of endogenous states (s_{t-1}). The relevant problem the political candidate faces is given by

$$^{u}(\ _t) = \underset{t\in[0,1]}{\text{argmax}} \ ! \left[\ln(\ ^{u}(\ _t)) + \frac{(1-\ )}{1+\ }\ln(1-\ _t)\right] + \ _t(1+\ )\ln(\mathcal{I}_t)$$

The term regarding $\mathcal{I}_t$ can be rewritten here using h_t^u:

$$\ln(\mathcal{I}_t) = \ln\left[(1-\ _t)^{1+(1-\ )\overline{1+}} + \frac{}{1+\ }\left(X^{1+} - (1-\ _t)\right)\right] + \text{constants}$$

The first order condition for an interior solution is then given by

$$!\ (1-\ )\left[\frac{1}{^{u}(\ _t)} - \frac{1}{1+\ }\frac{1}{1-\ _t}\right] + \ _t(1+\ )\frac{\overline{1+} - \left(1+(1-\ )\overline{1+}\right)(1-\ _t)^{\frac{(1-\ )}{1+}}}{(1-\ _t)^{1+(1-\ )\overline{1+}} + \overline{1+}\left(X^{1+} - (1-\ _t)\right)} = 0.$$

We can write the solution in short as a function only of $_t$, however, due to the non-linearity in $_t$ an analytical solution is not available. In the contributive case the political objective function is given by

$$
\begin{aligned}
W_t^c = ! \; & \left[(1 - \;)\ln(h_t^c) + h_{t-1}^c \ln(\;^c(h_{t-1}^c, \;_t))\right] \\
& + \;_t \left[\ln(\;^c) + \; \ln(1 - \;^c) + (1 + \;)\ln(\mathcal{I}_t) + \;(1 - \;)\ln(h_{t+1}^c) + \; h_t^c \ln(\;^c)\right]
\end{aligned}
$$

The most notable change compared to the model in the main part is that the indirect utility of young workers now also hinges on the level h_{t+1}. This is due to the endogenous state: A change in $_t$ has an effect on h_t, which has an effect on $_{t+1}$, which again has an effect on h_{t+1}. This has an effect on the pension benefits, when the current young generation retires.

D.2 Terminal policy functions without productive externalities

In the terminal period the consumption of retirees follows the usual formulas in both the universal and the contributive case. The terminal period generation of working households simply consume the labor income $\mathcal{I}_t$ and provide labor supply as in the universal case (no matter the pension system). Thus economic functions are given by:

$$
\begin{aligned}
h_T &= \left(\frac{1 - \;_T}{X^{1+}}\right)^{\frac{}{1+}}, \\
c_{1,T} &= \mathcal{I}_t. \\
c_{2,T}^u &= \; A \;^u(\;_T) s_{T-1}(\;_T h_T)^{1-}, \\
c_{2,T}^{c,0} &= \; A s_{T-1}(\;_T h_T)^{1-}, \\
c_{2,T}^{c,1} &= \; A \;^c(h_{T-1}, \;_T) s_{T-1}(\;_T h_T)^{1-},
\end{aligned}
$$

In this terminal state the political objective functions are given by

$$
\begin{aligned}
W_T^u &= ! \left[\ln(\;^u(\;_T)) + (1 - \;)\ln(h_T)\right] + \;_T \left[\ln\left(h_T^{1-} \;(1 - \;_T) + X \; F(h_T)\right)\right]. \\
W_T^c &= ! \left[h_{T-1}^c \ln(\;^c(h_{T-1}^c, \;_T)) + (1 - \;)\ln(h_T)\right] + \;_T \left[\ln\left(h_T^{1-} \;(1 - \;_T) + X \; F(h_T)\right)\right].
\end{aligned}
$$

Note that W_T^u coincides with W_t^u when $\; = 0$. Furthermore, note that the two functions W_T^c, W_T^u coincide when $h_{T-1}^c = 1$.

D.3 Calibration of model without productive externalities

Without the productive externalities we have to re-calibrate the model as well.

- We define from the labor share of income.
- is defined as the elasticity of labor supply; around [0.2, 0.5].
- Given and the target pension tax rate $_{t+1}$ the savings rate only depends on and h_t^c. We define $= f \ (h)$.
- Next the informal-to-formal activity ratio is defined by

$$\frac{w_t^* F(h_t)}{w_t(1 - \ _t)h_t} = \frac{F(h_t)}{h_t^{1-} \ (h_t^*) \ (1 - \ _t)}.$$

  With a target for this ratio, the tax rate $_t$ and the elasticity of labor supply in , this allows to write X as a function of h_t: $X = f_X(h)$.

- Imposing steady state of savings we have

$$s = \left(\ ^c(h, \ )(1 - \ )A \ ^- \ \left[h^{1-} \ (1 - \ ) + X \ F(h)\right]\right)^{\frac{1}{1-}} .$$

  Using this in the real interest rate relation we then have

$$R = \ A\left(\frac{s}{h}\right) \ .$$

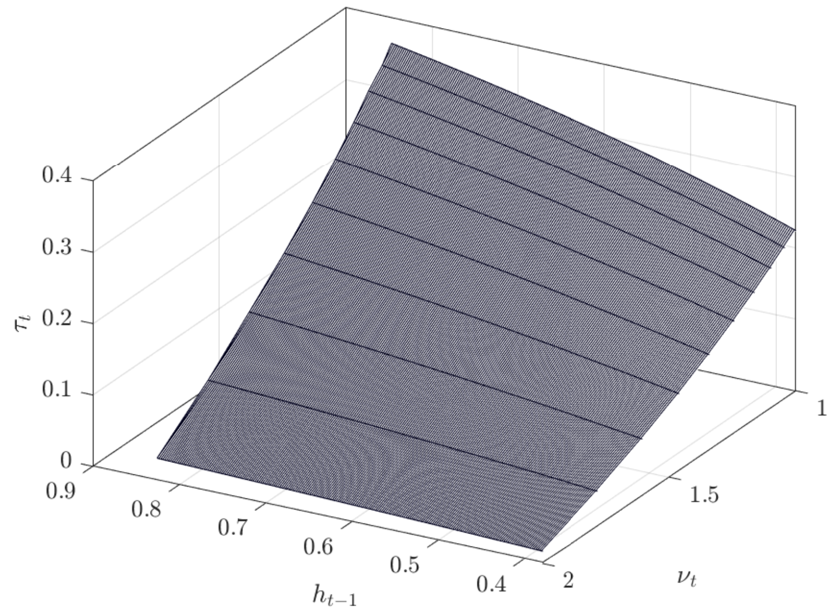
  Given that X and can be written as functions of h, we can use a target for R to calibrate A: $A = f_{\tilde{A}}(X(h), \ (h), h) = f_A(h)$.

- Using the labor supply function we can now solve for $, X, h, A$.
- Finally we calibrate ! to target the level of $_t$.

D.4 Results from model without productive externalities

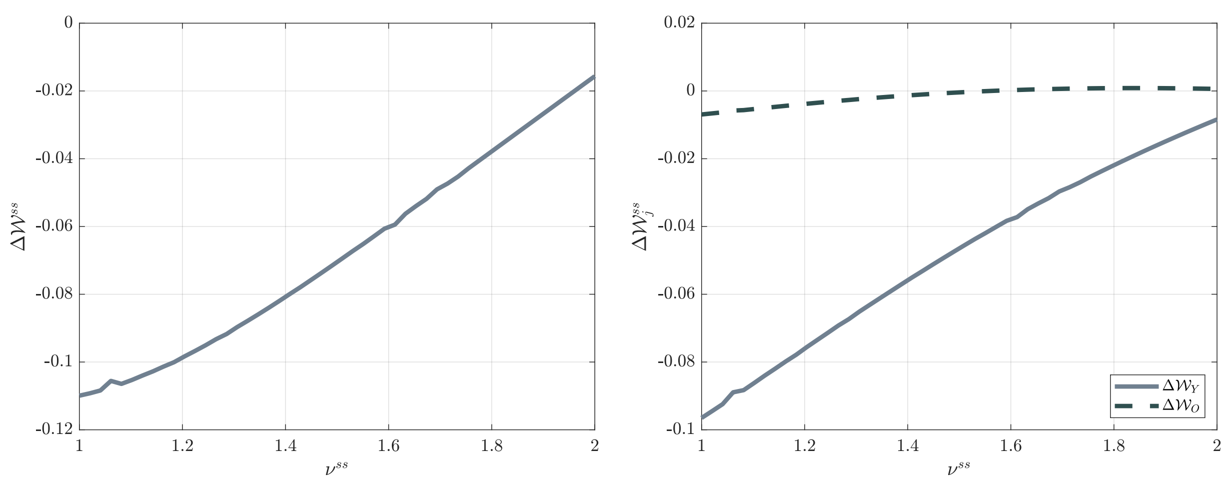
We start by plotting the policy function on a grid of h_{t-1}, varying $_t$ according to the experiment in section 5: We let $_1 = 2$ and decrease around 9.33 % per period until it reaches 1 after exactly 10 periods.

Figure D.1: Time Dependent Policy function without productive externalities



The resulting function overall has the same shape as the one in the main section. One notable change is that the gradient in the direction is numerically smaller. The result from the (political) welfare comparison is similarly largely the same as in appendix C.

Figure D.2: Difference in steady state (political) welfare



The figure D.2 shows that $\mathcal{W} \leq 0$ and increasing in . The second part shows how the difference in political support is for ’one unit’ of young (Y) and old (O) households.

Figure D.3: Steady state labor supply and tax rates