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Social Security Reform

The Capital Accumulation and Intergenerational Distribution Effect

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Substituting the pay-as-you-go social security system by a fully funded individual-accounts system may generate long-run capital accumulation, but often at the cost of income redistribution away from the elderly. Different deficit-financing schemes are studied having this issue in mind.

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This paper — a product of the Country Operations Division, Country Department II, Latin America and the Caribbean Regional Office — analyzes important policy issues using new approaches. Copies are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Sheilah King-Watson, room S8-025, extension 31047 (53 pages with figures and tables).

Using the Auerbach-Kotlikoff model, Arrau studies a switch from an unfunded, defined-benefit (pay-as-you-go) social security system to a fully funded individual-accounts system.

Important questions arise about the transition period. Contributions to the old system by currently active workers disappear as pensions, so the government must assign a value to those past contributions and finance their deposit into the new accounts.

It must also finance the transitional social security deficit from the old system. That deficit arises because the government must pay pensions to current retirees without collecting the social security tax that now goes to individual savings accounts.

Arrau quantifies the impact of social security reform on capital accumulation and intergenerational distribution using a model calibrated for Mexico. There seems to be confusion about the effect of the reform on capital accumulation and a complete neglect of the effect on intergenerational distribution.

Arrau also explores the implications of tax incentives for pension funds. He studies the effects of two alternatives: (1) if the social security contribution is deductible from income tax and pensions are taxable, and (2) if contributions are not deductible and pensions are exempt.

Option 1 provides a higher taxable base than option 2 and a flatter path of income tax during the period of transition — which is important if one wants to prevent substitution of future consumption by present consumption. Option 2 provides revenue earlier than option 1. The simulations, however, seem to favor option 1.

Contents

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1 Introduction

Reforming the social security system has received increasing attention in recent years. In this paper we study in a dynamic neoclassical model (the Auerbach-Kotlikoff model) a switch from an unfunded defined-benefit system (pay-as-you-go) to a fully-funded defined-contribution system in a stable demographic environment. While the former finances current pensions with current social security taxes which are not perceived as linked to the benefits (defined benefits contract), the latter finances the pensions out of the funds accumulated in special accounts for retirement purposes. Therefore, the contributions are directly linked to the benefits (defined contributions contract). The reform was carried out in Chile in 1980.

Important questions arise about the transition period. It is necessary to recognize and fund past contributions to the old system by currently active workers, and to finance the transitional social security deficit from the old system. The deficit arises as the government must pay pensions to current retirees without collecting the social security tax from the old system which now goes to individual saving accounts. The paper analyzes different alternatives to recognize past contributions (based on the formula applied in Chile) and to finance the transitional budget deficit. Combinations of income taxes and national debt (income taxes today or tomorrow), and tax incentives to pension funds are studied.

We are concerned with both the impact of the reform on capital accumulation and other macroeconomic variables, and on intergenerational distribution. There seems to be a lot of confusion regarding the first effect and a complete neglect on the second. The fact is that they are closely related.[1]

The paper is organized as follows. Section 2 describes the theoretical model. Section 3 discusses the data for the calibration. The model is calibrated to resemble the Mexican economy. Section 4 indicates how the reform is actually carried out and the alternatives of the government to finance the transition. The simulation results are presented in section 5. The sixth section summarizes the main results.

2 The Model

The purpose of this section is to develop a neoclassical model to study social security reform. Being the purpose to obtain quantitatively relevant information, we use a variation of a large-scale version of Diamond's (1965) neoclassical model which is due to Auerbach and Kotlikoff (1987).[2] Unlike the latter model, and mainly due to the lack of reliable data, we do not include leisure. We first describe the optimization problem of individuals and firms, and then the aggregation and the equilibrium

[1] For alternatives views on the impact of the reform on capital accumulation in the context of the Chilean reform see articles by Arellano and Cheyre in Baeza and Manubens (1988).

[2] By neoclassical we mean Bernheim's (1987) classification which distinguishes macroeconomic models as Keynesian, neoclassical and Ricardian models. While Solow-type growth models are normally labeled "neoclassical" (because he introduces the neoclassical production function into previous Leontief-type production function), the fix-saving rule equation makes more appropriate to label the Solow model as Keynesian. It is not until Diamond (1965) that the neoclassical demand side is also included. The infinite-horizon Ramsey-Cass-Koopmans framework on the other hand is labeled Ricardian because of its Ricardian equivalence implication.

solution.

2.1 The Individual Optimization

Individuals have a life span from adult-age 1 through 55 (actual age 21 through 75). They work from adult-age 1 through 45 (actual age 21 to 65) and then they retire for the last 10 years of life. In what follows we describe the optimization problem for the particular cohort age 1 at period 1 so the subscript represents both age and year.

The individual maximizes the time separable intertemporally isoelastic utility function

$$U = \frac{1}{1-1/\gamma}\sum_{t=1}^{55}(1+\delta)^{-(t-1)}c_t^{1-1/\gamma} \tag{1}$$

subject to the budget constraint

$$a_{t+1} = (1+r_t)a_t + p_t + w_te_t - c_t - \tau(r_ta_t + w_te_t) - \tau_w w_te_t \tag{2}$$

where c_t is consumption, p_t is payment of pension benefits (positive when individual is retired, between adult-age 46 to 55), w_te_t is labor income or earnings (efficiency unit wage w_t times the units of human capital at age t e_t; where e_t is set to zero for retirement age, 46 to 55), τ is the income tax, τ_w is the social security tax, a_t is the stock of financial assets, and r_{t+1} is the real domestic interest rate between period t and $t+1$.

Individuals observe interest rates and wages for their relevant horizon and choose sequences of c_t and a_{t+1}, for all $t = 1,..,55$, in order to maximize (1) subject to (2). The individual problem is fully described by the budget constraint (2), the initial and terminal conditions

$$a_1 = a_{56} = 0 \tag{3}$$

and the first order condition

$$\frac{c_{t+1}}{c_t} = \left(\frac{1 + r_{t+1}(1-\tau)}{1+\delta}\right)^{\gamma} \tag{4}$$

The last expression says that the slope of the household's age-profile of consumption is increasing in the interest rate and in the intertemporal elasticity of substitution γ, and decreasing in the time preference parameter δ.[3]

2.2 Firms

Firms hire nondepreciating homogeneous capital and effective units of labor until factor prices and marginal rates of substitution are equalized. Firms face the Cobb-Douglas technology

$$Y_t = K_t^{1-\beta} L_t^{\beta} \tag{5}$$

where K_t and L_t are aggregate physical capital and effective labor respectively (hereafter an uppercase letter indicates aggregate variables).

[3]The slope of the consumption profile is increasing in parameter γ if $r(1-\tau) > \delta$ which we assume to be the case.

The first order conditions for the firm's problem are

$$w_t = \beta \left(\frac{K_t}{L_t}\right)^{1-\beta} \tag{6}$$

$$r_t = (1-\beta) \left(\frac{K_t}{L_t}\right)^{-\beta} \tag{7}$$

2.3 Aggregation and Government

Aggregate financial assets in private hands at period t are

$$A_t = \sum_{s=1}^{55} a_t^s (1+n)^{t-s+1} \tag{8}$$

where x_t^s means variable x at year t for cohort age s, and n is a fixed and exogenous rate of population growth. Now we need to keep track of both age and year independently. Notice in the expression above that we have implicitly normalized the size of cohort age 1 at year 0 to be equal to 1. Aggregate financial assets are the sum of national debt B_t and equity or claims on firms' cash flow. Capital therefore is

$$K_t = A_t - B_t \tag{9}$$

and labor can be expressed as

$$L_t = \sum_{s=1}^{55} e_t^s (1+n)^{t-s+1} \tag{10}$$

A sequence $\{w_t, r_t\}$ represents an equilibrium if it satisfies the individual optimization problem (2)–(4), the firm problem (6)-(7) and the equilibrium conditions

(8)-(10). Furthermore, in a "steady state" (or balanced growth) equilibrium the sequence $\{w_t, r_t\}$ is constant for all t.

The government budget, under the pay-as-you-go system can be expressed as

$$B_{t+1} = (1 + r_t)B_t + G_t + P_t - \tau(W_t + r_t A_t) - \tau_w W_t + NT_t \tag{11}$$

where besides the variables already defined, G_t is government consumption, P_t is total pensions payments or social security benefits, W_t is the economy's wage bill, NT_t is the net transfers to the rest of the world (which will be defined later).

The social security Pay-as-you-go system require that the payments of benefits to retirees be equal to the contributions by active workers, so the social security tax is chosen to satisfy the equation

$$\tau_w W_t = P_t \tag{12}$$

where

$$P_t = \sum_{s=1}^{55} p_t^s (1 + n)^{t-s+1} \tag{13}$$

and $p_t^s = 0$ for $s = 1, ..., 45$.

For every individual, the pension stream p_t^s is typically computed in relation to some average of past wages at the moment of retirement, times a "replacement rate" (defined-benefit contract). For simplicity, and without loss of generality for our analysis, we will assume that the pension is a fixed amount in consumption units and it is related to the last year salary by a replacement rate ϵ. Therefore

$$p_{t+i}^{45+i} = \epsilon w_t e_t^{45}(1 - \tau - \tau_w) \tag{14}$$

for all $i = 1, ..., 10$. In other words, every individual have a fixed pension equal to $(1 - \epsilon)100$ percent of his/her net of taxes wage at retirement adult-age 45 (actual age 65).

2.4 Earnings and Growth

The profile of human capital e^s will be assumed fixed for all individuals. However, in the presence of productivity growth, the initial level is higher for new generations. We assume that new cohorts are endowed when born with a level of human capital that is greater than previous cohorts by a fixed factor $1 + x$, so $e_{t+1}^1/e_t^1 = 1 + x$. Using (10), it can be verified that $L_{t+1}/L_t = (1 + x)(1 + n)$ in the steady state. Aggregate labor grows at a factor equal to the composite of population growth and productivity growth. Furthermore, in the steady state, and due to the homogeneity of degree one property of the production function, both output and capital will also grow at the same rate. Hence, x is the long-run rate of output growth per capita. This is a natural way to introduce productivity growth in our neoclassical setting. To keep things simple, we assume that this rate of technological change is exogenous.

Having described the model, we close this section with a proposition which will be useful later. The proof is in an Appendix.

Proposition 1. In the Neoclassical framework described in this section, and in a stationary steady state equilibrium, the implicit (or internal) rate of return of the Pay-as-you-go system for a typical household is equal to the rate of growth of the economy (the composite of population and productivity growth).

3 Parameterization

The calibration of the model requires choosing the utility parameters γ and δ, the government policy parameters, the technological parameter from the production function β and the profile of human capital e^s. In order to give our results a quantitative interpretation, we choose to calibrate the model to resemble the Mexican economy as we were able to obtain data on the age-profile of earnings. The calibration, however, could be considered applicable to many developing countries.

3.1 Calibration

Utility Parameters.

The parameter γ, the intertemporal elasticity of substitution or (the inverse of) the constant relative risk aversion parameter, has been the purpose of many investigations. Early estimates for the U.S. economy range from .10 to more than one, although most of them do not satisfy specification tests of the model and are not precisely estimated.[4] A recent paper by Hall (1989) suggests a very low value for γ, virtually zero.

A different picture seem to be coming up from recent literature that question the "expected utility" specification employed in the above literature as it mixes the two different concepts of intertemporal substitution and risk aversion. Epstein and Zin (1987) obtain more precise values between 0.10 and 0.50 and Attanasio and Weber (1987) estimate γ at about 2. As we can see the knowledge on this parameter is rather unsettled.

For developing countries the evidence is much scarcer. Giovannini (1985) finds rather inconclusive values for many developing countries.[5] Later evidence provides rather high estimates to this parameter. Schmidt-Hebbel (1987) provides precise estimates around 1 (logarithmic) for the Chilean Economy. Eckstein and Leiderman's (1989) estimates for Israel are not inconsistent with the above result, with the point estimate largely depending on the data set option. In my own (1990a) paper, for the Chilean and Mexican economies, the results are around 1.5 for γ.[6] Given this

[4]Hansen and Singleton (1982, 1983, 1984). See also other references in Auerbach and Kotlikoff (1987, p. 50)

[5]He runs log-linear versions of the Euler equation (growth of consumption against real interest rate) with annual data, where most estimates of the intertemporal elasticity are not significantly greater than zero. A closer look to Giovannini's results, however, suggests that his results provide little information regarding the intertemporal elasticity. Most country estimations cannot reject the null hypothesis that the intertemporal elasticity is less than 0.5.

[6]The last two papers estimate monetary Euler systems of the "expected utility" maximizing representative consumer, and therefore they restrict the relative risk aversion parameter to be the

rat' er vague evidence, a sensible strategy, would be to do some sensitivity analysis. After trying different parameters for the steady state, we use two values for γ, 0.70 and 1.2; largely because the evidence on Mexico suggests high substitutability and because the steady state calibration looks fairly sensible given the other choices (see section 3.2). For δ we use 0.07 which is in the upper bound of the range estimated in Arrau (1990a).

Government Policy.

First we choose the social security replacement rate ϵ. The largest social security institution in Mexico (IMSS) pays 79% replacement rate on the pension base.[7] The salary base for pensions, however, is the nominal average of the last 5 years previous to retirement. This is equivalent to 70% of the last year salary when inflation is 20% a year.[8] The two numbers above represent an efective replacement rate of about 0.55 (0.70x79) for the IMSS. The IMSS includes about 31% of the labor force in Mexico and another 7% contribute to the public emplcyees social security institution (ISSSTE), which pays 100% replacemment rate over last year salary. Combining

inverse of intertemporal substitution. If the true utility is of the recursive type which allow independent values for intertemporal substitution and risk aversion (e.g. Epstein and Zin, 1987), we still would obtain un expression like (1) with no uncertainty. In this case γ would be a function of the two relevant parameters, but perfect foresight exercises with a function like (1) are still valid. Besides it is interesting to remark that monetary versions of the Euler approach applied to developing countries have successfully satisfied the critical overidentifying restriction test.

[7] Assuming 45 years of working time.

[8] The inflation rate in Mexico in the late seventies and after the 1988 stabilization program was 20% a year.

both institutions the economy wide replacement rate would be about 0.65, and it would go up to 0.72 with an inflation of 10% a year.[9] For the simulations we employ a replacement rate of 0.70.

The government picks its consumption policy as a fixed proportion of the GDP. We take $g = G/Y$ equal to 0.09 from Mexican national accounting.[10] The government finances the budget by keeping constant the national debt to GDP ratio, where $b = B/Y$ is taken to be 0.25 (about current ratio in Mexico), and by an income tax τ chosen endogenously in the initial steady state to balance the budget. The social security tax τ_w is also chosen endogenously to satisfy (12) given the other choices.

Finally we assume that this an open economy where the only good is tradable. The economy, however, is not open to capital mobility and the interest rate is endogenous. Mexico and many other developing countries are currently facing a serious foreign debt overhang situation which requires a positive net transfer to the rest of the world. That is probably going to be the case for years to come. We assume that the government must transfer abroad NT_t, which is assumed to be a fixed proportion of GDP. NT_t in (11) can also be interpreted as the non-interest current account surplus (or net export surplus or resource balance). This

[9] A declared objective of the economic authorities

[10] The no depreciation assumption requires to interpret output as net domestic product. Hereafter we neglect this difference as it has no important consequences to our analysis. We calibrate the model by using ratios related to GDP.

transfer is permanent because it is not enough to serve the full face value of the foreign debt, which implies that the foreign debt trades abroad at a discount.[11] We choose $nt = NT/Y$ to be equal to 0.02. In practice this assumption recovers closed economy dynamics and the nt ratio could be treated analogously to the government consumption ratio g.

Technology Parameters, Demographics and Earnings Age Profile.

The technology parameter β is chosen, as usual, to be the share of labor income in the national accounts. The share of labor has been substantially lower in Mexico during the eighties than the historical value of about 0.50. Presumably this is due to the high unemployment (or movement to the informal sector) that occurred over this period. We choose the historical value of 0.50. The productivity growth x is taken somewhat arbitrarily to be 0.02. This is likely to be a closer estimate of future growth per capita than the high 3% observed in the past in Mexico. For population growth n we choose a standard value equal to 0.02. The last two assumptions imply a long-run growth rate of 4.04%.

The cross-section age profile of earnings over the life cycle is taken from the wages reported to the larger social security institution in Mexico (Instituto Mexicano de Seguridad Social, IMSS) for the year 1988. The IMSS includes about one third of

[11] This framework is further developed and justified in Arrau (1990b).

the Mexican labor force. The profile is plotted in Figure 1a.[12] The longitudinal profile of earnings is obtained by multiplying the slope of the cross-section profile by the fixed productivity factor 1.02. Figure 1b shows the longitudinal profile of earnings and the fixed stream of pensions when the replacement rate is 70%. As we can see, the cross section profile peaks at age 37 and the longitudinal profile peaks at an age close to retirement. One problem with the data from the IMSS is that the social security contributions are paid only over a salary base not greater than 10 times the minimum salary. We do not have information on how binding is this truncation value. This implies that our cross-section and longitudinal age-profile of earnings are somewhat flatter than the actual age profiles.

3.2 Steady State Sensitivity Analysis

Table 1 show the pay-as-you-go steady state solution of the model for our base case parameters, and how the equilibrium changes when we change the rate of growth of the population, the social security replacement rate, the intertemporal substitution and the time preference parameter. In the table we can see that the main difference between γ equal to 1.2 or 0.7 is the capital-output ratio and therefore the interest rate and investment rate. In the former case the capital-output ratio is between 3.5 and 3.7, the interest rate at about 13% and the (net) investment rate between 11

[12]The actual data set contains the cross-section wages for cohort age 15 through 89. We just take the profile for cohort ages 21 through 65.

and 18%, while in the latter case the capital-output ratio is below 3, the interest rate at about 18% and the investment rate between 9 and 14%. The reason is that a higher intertemporal elasticity implies a steeper profile of consumption and more saving (investment) and savings (capital stock) over the life cycle.

The lower the social security replacement rate, the higher the savings households must accumulate to face retirement age. Reducing the replacement rate from 70 to 30% causes a small change because the high intertemporal elasticity implies high proportion of voluntary savings accumulated for retirement.

We also observe that the equilibrium income tax is fairly stable at about 13% in order to finance the fixed government consumption and payments abroad (11% of GDP) and the interest bill on the national debt (25% of GDP).

The equilibrium social security tax, however, is very sensitive to the rate of population growth. If the rate of population growth is reduced from 3 to 1%, the population becomes older on average and therefore a higher social security tax rate is required to pay the pensions of a higher proportion of the population which is retired. The tax rate increases from about 3.4 to 5.8%.[13]

In Table 1 we can see that our base case parameters (rows 4 and 10 in Table 1) lead to sensible results. In Mexico the capital-output ratio is about 3, and some estimates suggest that between 30 to 40% of GDP is outside the country (flight capital).

[13]These rates may look low compared with actual social security tax rates. The reason is that here we only consider retirement benefits, excluding disability, survival, orphanhood and some health benefits normally included in the social security tax rate.

The total wealth of Mexico, therefore, is about 3.4 times GDP. The capital-output ratio in Table 1 could be interpreted as total wealth over GDP, which suggests that $\gamma = 1.2$ could be accurate.[14] The above statement, however, depends crucially on the assumption of 0.07 for the time preference parameter δ. If we reduce that parameter to 0.03, an intertemporal parameter of 0.7 can also accommodate an appropriate wealth stock (last 3 rows in Table 1). Since the evidence on the time preference parameter is not conclusive, it is appropriate to keep using both 1.2 and 0.7 for the intertemporal elasticity.[15]

4 From the Pay-As-You-Go to a Fully–Funded Social Security System

In the previous section we have described and calibrated the model for Mexico. Here we describe a switch to a fully-funded individual-account social security system and study alternative ways to "recognize" past contributions and to finance the transition pericd. We are specially interested in studying impact of the reform on intergenerational distribution and on real macroeconomic variables like interest rates, capital accumulation, investment and saving rates.

The two aspects of the new system, the facts that it is fully funded and the

[14]Of course if a fraction of that wealth is not in domestic capital, the interest rate would be different.

[15]Our estimates in Arrau (1990a) for the time preference parameter fluctuate between 0.03 and 0.07 for Chile, while for Mexico the estimate is negative. We rule out the estimates from Mexico as data with positive real return was not available, what probably bias the time preference parameter downward.

fact that it is based on individual accounts are different and can be thought as independent. By Pay-as-you-go we actually mean not only the way the system is financed through time (unfunded), but also the fact that the system is a defined benefit contract, where the benefits are not related to the contributions, but they are a fraction of some base salary. There is no tax-benefit links.[16]

By fully-funded we mean a system where pensions are financed by the return of past accumulated assets. By individual-account we mean a defined contribution system where the benefits are linked one by one to past contributions. The second property, however, does not require actual funding. In fact, Boskin, Kotlikoff and Shoven (1985) have proposed an unfunded individual-account system in order to have the efficiency gains associated with the pure tax-benefit link.[17]

4.1 The Social Security Deficit

The government faces two challenges. First, it must recognize past contributions for all currently active workers, for which it issues "recognition bonds".[18] The second challenge is to finance a transitional social security deficit and (the interest on) the new recognition bonds. The transitional social security deficit arises because

[16] This assumption is extreme as actual social security systems do have tax-benefits links, which are very different for different households. While some old households probably view their contributions closely linked to their retirement benefits, that is not true for younger households. See Boskin et. al. (1987).

[17] Auerbach and Kotlikoff (1987), p. 154 explore the efficiency gains associated to unfunded tax-benefit linkages.

[18] Direct translation from the spanish name given in Chile, "bono de reconocimiento".

the government must pay pensions for current retirees without having the income from currently active workers, who now deposit the contributions into individual accounts. This transitional (or operational or primary) social security deficit will be labeled simply social security deficit. It only includes the payment of pensions to individuals retired at the moment of the reform (period 1), it does not include any interest on debt. The deficit disappears as the last retiree at the moment of the reform dies (by the year 11 in our model). We will explore three alternatives to finance the transition, which are different combinations of income taxes and national debt (income taxes today or tomorrow). Later we also introduce an additional fiscal exercise which is to include tax incentives to pension funds.

4.2 The Recognition Bond

In the beginning of period 1 the government must transfer to all individuals alive how much the old system is worth to them. In our framework it would be easy to compute an exact bond, conditional to the transitional path, for all individuals. The exercise, however, would not have much policy content. It is preferable to restrict the computation of the bond to some typical formula whose variables the government could observe at the moment of the reform.

We will study a variation of the formula applied in Chile to compute this recognition bond. The government must consider three aspects to compute the bond. a)

The old system pays an internal return equal to the rate of growth of the economy (see Proposition 1) and the new contributions will pay market interest rates. b) The fact that some workers are more productive than others and therefore have contributed more in the past. And c), that some people have contributed for more years. We will explain the computation of the formula and later see how these aspects are considered.

First the government computes a "base bond" for all active workers age s at period 1 in a fashion similar to the computation of pensions. The bond is

$$BB_1^s = 0.70 E_0^s \frac{YC^s}{45} a \tag{15}$$

where s is the cohort's age, BB is the base bond, YC are the years of contribution to the old system, E is labor earnings in last year previous to the reform ($w_0 e_0^s$), and a is the cost of a unitary annuity at adult-age 46 (retirement age 66). For individuals less than 46 years old, the bond pays an interest equal to the rate of growth of the economy up to retirement age. At retirement age funds recognized by the government and the accumulated funds in the new accounts allow the individual to buy an annuity pension in the insurance market.

Unlike the Chilean case where the bond BB is actually issued at retirement age instead of period 1,[19], we can compute the (net of taxes) value of the bond in the

[19] Including 4% interest between period 1 and retirement year

beginning of period 1 as

$$R_1^s = BB_1^s\left(\frac{(1+x)(1+n)}{1+\bar{r}(1-\tau)}\right)^{46-s} \tag{16}$$

where we use the steady state values of interest and taxes to compute the value of the recognition bond.[20]

A typical worker in our model contributes 45 years. For the worker adult-age 46 in period 1, therefore, the bond R from (15)–(16) allows him to buy an annuity equal to 70% the last salary, which is the same paid by the old system.[21] The above equations allow us to compute the recognition bond for all active workers in terms of the recognition bond of the workers retiring at year 1. For all workers adult-ages $s = 1,...,45$ in year 1 the bond is

$$R_1^s = R_1^{46}\frac{E_0^s}{E_0^{45}}\frac{YC^s}{45}\left(\frac{(1+x)(1+n)}{1+\bar{r}(1-\tau)}\right)^{46-s} \tag{17}$$

The three terms in (17) are the elements referred above. The younger the worker, the lower the value of the bond due to the difference between the interest rate and the economy's growth rate on one hand and due to less years of contributions on the other. The bond however will be higher for workers with higher salary at period zero (recall that the cross-section profile of salary peaks at age 37).

[20] Strictly speaking the formula (15) in Chile has an 80% replacement rate (instead of 70%), the maximum years of contribution are 35 (instead of 45), the interest on the bond is 4%, and the annuity a was computed as 10.35 for male workers and 11.36 for female workers.

[21] For workers already retired at period 1, that is workers ages 67 through 75, the government does not issue a bond but keeps paying the pensions.

Of course there is no reason why the linearity of formula (17) should lead to a fair computation of the bond. We explore the welfare effect in section 5.

4.3 Financing the Transition

The intergenerational distribution and real impact of the transition not only depend on the formula to compute the bond, but also on the way the government finances the transition. The government must raise revenues to issue the recognition bonds, to compensate the loss in social security contributions which now go to individual saving accounts, and to finance the interest bill of any issue of national debt due to the reform. We use the income tax as the equilibrating source of revenue. The question is when to raise the tax (today or tomorrow), or in other words, how to combine income tax and debt financing during the transition.

First we discuss the issue of the recognition bonds in the beginning of period 1. Because these bonds represent a recognition of future government liabilities, it makes the most sense to issue national debt. In this case the government is actually relabeling or acknowledging future liabilities. Agents without "fiscal illusion" should not be concerned for this large issue of national debt as, if done correctly, it just represents the present value of future pension payments. In other words, the government is writing on the books unwritten but actual future liabilities.[22]

[22]See Kotlikoff (1988) for a nice theoretical discussion of the problem of fiscal illusion and labeling government deficits in the neoclassical framework. In fact, the reform under study here is one of Kotlikoff examples on "illusionary" labeling of the government's accounts.

Therefore the initial issue is

$$\Delta B_1 = \sum_{s=1}^{46} R_1^s \tag{18}$$

where ΔB_1 is an issue of national debt in the beginning of period 1 to back the recognition bonds.

The second question is how to finance the transition. We use three alternatives for the latter.

Case 1. After the national debt issue at period 1, the government fixes the debt-GDP ratio and raises income taxes to serve the debt in the future and to pay the pensions for the people retired at the moment of the reform.

Case 2. Unlike case 1, the government finances the first 10 years of fiscal deficit with national debt. Then it increases income taxes in year 11 to equilibrate the budget (fixing debt/GDP ratio from there on).

Case 3. As an intermediate policy between cases 1 and 2, the government only finances the social security deficit with debt and the interest on the new bonds with taxes.

4.4 Intergenerational Distribution

In the next section we study how the formula for the recognition bond and the alternative financing schemes affect the welfare of every cohort into the future. To do that we use the concept of wealth equivalent, which means that we evaluate the present value of lifetime resources that is necessary at the new relative prices in order to attain the level of utility implied by the old system.[23] The welfare effects that we report in next section are the percentage change between this theoretical level of wealth for every cohort and the actual level of wealth. If the latter is greater (smaller) than the former, then the cohort gains (loses) from the reform in wealth equivalent terms.

There are two reasons why a cohort can gain. One is a transfer from other cohorts, and therefore the gain represents the loss of somebody else. The second possibility is that there are efficiency gains, so the society as a whole gains from the reform and therefore the gains of some do not represent losses of others. From the point of view of the individual the reason for his loss or gain is irrelevant. Whether it represents an aggregate gain or a transfer does not matter.

The efficiency gains issue however is important to interpret the impact of the reform being undertaken on macroeconomic variables, so we discuss some results from the literature.

Wage and social security taxes distort the choice between leisure and consumption, while income taxes also distort the allocation between consumption and saving (future consumption). The pay-as-you-go system represents a given combination between wage and income taxation. The reform of the social security system to a

[23]For individuals alive in period 1 we are only concerned with the remaining lifetime consumption and utility.

fully-funded individual-account system represents a switch from wage and income taxation toward income taxation. The efficiency gains from such a switch are positively related to the elasticity of substitution between consumption and leisure (assumed zero here), and inversely related to the intertemporal elasticity of substitution (around one). Unlike the Auerbach-Kotlikoff model, and largely because of lack of reliable data, we exclude leisure from the analysis. This assumption together with the high intertemporal elasticity of substitution favors wage taxation, as the latter is actually a lump sum taxation in our framework. The proposed reform, therefore, implies efficiency losses in our setting.

Due to this limitation of our model, we do not quantify dead weight losses. Simulations from public finance, however, tend to show that the effeciency gains or losses from tax reform are small when public expenditure is kept fixed.[24] In the neoclassical framework, the best criterion to evaluate government policy is the infinite sequence of wealth equivalent changes, which measures the impact of policy on every household's welfare. That is the main evaluation criterion employed in the next section.

[24] Aurbach and Kotlikoff (1987, ch.5).

5 Simulations

5.1 The Solution Method

The model is solved numerically by using a Gauss-Seidel algorithm which iterates the first order conditions of all agents and the equilibrium conditions.[25]

The solution method requires the dynamic model to be saddle-path stable in order to yield sensible results which can be trusted. If the dynamic model contains more roots out of the unit circle than "jumping variables", then the system does not have a unique convergent rational expectation equilibrium, while in the opposite case the system does not converge. The tendency of the model to converge somewhat guarantees that the second problem is not present, but the doubt persists about the first problem.

Laitner (1990) has computed the eigenvalues in the neighborhood of the steady state for the a range of parameters of the Auerbach-Kotlikoff model. The saddle-path condition is always satisfied. Because our model is a particular case of the Auerbach-Kotlikoff model, the same condition is presumably satisfied.[26]

[25]See Auerbach and Kotlikoff (1987, ch. 4) for more details on the mechanics of the algorithm. We employed an algorithm written in GAUSS which is fairly quick. A typical simulation takes about 8 minutes when the new GAUSS-386 release is employed.

[26]Our model set the consumption-leisure elasticity in the Auerbach-Kotlikoff model equal to zero, so it is a particular case. We say "presumably" because Laitner (1990) did not study our particular parameter choice.

5.2 Income Taxation and Debt Financing

What is the impact of the social security reform described in the previous section on real macroeconomic variables and capital accumulation? Perhaps the biggest confusion regarding these issues comes from the fact that the introduction of a pay-as-you-go system when there is none causes a large crowding out of the capital stock and capital formation. For instance, Auerbach and Kotlikoff (1987, ch 10) compute for the U. S. economy that the introduction of such a program crowds out long-run capital by 24%. The reason for the crowding out is fairly obvious. The introduction of such a program represents a large transfer from those who save (the young) to those who dissave (the old). The same simulation referred above shows that the welfare of the old improves by 60% of their remaining lifetime resources and worsens all future generations by 6% each.

There is now doubt that a symmetric reversal, that is abolishing the system (defaulting on pensions), would increase the saving rate and long-run capital. Although we are concerned here with a fairer switch, it is interesting as a benchmark to study the quantitative results of such a reversal which includes both defaulting on pensions and reducing the social security tax to zero.

The macroeconomic results are provided in Tables 2a and 2b (γ equal to 1.2 and 0.7 respectively), and the welfare effect in Figure 2. Both Tables show a reduction in the interest rate through time, an increase in the capital-output ratio, an increase in the investment (and saving) rate and temporary increase in output growth.

The reasons for these "positive" real effects to happen are depicted in Figure 2. The horizontal axis indexes the cohorts, being cohort 1 the oldest of all in period 1. It is convenient to think of the index as the year in which the individual dies. Generations index 56 and higher in Figure 2 are not yet born as of period 1. As we can see, all individual retired at period 1 (households index 1 to 11 in Figure 2) suffer a loss between 9 to 13% of their remaining resources. All active workers older than 45 years old also lose (cohorts index 12 to 30 in Figure 2) while younger and future generations gain. Future generations are better off by 6 to 8% of their lifetime resources. The policy is a large transfer program from the elderly to young and future generations. Hence the result is capital accumulation.[27] We rule out, however, such a policy as an effort should be done to compensate the losers. That is the purpose of the recognition bond.

Now we simulate the implications of switching to a fully funded system with the recognition bond as described in the previous section, and with the three cases for financing.

[27] The magnitude of the losses to the elderly contrast with the gains reported above for the U.S. when the unfunded system was introduced (the dual simulation). This can be traced to the different parameters in our model. Mainly, our high intertemporal elasticity, along with the other parameters of the calibration, results in a much bigger amount of voluntary savings accumulated for retirement purposes. The default on pensions does not reduce elderly's wealth very dramatically. The apparently low impact on long-run capital-output ratio is also associated to our much higher share of capital on income (which causes capital and output to move closer) and to the nature of the fiscal policy. Keeping debt and public expenditure as a fixed proportion of output means that debt and public expenditure grow faster together with output, which lowers the impact on output further.

Case 1, Income Financing. Table 3a, 3b and Figure 3 show the results when the transition is financed with income taxes and debt is kept at a fixed proportion of GDP after the initial issue. National debt, therefore, jumps from 25% to 45 or 37% of GDP (resp. γ 1.2 or 0.7). The income tax must increase by about 3 percentage points to finance current pensions and the higher interest bill, to go down later as the social security deficit disappears by the year 11. The increase in taxes affects slightly the investment rate, as households face a lower post-tax interest rate, although the growth rate, capital-output ratio and interest rate are virtually unaffected. Figure 3 depicts the intergenerational distribution picture. We can see that retirees and older workers loose up to 2% of their wealth and future generations gain between 2 to 3.5% of their wealth equivalent. Older workers and retirees have a high proportion of their wealth in assets and therefore they are more vulnerable to the increase in income taxation. They do not obtain enough compensation from the fact that now the social security tax is no longer a tax but a deposit, which pays market rates. Younger workers and future generations do gain from the latter effect. Of course, part of the intergenerational impact do depend on the arbitrary nature of formulae (15)–(16) which compute the recognition bond. However it is interesting to remark that the effects are not too big, specially when γ is 1.2.[28]

[28]The general pattern here and later is that the intergenerational effect is higher when γ is 0.7 than when it is 1.2. The reason is that level of the interest rate is 4 percentage points higher in the former case. The difference between interest rate and the economy growth is important for the wealth impact of formulae (15)–(16).

Case 2, 10-Years Debt Financing. Tables 4a and 4b show that capital is considerable crowded out in the long-run when the transition is financed for 10 years with national debt. The capital-output ratio goes down 3 points in the long-run (30% of GDP). The national debt goes from 25 to 85% of GDP. Figure 4 show that future generations loose between 7 and 13% of their wealth equivalent, mainly because the income tax jumps by 7% in the long-run. Retirees' welfare, on the contrary (cohorts 1 through 11 in Figure 4) is unaffected because the debt-financing allows the economy to keep the income tax fixed, shielding their assets, while the consequences of such large debt issue is not felt until after they die. Currently active workers also gain marginally (cohorts 12 through 55 in Figure 4), showing that the negative effect from too much debt financing may take long to show up.

Case 3, Financing Social Security Deficit with Debt and the Remaining Budget with Taxes. Tables 5a and 5b show the macroeconomic effect of an intermediate mix between income tax and debt financing. Now the government only finances the payment of pensions to current retirees with national debt, and the rest of the budget with taxes. The social security deficit represents about 2.2% of GDP in year 1 and goes to zero by year 11. This can be corroborated by the rate at which the debt-GDP ratio increases in the Tables 4a and 4b. The impact of the reform on capital accumulation is in between the virtual neutrality of Case 1 and the greater impact of Case 2. The intergenerational impact is shown in Figure 5. We can see that this case represents a more neutral position regarding intergenerational distribution than Case 1. We can see that the range of intergenerational distribution is less than 1% in Figure 5, while it is more than 1.5% in Figure 3 (both for γ 1.2).

Now we are interested in learning the consequences of deviating from the recognition bond formulae (15)–(16). Specifically we want to quantify the consequences of paying the market interest rate on the recognition bond instead of the rate of growth of the economy (up to the retirement age). The results are in Tables 6a-b and in Figure 6 when the transition is financed with income taxes, so we can compare this effects with Tables 3a-b and Figure 3 to assess the net impact. Now national debt jumps much more (to 83 or 75% of GDP for γ 1.2 and 0.7 respectively), which implies a higher income tax, crowding out of capital through time, reducing investment rate, higher interest rate, and a temporary reduction in output growth on impact of about 4 point of a percent. This results contrast with the neutrality results from Tables 3a-b. The welfare effects in Figure 6 are as expected. Most active workers gain (actual ages 28 to 61, or cohort index 48 to 15 in Figure 6) as their past contributions receive implicitly the market return instead of the rate of growth of the economy which the old system pays (Proposition 1). The retirees losses can reach up to 4% of their wealth equivalent, and future generations may lose up to 10%. This result show that formulae (15)–(16) could be fairly accurate when the recognition bond pays the rate of growth of the economy (Figure and

Tables 3), but they could be very distabilizing if the market rate is paid for the bonds (Figure and Tables 6).

5.3 Tax Incentives to Pension Funds

In the previous section the funds, deposited in special accounts for retirements and any other voluntary saving account have no meaningful differences. In fact, we did not compute the volume of savings in the form pension funds and did not keep track of the social security contribution rate of the new system. That because the results are unchanged when the accounts are identical. In this section however, we deviate from that assumption and differentiate the saving accounts in a fundamental way: tax incentives in the direction of consumption taxation.

Consider the following 2 period example to see how tax incentives to saving accounts can be equivalent to consumption taxes. Suppose that individuals maximize a value function of present and future consumption subject to the constraints

$$A_2 = w_1 - c_1 - F_2 - \tau(w_1 - F_2) \tag{19}$$

$$c_2 = w_2 + (1+r)(A_2 + F_2) - \tau[w_2 + rA_2 + (1+\tilde{r})F_2] \tag{20}$$

where A_2 is a voluntary saving account (the subscript stands for beginning of period) which cannot be deducted from income taxes in period 1 and that pays taxes on interest income on period 2; and F_2 is a special account which is deductible from income taxation in period 1 but pays taxes on both principal and interest in period

2. Let us think of F_2 as pension contributions in period 1, and $(1+r)F_2$ as taxable pensions (second period pension in this defined-contribution scheme is $(1+r)F_2$). In the previous section we only considered savings type A_2, which pay a post-tax marginal return equal to $[1+r(1-\tau)]$. In the case of F_2 the marginal return is equal to $(1+r)$ due to the fact that this account allows individuals to reduce today's consumption in $(1-\tau)$ units and obtain a return next period of $(1-\tau)(1+r)$.

To see why this tax incentive moves in the direction of consumption taxation, assume that A_2 is zero, that is all saving is subject to this tax incentive. Rearranging, (19) and (20) we can express both equations as

$$F_2 = w_1 - c_1/(1-\tau) \tag{21}$$

$$c_2/(1-\tau) = w_2 + (1+r)F_2 \tag{22}$$

which lead to

$$c_1/(1-\tau) + \frac{c_2/(1-\tau)}{1+r} = w_1 + \frac{w_2}{1+r} \tag{23}$$

An alternative way to give tax incentives would be not to allow deductibility in period 1 and not to tax pensions in period 2. The two expressions (19)–(20), again assuming $A_2 = 0$, can be expressed as

$$F_2 = w_1(1-\tau) - c_1 \tag{24}$$

$$c_2 = w_2(1-\tau) + (1+r)F_2 \tag{25}$$

Combining the two equations above again we can obtain (23). This second alternative, however, would imply lower revenue than the previous one for the same saving and tax rate. The reason is that the second alternative is equivalent to wage taxation which has a smaller base than consumption.[29] Without leisure, wage taxation is also non-distortionary (that is why we can obtain 23). The two alternatives, however, are not identical when transitional considerations are taking into account. As we will see in this section, they have different transitional impact on the government budget and across generations.

There is a final aspect of our exercise that must be clarified. In our case, F_2 are actually forced savings and the volume of pension funds cannot be chosen by individuals in the margin.[30] In the margin the individual saves in accounts type "A", which means that it is important the income tax rate for their saving decisions. This latter aspect, together with the different base for the two alternatives, have important implications when it comes to the question of choosing between the two alternatives.

Table 8a-b and Figure 8 compare the two options to give tax incentives to pension funds. We do the comparison only for γ equal to 1.2, and for the government

[29] Labor share in income is 50%, lower than consumption.

[30] In our perferct foresight setting without term structure of the interest rate savings type "A" and savings type "F" would not be both held voluntarily due to the tax incentive to the second. In a more realistic setting the tax incentive could represent the premium for longer term holdings. However, the financial system would be strained if pension funds were absolutely voluntary. That is why there is normally a cap to the maximum volume of contributions. That is the case in Chile.

financing policy case 3 above (the social security deficit and the initial issue of "recognition bonds" is financed with national debt). The simulations assume a contribution rate of 0.3% of labor income. The reasons to choose a low contribution rate are two. First, the higher the contribution rate the longer is the period of convergency to the steady state what complicates the simulation. Second, the difference between the rate of growth of the economy and the interest rate is about 8 percentage points, what makes that a higher contribution rate increase substantially the rate at which pension funds are accumulated.[31] However, the qualitative results of these simulations are robust to this choice.

Comparing the two Tables 8a and 8b regarding the capital-output ratio we can see that the second alternative (no deductibility and pensions exempt) is worse in the long-run. In this case the capital output ratio goes down to 3.48 (from 3.62). When contributions are deductible and pensions taxable, the long-run capital-output ratio only is reduced to 3.54. New pension funds increase to stabilize at about 40% of GDP and new pensions at about 4%. The most interesting result is that the option that does not allow deductibility of contributions converges to a higher income tax in the long run, which of course disincentive (marginal) savings in the long-run. The reason, as we mentioned above, is that this option is actually closer to wage taxation which has a lower base than consumption taxation (50% of GDP against

[31] In part this is due to the unrealistic exclusion of depreciation in our model.

75%). Allowing contribution deductibility means a higher base in the long-run and therefore a lower rate of income tax is needed. However in the very short-run the opposite is true. Allowing deductibility of contribution reduce the base on impact by the amount of the contributions, while the government must wait the retirement period to tax pensions.[32]

Another independent explanation for the capital accumulation results on Tables 8a and 8b is related to intertemporal substitution and the private saving rate. As we can see in the Tables, consumption on impact is higher when we do not allow deductibility (and do not tax pensions) than when we allow deductibility (and pensions are exempt). The reason is that if agents can foresee that the tax rate is increasing more in the future, they would increase more consumption today to offset the higher income tax in the future. With contributions deductibility the path of income tax is flatter and therefore the consumption te (saving rate) is lower (higher).

The picture on intergenerational distribution is depicted in Figure 8. With deductibility future generations loose less than 1% while they lose about 2.5% with no deductibility. Generations close to retirement prefer pensions exempt as they will not work long enough to take advantage of the tax deductibility and they will have to pay taxes on pensions soon. The opposite is true for those just entering the

[32]This effect is negligible in our simulation due to the very low contribution rate used. This effect, however, is potentially an important one in the short run when contributions to pension funds are higher.

labor force.

Finally it is interesting to compare the results between Tables 7a (tax incentives to pension funds with deductibility of contributions) and Table 5a (no tax incentives). It is hard to argue in favor of tax incentives when looking at these tables. There seem to be no benefit in terms of the capital accumulation front, and no clear gain in the distributional front. This conclusion could be biased, however, by the character of the simulation. If the government were able to choose in period 1 a fix income tax that equilibrates the intertemporal budget constraint, the benefit of tax incentives to pension funds could be more apparent.

6 Conclusions

The paper examines in a neoclassical dynamic simulation model the macroeconomic and intergenerational distribution impact of switching from the pay-as-you-go social security system to a funded individual accounts system. The reform was carried out in Chile in 1980, and it has spawned much debate regarding the saving and capital accumulation impact.

The model was calibrated with data from Mexico, although its results are relevant to many developing economies.

The main results of the paper are summarized as follows.

a) Comparing our three cases to finance the transition to a fully-funded system we can rank the performance of the cases regarding capital accumulation from better to worse depending on the magnitude of national debt issued to finance the transition. The extreme case of no new issues (defaulting on pensions) yields substantial capital accumulation (Tables 2). The more reasonable cases of income tax financing, social security deficit financed with debt and 10-years debt financing rank from better to worse in that order (Tables 3, 5 and 4 resp.).

b) The capital accumulation criterion, however, is misleading.[33] It hides the true force driving the capital formation effect which is intergenerational distribution against the elderly. As we can see in Figure 7, the same three cases explained above (excluding defaulting on pensions) rank from worse to better regarding the welfare effect on the elderly (indexes 1 through 21 in Figure 7 represent cohorts 75 through 55 years old at the moment of the reform).

c) The formula applied in Chile to recognize past contributions could be fairly accurate to minimize intergenerational distribution and real effects of the reform. The formula to compute the recognition bond relates linearly the cost of a unitary annuity, the years of contributions to the old system and the workers earnings at the moment of the reform. The bond bears an interest equal to the (long-run) rate of growth of the economy up to the year of retirement. Our results also show that

[33]This is not necessarily true in the context of permanent or temporary demographic transition. In those cases make the most sense to accumulate capital to finance a larger proportion of retirees in the future (permanent), or the pensions of an unusually large cohort like a baby-boom generation (transitory). See Aaron et. al. (1989) for an study of the latter case applied to the U. S.

paying market interest rate for the bond could lead to sizable crowding out of capital and large intergenerational distribution against retirees and future generations.

d) Bearing in mind that perhaps the best way to evaluate the reform of an intergenerational arrangement like the pay-as-you-go system is to minimize intergenerational distribution, the best transitional financing scheme requires to issue national debt for the recognition bonds and to finance the transitional social security deficit with national debt. The deficit arises because the governm . loses the income from contributions and must pay pensions to those retired at the moment of the reform. The interest bill on new debt, however, requires new taxes.

e) Finally we explore the effect of tax incentives to pension funds. Two alternatives which increase the return of savings on pension funds are studied: i) social security contribution are deductible from income tax and pensions are taxable; ii) contributions are not deductible and pensions are exempt. The exercise provides interesting results. Both cases have different implications regarding total revenue in the long-run. Option i) has a higher taxable base than option ii). Both alternatives provide revenue at different moment in time; option ii) provides revenue earlier than option i). Our simulation results suggest that the long-run revenue advantage of alternative i) seems to favor this case. Option i) also provides a flatter path of income tax during the transition which is important to avoid substitution of future consumption by present consumption. The result however requires further exploration in order to be robust.

There are certainly many reasons at the microeconomic level to assess positively the proposed reform. The paper shows that capital accumulation is not one of them, at least in the context of the neoclassical model described here. Capital accumulation would indicate that important redistribution against those who disave (the elderly) has occurred.

Perhaps if the most important benefit of this reform, which cannot be studied in this setting, is the support it provides to the consolidation of a healthy financial system. The social security contribution of a 21 year old worker in a fully-funded individual-account system is a 45-year deposit, more than useful in a developing economy. This aspect certainly deserve to be explored in future research.

Appendix: Proof of Proposition 1

For the sake of a clearer exposition, we prove the proposition for household age 1 at year 1 so we keep track of only one index for both age and year. The generalization is straightforward.

We want to know the discount factor R such that the present value of contributions and benefits is equal. So

$$\sum_{s=1}^{45} \frac{\tau \bar{w} e_s^s}{R^{i-1}} = \sum_{s=46}^{55} \frac{p_s^s}{R^{i-1}} \tag{A.1}$$

where $\bar{w}$ is the wage in efficiency units, which is fixed in a stationary steady state equilibrium, and the other variables are defined in the text.

Due to the assumptions on section 2.4, we can express the longitudinal profiles of human capital and pensions in terms of the cross section profile in period 1. Therefore $e_s^s = e_1^s(1+x)^{s-1}$ and $p_s^s = p_1^s(1+.\ )^{s-1}$ (see also equation 14). Substituting in (A.1), multiplying every number in (A.1) (numerator and denominator) by $(1+n)^{1-s}$ and rearranging terms, we can express (A.1) as

$$\sum_{s=1}^{45} \frac{\tau \bar{w} e_1^s (1+n)^{1-s}}{R^{s-1}[(1+n)(1+x)]^{1-s}} = \sum_{s=46}^{55} \frac{p_1^s (1+n)^{1-s}}{R^{s-1}[(1+n)(1+x)]^{1-s}} \qquad \text{(A.2)}$$

From (A.2), for $R = (1+n)(1+x)$, the LHS of (A.2) is τW_1, where W_1 is the economy's wage bill in year 1. The RHS of (A.2) is P_1, that is total pensions paid in year 1. From (12), we can see that LHS and RHS of (A.2) are equal in an equilibrium.

Because all terms in the numerator of expression (A.2) are positive, it must be true that for $R > (1+n)(1+x)$ the LHS is greater than the RHS in (A.2), and the opposite is true for $R < (1+n)(1+x)$. Therefore, (A.1) holds in equilibrium only when $R = (1+n)(1+x)$. Q.E.D.

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Table 1: Pay-as-you-go Sysytem: Steady State Sensitivity Analysis

Parameters							
Gamma	Popul. rat.(%)	Replac. rate	K/Y	Income tax (%)	Social Security tax (%)	Invest. rate (% GDP)	Interest rate (%)
1.2	1	0.3	3.74	13.1	2.6	11.3	13.4
1.2	1	0.7	3.69	13.2	5.8	11.1	13.6
1.2	2	0.3	3.66	13.0	2.0	14.8	13.7
1.2	**2**	**0.7**	**3.61**	**13.0**	**4.4**	**14.6**	**13.8**
1.2	3	0.3	3.58	12.8	1.5	18.1	14.0
1.2	3	0.7	3.54	12.8	3.3	17.9	14.1
0.7	1	0.3	2.91	13.9	2.6	8.8	17.2
0.7	1	0.7	2.86	14.0	5.8	8.6	17.5
0.7	2	0.3	2.82	13.8	1.9	11.4	17.7
0.7	**2**	**0.7**	**2.78**	**13.9**	**4.4**	**11.2**	**18.0**
0.7	3	0.3	2.73	13.7	1.4	13.8	18.3
0.7	3	0.7	2.69	13.7	3.4	13.6	18.5
(Delta = 0.03)							
1.2	2	0.7	5.20	12.1	4.5	21.0	9.6
0.7	2	0.7	3.78	12.9	4.5	15.3	13.2
0.3	2	0.7	1.81	15.8	4.3	7.3	27.7

Note: Base case parameters are gamma, 1.2 and 0.7; delta, 0.07; population growth, 0.02; replacement rate, 0.7; government consumption, .09; national debt ratio, .25; trade surplus, 0.02; productivity growth, 0.02; beta, 0.50. By construction the saving rate is equal to the investment rate plus the 2 percentage points of the trade surplus (see text).

Table 2a: Defaulting on Pensions (Gamma = 1.2)

Year	Interest rate (%)	Capital output ratio	Investment rate (% GDP)	Income tax (%)	GDP growth (%)	National debt (% GDP)	Wealth equiv. (%)
0	13.83	3.62	14.61	13.00	4.04	25.0	-
1	13.83	3.62	16.25	12.94	4.04	25.0	0.0
2	13.80	3.62	16.21	12.94	4.27	25.0	-9.2
3	13.77	3.63	16.17	12.94	4.26	25.0	-9.5
4	13.74	3.64	16.12	12.93	4.25	25.0	-9.8
5	13.72	3.64	16.07	12.93	4.23	25.0	-10.1
6	13.69	3.65	16.01	12.93	4.22	25.0	-10.5
7	13.67	3.66	15.94	12.93	4.21	25.0	-10.9
8	13.65	3.66	15.87	12.93	4.20	25.0	-11.2
9	13.63	3.67	15.78	12.93	4.19	25.0	-11.7
10	13.61	3.67	15.68	12.93	4.17	25.0	-12.1
15	13.56	3.69	15.26	12.93	4.10	25.0	-7.6
30	13.52	3.70	14.94	12.93	4.04	25.0	-0.6
50	13.53	3.70	14.94	12.93	4.04	25.0	4.5
new s.s.	13.52	3.70	14.94	12.93	4.04	25.0	6.4

Table 2b: Defaulting on Pensions (Gamma = 0.7)

Year	Interest rate (%)	Capital output ratio	Investment rate (% GDP)	Income tax (%)	GDP growth (%)	National debt (% GDP)	Wealth equiv. (%)
0	18.01	2.78	11.22	13.87	4.04	25.0	-
1	18.01	2.78	12.68	13.81	4.04	25.0	0.0
2	17.97	2.78	12.65	13.80	4.30	25.0	-9.1
3	17.92	2.79	12.63	13.79	4.29	25.0	-9.4
4	17.88	2.80	12.60	13.79	4.28	25.0	-9.6
5	17.84	2.80	12.56	13.78	4.27	25.0	-10.0
6	17.80	2.81	12.52	13.78	4.26	25.0	-10.3
7	17.77	2.81	12.47	13.77	4.25	25.0	-10.7
8	17.73	2.82	12.41	13.77	4.24	25.0	-11.1
9	17.70	2.82	12.33	13.77	4.22	25.0	-11.5
10	17.67	2.83	12.24	13.77	4.20	25.0	-12.0
15	17.59	2.84	11.84	13.77	4.11	25.0	-6.9
30	17.52	2.85	11.55	13.77	4.05	25.0	0.3
50	17.52	2.85	11.55	13.77	4.04	25.0	5.4
new s.s.	17.51	2.86	11.54	13.77	4.04	25.0	7.6

Table 3a: Income Tax Financing (Gamma = 1.2)

Year	Interest rate (%)	Capital output ratio	Investment rate (% GDP)	Income tax (%)	GDP growth (%)	National debt (% GDP)	Wealth equiv. (%)
0	13.83	3.62	14.61	13.00	4.04	25.0	-
1	13.83	3.62	13.56	16.63	4.04	44.6	0.0
2	13.85	3.61	13.72	16.38	3.90	44.6	-0.4
3	13.86	3.61	13.87	16.14	3.92	44.6	-0.6
4	13.88	3.60	13.99	15.91	3.94	44.6	-0.7
5	13.89	3.60	14.10	15.68	3.96	44.6	-0.9
6	13.90	3.60	14.19	15.47	3.98	44.6	-1.0
7	13.90	3.60	14.27	15.26	3.99	44.6	-1.1
8	13.91	3.60	14.32	15.06	4.00	44.6	-1.2
9	13.91	3.59	14.36	14.87	4.01	44.6	-1.3
10	13.91	3.59	14.39	14.69	4.02	44.6	-1.4
15	13.92	3.59	14.42	14.52	4.03	44.6	-1.3
30	13.93	3.59	14.55	14.51	4.05	44.6	-0.7
50	13.91	3.60	14.56	14.50	4.05	44.6	0.7
new s.s.	13.91	3.60	14.52	14.50	4.04	44.6	2.1

Table 3b: Income Tax Financing (Gamma = 0.7)

Year	Interest rate (%)	Capital output ratio	Investment rate (% GDP)	Income tax (%)	GDP growth (%)	National debt (% GDP)	Wealth equiv. (%)
0	18.01	2.78	11.22	13.87	4.04	25.0	-
1	18.01	2.78	10.66	17.29	4.04	37.4	0.0
2	18.03	2.77	10.77	17.05	3.94	37.4	-0.5
3	18.04	2.77	10.87	16.81	3.96	37.4	-0.7
4	18.05	2.77	10.95	16.58	3.98	37.4	-0.9
5	18.06	2.77	11.02	16.36	4.00	37.4	-1.0
6	18.06	2.77	11.09	16.15	4.01	37.4	-1.2
7	18.07	2.77	11.14	15.95	4.02	37.4	-1.3
8	18.07	2.77	11.18	15.75	4.03	37.4	-1.5
9	18.07	2.77	11.20	15.56	4.04	37.4	-1.6
10	18.07	2.77	11.22	15.38	4.04	37.4	-1.7
15	18.06	2.77	11.22	15.21	4.05	37.4	-1.6
30	18.03	2.77	11.29	15.20	4.06	37.4	-0.8
50	17.99	2.78	11.27	15.19	4.05	37.4	1.4
new s.s.	17.98	2.78	11.23	15.19	4.04	37.4	3.3

Table 4a: 10 years Debt Financing (Gamma = 1.2)

Year	Interest rate (%)	Capital output ratio	Investment rate (% GDP)	Income tax (%)	GDP growth (%)	National debt (% GDP)	Wealth equiv. (%)
0	13.83	3.62	14.61	13.00	4.04	25.0	-
1	13.83	3.62	13.81	13.00	4.04	44.6	0.0
2	13.84	3.61	13.70	13.00	3.93	48.3	0.0
3	13.86	3.61	13.57	13.00	3.92	52.1	0.0
4	13.88	3.60	13.42	13.00	3.90	55.9	0.0
5	13.90	3.60	13.25	13.00	3.88	59.8	0.0
6	13.92	3.59	13.05	13.00	3.86	63.8	0.0
7	13.95	3.58	12.82	13.00	3.84	67.9	0.1
8	13.98	3.58	12.54	13.00	3.81	72.2	0.1
9	14.02	3.57	12.22	13.00	3.77	76.7	0.1
10	14.06	3.56	11.85	13.00	3.73	81.4	0.1
15	14.27	3.50	12.39	17.85	3.77	86.3	1.2
30	14.62	3.42	13.14	17.96	3.93	86.3	1.0
50	14.79	3.38	13.45	18.01	4.01	86.3	0.4
new s.s.	14.81	3.38	13.64	18.00	4.04	86.3	-7.2

Table 4b: 10 years Debt Financing (Gamma = 0.7)

Year	Interest rate (%)	Capital output ratio	Investment rate (% GDP)	Income tax (%)	GDP growth (%)	National debt (% GDP)	Wealth equiv. (%)
0	18.01	2.78	11.22	13.87	4.04	25.0	-
1	18.01	2.78	10.52	13.87	4.04	37.4	0.0
2	18.03	2.77	10.41	13.87	3.92	40.9	0.0
3	18.06	2.77	10.27	13.87	3.90	44.6	0.0
4	18.09	2.76	10.12	13.87	3.88	48.5	0.0
5	18.12	2.76	9.93	13.87	3.85	52.6	0.0
6	18.16	2.75	9.72	13.87	3.82	57.0	0.1
7	18.20	2.75	9.46	13.87	3.78	61.7	0.1
8	18.25	2.74	9.16	13.87	3.74	66.8	0.1
9	18.32	2.73	8.80	13.87	3.69	72.3	0.2
10	18.39	2.72	8.37	13.87	3.63	78.4	0.2
15	18.77	2.66	8.82	20.56	3.66	85.1	1.2
30	19.50	2.56	9.44	20.85	3.85	85.1	0.6
50	20.00	2.50	9.68	21.07	3.95	85.1	0.4
new s.s.	20.11	2.49	10.05	21.07	4.04	85.1	-12.7

Table 5a: Financing Social Security Deficit with Debt (Gamma = 1.2)

Year	Interest rate (%)	Capital output ratio	Investment rate (% GDP)	Income tax (%)	GDP growth (%)	National debt (% GDP)	Wealth equiv. (%)
0	13.83	3.62	14.61	13.00	4.04	25.0	-
1	13.83	3.62	13.57	14.45	4.04	44.6	0.0
2	13.85	3.61	13.58	14.63	3.90	46.9	-0.2
3	13.87	3.61	13.59	14.79	3.90	48.8	-0.2
4	13.89	3.60	13.61	14.93	3.90	50.5	-0.3
5	13.90	3.60	13.63	15.05	3.91	52.0	-0.4
6	13.92	3.59	13.65	15.16	3.91	53.2	-0.5
7	13.94	3.59	13.68	15.24	3.92	54.2	-0.6
8	13.95	3.58	13.71	15.31	3.93	55.0	-0.6
9	13.97	3.58	13.74	15.37	3.93	55.6	-0.7
10	13.98	3.58	13.77	15.40	3.94	56.0	-0.8
15	14.04	3.56	13.89	15.44	3.96	56.2	-0.4
30	14.12	3.54	14.17	15.45	4.02	56.2	-0.2
50	14.14	3.54	14.28	15.45	4.04	56.2	0.5
new s.s.	14.14	3.54	14.28	15.45	4.04	56.2	-0.5

Table 5b: Financing Social Security Deficit with Debt (Gamma = 0.7)

Year	Interest rate (%)	Capital output ratio	Investment rate (% GDP)	Income tax (%)	GDP growth (%)	National debt (% GDP)	Wealth equiv. (%)
0	18.01	2.78	11.22	13.87	4.04	25.0	-
1	18.01	2.78	10.53	15.16	4.04	37.4	0.0
2	18.03	2.77	10.51	15.41	3.92	39.6	-0.2
3	18.05	2.77	10.50	15.63	3.92	41.5	-0.3
4	18.08	2.77	10.50	15.82	3.92	43.2	-0.4
5	18.10	2.76	10.51	15.99	3.92	44.7	-0.5
6	18.12	2.76	10.52	16.13	3.92	45.9	-0.6
7	18.14	2.76	10.54	16.25	3.93	46.9	-0.7
8	18.16	2.75	10.55	16.34	3.93	47.7	-0.8
9	18.17	2.75	10.57	16.41	3.94	48.2	-0.9
10	18.19	2.75	10.59	16.46	3.94	48.6	-0.9
15	18.27	2.74	10.67	16.50	3.96	48.8	-0.6
30	18.39	2.72	10.86	16.53	4.01	48.8	-0.4
50	18.44	2.71	10.92	16.54	4.03	48.8	1.0
new s.s.	18.45	2.71	10.95	16.54	4.04	48.8	-0.6

Table 6a: Income Tax Financing, Market Rate for Bonds (Gamma = 1.2)

Year	Interest rate (%)	Capital output ratio	Investment rate (% GDP)	Income tax (%)	GDP growth (%)	National debt (% GDP)	Wealth equiv. (%)
0	13.83	3.62	14.61	13.00	4.04	25.0	-
1	13.83	3.62	11.43	19.49	4.04	83.3	0.0
2	13.89	3.60	11.68	19.27	3.60	83.3	-0.7
3	13.94	3.59	11.90	19.05	3.64	83.3	-1.0
4	13.99	3.57	12.10	18.84	3.68	83.3	-1.3
5	14.03	3.56	12.27	18.64	3.71	83.3	-1.6
6	14.07	3.55	12.42	18.44	3.74	83.3	-1.8
7	14.11	3.54	12.53	18.25	3.77	83.3	-2.1
8	14.15	3.53	12.63	18.07	3.79	83.3	-2.3
9	14.18	3.53	12.69	17.90	3.81	83.3	-2.4
10	14.21	3.52	12.73	17.74	3.82	83.3	-2.6
15	14.35	3.49	12.79	17.63	3.85	83.3	-0.6
30	14.65	3.41	13.14	17.75	3.94	[illegible].3	3.4
50	14.75	3.39	13.83	17.73	4.06	83.3	-1.0
new s.s.	14.74	3.39	13.71	17.73	4.04	83.3	-6.6

Table 6b: Income Tax Financing, Market Rate for Bonds (Gamma = 0.7)

Year	Interest rate (%)	Capital output ratio	Investment rate (% GDP)	Income tax (%)	GDP growth (%)	National debt (% GDP)	Wealth equiv. (%)
0	18.01	2.78	11.22	13.87	4.04	25.0	-
1	18.01	2.78	8.68	21.19	4.04	75.4	0.0
2	18.09	2.76	8.85	20.99	3.58	75.4	-1.0
3	18.16	2.75	9.00	20.79	3.62	75.4	-1.5
4	18.23	2.74	9.14	20.59	3.65	75.4	-1.9
5	18.29	2.73	9.25	20.41	3.69	75.4	-2.3
6	18.35	2.72	9.35	20.22	3.71	75.4	-2.6
7	18.41	2.72	9.42	20.05	3.73	75.4	-2.9
8	18.46	2.71	9.48	19.88	3.75	75.4	-3.2
9	18.50	2.70	9.51	19.73	3.77	75.4	-3.4
10	18.55	2.70	9.52	19.58	3.78	75.4	-3.7
15	18.78	2.66	9.46	19.53	3.79	75.4	-1.2
30	19.34	2.58	9.63	19.77	3.88	75.4	3.6
50	19.62	2.55	10.37	19.80	4.05	75.4	-1.4
new s.s.	19.63	2.55	10.29	19.82	4.04	75.4	-9.7

Table 7a: Tax incentives to Pension Funds: Contributions Deductible, Pensions Taxable (Gamma = 1.2, Contribution rate = 0.3%)

Year	Interest rate (%)	Capital output ratio	Private Consump. (% GDP)	Income tax (%)	National debt (% GDP)	Pension Funds (% GDP)	New Pensions (% GDP)
0	13.83	3.62	74.39	13.00	25.0	0.00	0.00
1	13.83	3.62	75.71	14.87	44.6	19.63	0.00
2	13.85	3.61	75.68	15.05	46.9	21.66	0.25
3	13.87	3.60	75.65	15.22	48.8	23.61	0.49
4	13.90	3.60	75.61	15.36	50.5	25.47	0.74
5	13.92	3.59	75.56	15.47	52.0	27.23	0.99
6	13.94	3.59	75.52	15.57	53.2	28.88	1.24
7	13.96	3.58	75.47	15.64	54.2	30.40	1.49
8	13.97	3.58	75.42	15.70	55.0	31.79	1.74
9	13.99	3.57	75.38	15.74	55.6	33.03	1.99
10	14.00	3.57	75.34	15.75	56.0	34.11	2.24
15	14.07	3.55	75.21	15.76	56.2	37.63	2.82
30	14.17	3.53	74.87	15.70	56.2	41.94	3.80
50	14.19	3.52	74.76	15.70	56.2	39.06	3.45
new ss.	14.19	3.52	74.76	15.70	56.2	39.12	3.47

Table 7b: Tax incentives to Pension Funds: Contributions not Deductible, Pensions Exempt (Gamma = 1.2, Contribution rate = 0.3%)

Year	Interest rate (%)	Capital output ratio	Private Consump. (% GDP)	Income tax (%)	National debt (% GDP)	Pension Funds (% GDP)	New Pensions (% GDP)
0	13.83	3.62	74.39	13.00	25.0	0.00	0.00
1	13.83	3.62	75.98	14.86	44.6	19.63	0.00
2	13.86	3.61	75.98	15.10	46.9	21.67	0.29
3	13.89	3.60	75.97	15.31	48.8	23.63	0.58
4	13.91	3.59	75.95	15.49	50.5	25.50	0.87
5	13.94	3.59	75.93	15.66	52.0	27.28	1.17
6	13.97	3.58	75.90	15.81	53.2	28.95	1.47
7	13.99	3.57	75.87	15.94	54.2	30.50	1.77
8	14.01	3.57	75.85	16.04	55.0	31.91	2.07
9	14.04	3.56	75.82	16.13	55.6	33.19	2.37
10	14.06	3.55	75.80	16.20	56.0	34.30	2.67
15	14.16	3.53	75.63	16.34	56.2	38.04	3.39
30	14.33	3.49	75.17	16.50	56.2	43.19	4.66
50	14.37	3.48	74.96	16.45	56.2	40.89	4.34
new ss.	14.37	3.48	74.95	16.45	56.2	41.06	4.39

Figure 1a: Cross-Section Profile of Earnings

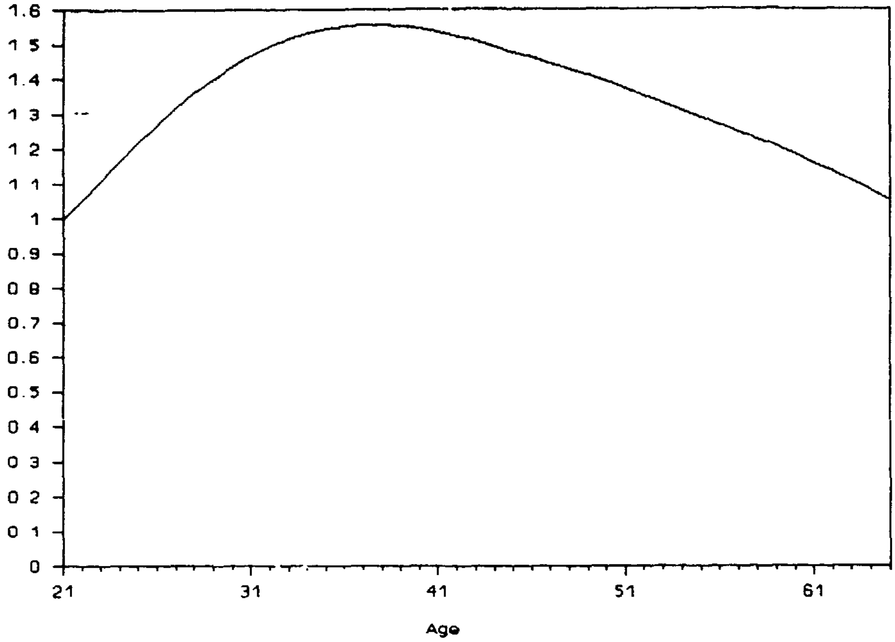


Figure 1b: Longitudinal Profile of Earnings and Pensions

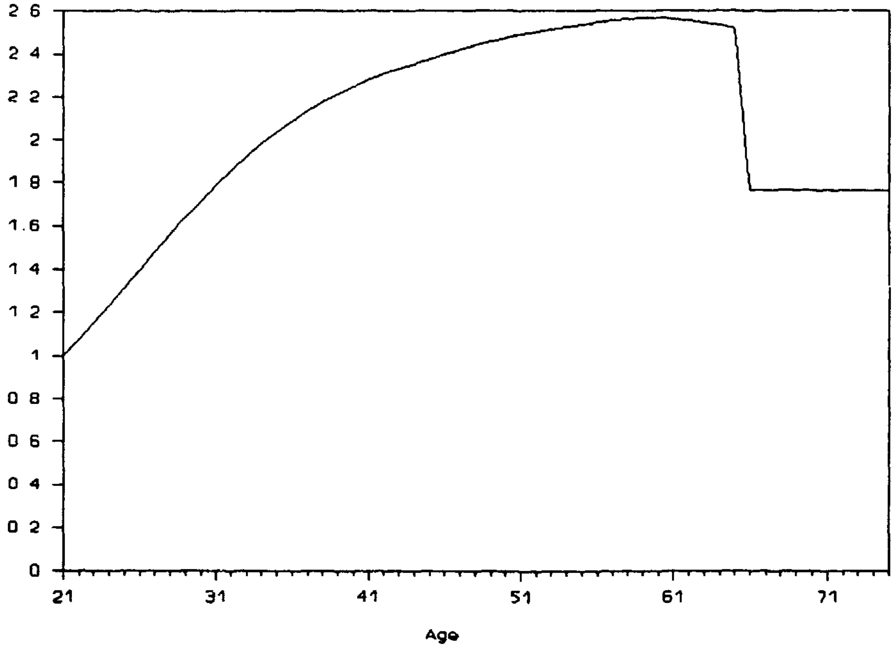


Figure 2: The Welfare Effects of Defaulting on Pensions (wealth equivalent, %)

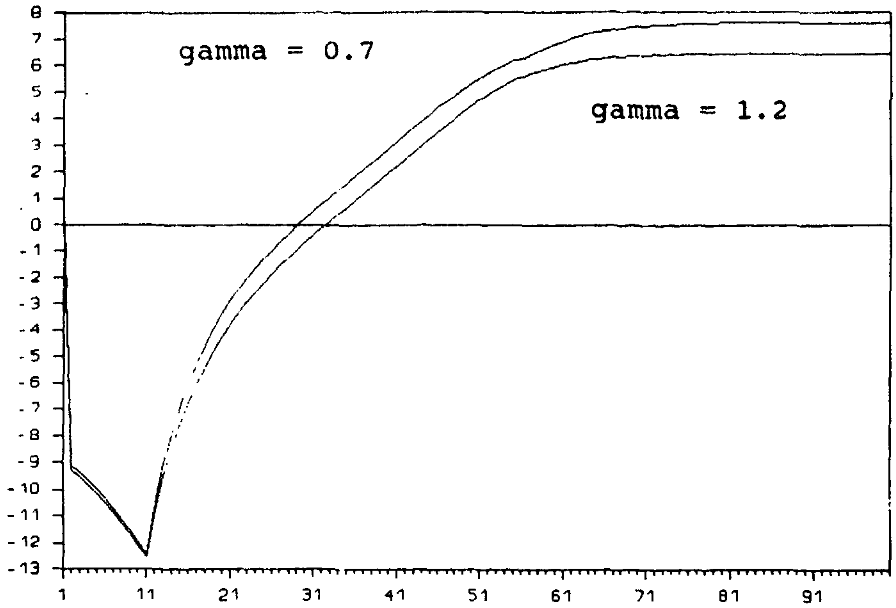


Figure 3: The Welfare Effects of Income Tax Financing (wealth equivalent, %)

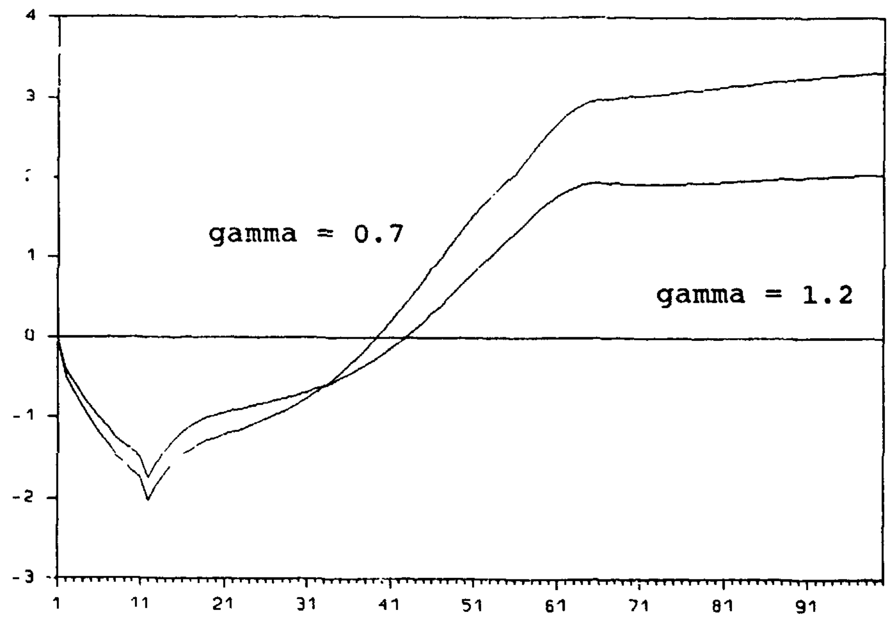


Figure 4: The Welfare Effects of 10-Years Debt Financing (wealth equivalent, %)

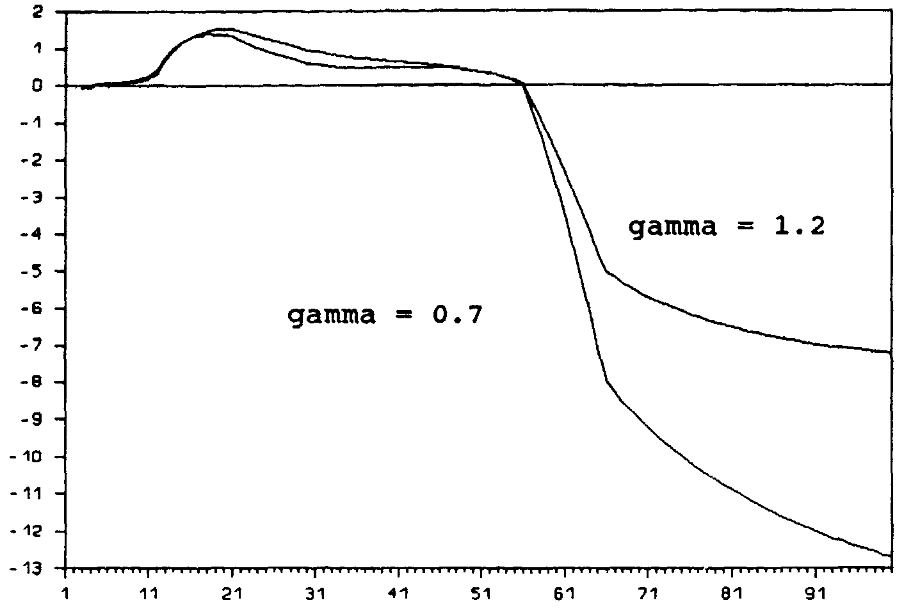
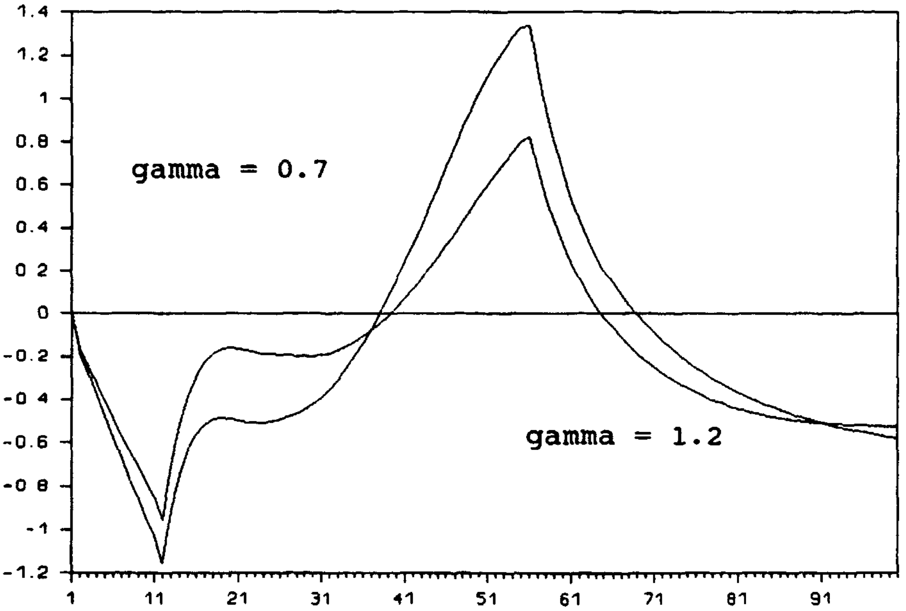
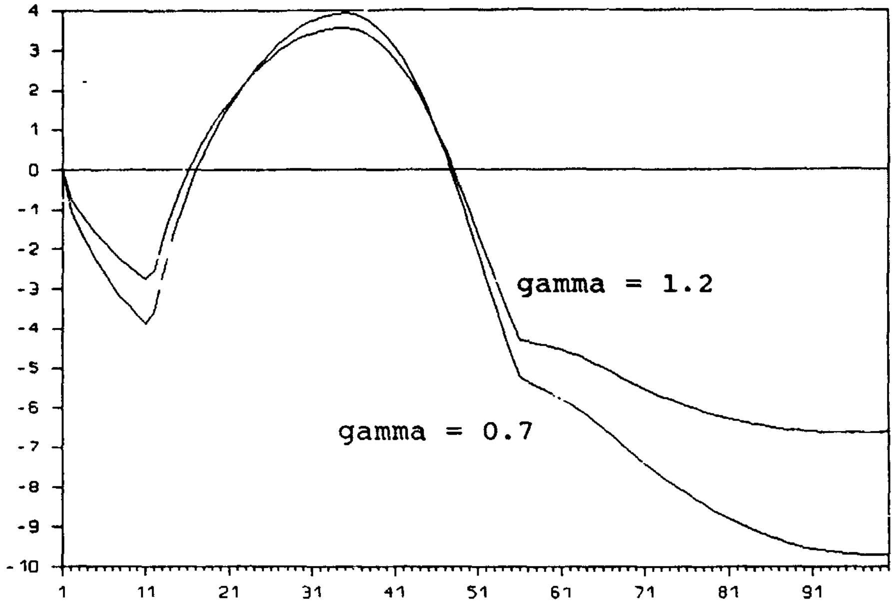


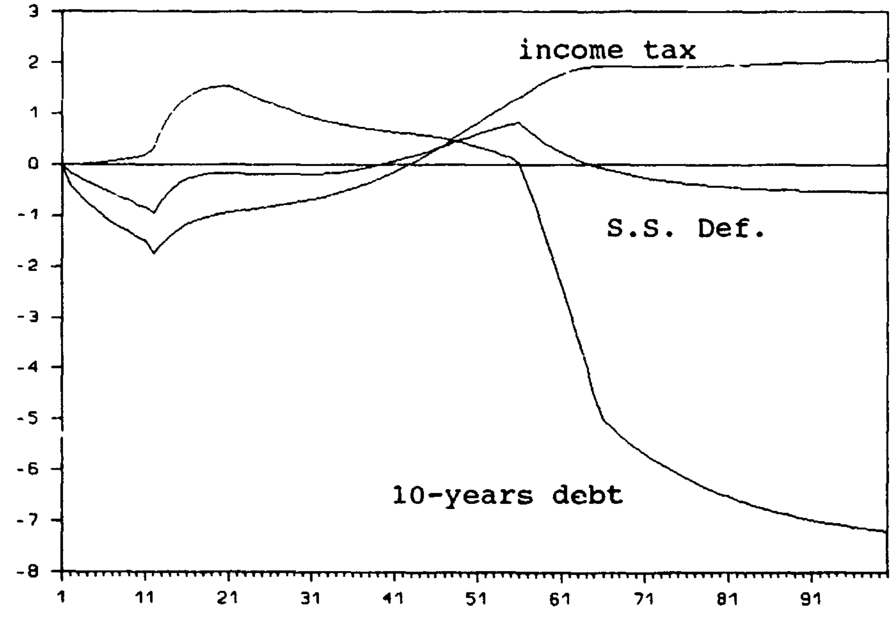
Figure 5: The Welfare Effects of Financing the Social Security Deficit with Debt (wealth equivalent, %)



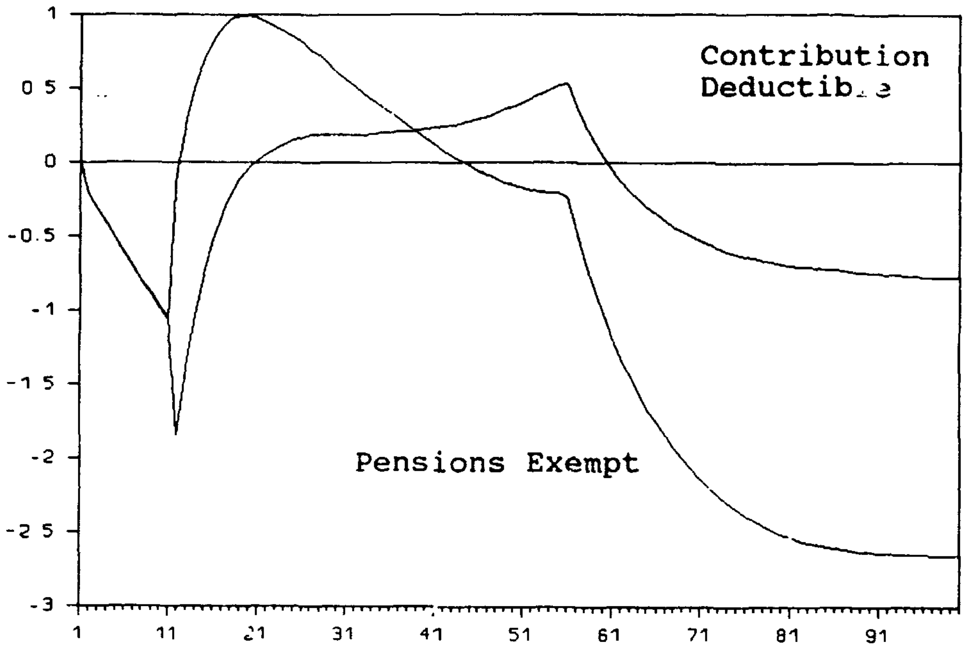
<u>Figure 6:</u> The Welfare Effects of Paying Market Interest Rate on Bond, Income tax Financing (wealth equivalent, %)



<u>Figure 7:</u> Comparing the Welfare Effects of the Three Base Cases for Gamma = 1.2 (wealth equivalent, %)



<u>Figure 8:</u> The Welfare Effect of Tax Incentives to Pension Funds (Gamma 1.2).



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