ALTERNATIVE SOCIAL SECURITY ARRANGEMENTS AND THE DISPERSION OF INCOME HISTORIES ACROSS GENERATIONS: THE SMALL-OPEN ECONOMY CASE

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Abstract - We develop an OLG model of a small-open economy (SOE) subjected to volatile international interest rates to study how different degrees of capitalization in the social security (SS) system may affect the dispersion of income histories across generations. Given some simplifying assumptions, we show that retirees and workers are affected in opposite directions by international shocks, and that alternative SS arrangements can play a role in lessening the dispersion of income across generations by affecting the exposure of agents to age-specific risks.

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INTRODUCTION

The worldwide phenomenon of demographic transition has led an increasing number of researchers and policy-makers to develop sound interest on the economic effects of alternative SS systems. As a result, an enormous and multi-faceted literature has been produced, delineating a research agenda that cuts across different fields within Economics. One topic that has received particular attention concerns the distributional implications of alternative SS arrangements, and this paper develops a stylized overlapping generations model addressing this issue in the context of a SOE.

Critics of the pay-as-you-go (PYG) regime often point out its conduciveness to distortionary taxation, depressed savings, and unbalanced fiscal positions; while supporters emphasize its benefits as a tool for management of idiosyncratic risks – see Shiller (1998). Such risks may assume the form of volatile earnings profile, uncertain life span, accidental loss of working capacity, premature loss of parents, or others. Building on the importance of PYG schemes as an insurance device, this paper deals with a type of shock that is cohort-specific and particularly important in SOE.[2]

We use a simple OLG model of a SOE in which agents live for two periods. In the first period the individual works and saves for retirement, while in the second period they must exit the workforce A key property of our model stems from the SOE assumption, which essentially causes the domestic capital stock to fluctuate in response to changes in the international interest rate. As noted by Storesletten, Telmer and Yaron (1999), the risk-sharing feature of PYG schemes stands out in the absence of "general equilibrium effects" linking savings to capital accumulation (which is the case in a SOE). While their paper features intra-generational heterogeneity, we suggest that volatile international interest rates in a SOE may be seen as giving rise to cohort heterogeneity.

In a frictionless world of neoclassical production functions a decrease in the international interest rate immediately leads to higher capital stock, higher wages and lower current return on savings. We draw upon this simplified setup to isolate an intuitive age-specific risk: a lower international interest rate increases the income of current workers via higher wages and decrease the income of retirees via lower return on their accumulated savings. With that in mind, we study different parameterizations of our model capturing how alternative SS arrangements may affect the dispersion of income across generations experiencing different interest rate shocks.

The paper is organized as follows. Section 2 presents the model. Section 3 describes the simulation exercise and section 4 presents the results. The last section discusses future extensions of the model.

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[2] Some proponents of PYG schemes also claim that market failures calls for government-run SS programs. An early paper of Merton (1983) illustrates this point in a model where missing markets for human capital generates economic inefficiencies that can be corrected through a mandatory transfer system.

2. THE MODEL

The economic environment is characterized by overlapping generations living in a small-open economy. Each generation remains alive for two periods and there is no bequest motive or population growth. Fluctuating international interest rates constitutes the source of randomness in the model.

2.1 Household

At any point in time, the newborn agent maximizes his expected utility by solving the following problem:

$$\underset{c_1,c_2}{Max} \sum_{j=1}^{2}\sum_{i=1}^{2} \beta^{i-1}(1-\sigma)^{-1} c_i^{1-\sigma}\pi_j \qquad (1)$$

Subject to

$$c_1 + s_1 = (1-\tau_1^{ss})w_1 \qquad (2)$$

$$c_2 = (1+r_2)s_1 + TR_2 \qquad (3)$$

Where

$$r_2 = r^{low} \ with \ prob \ \pi_1 \ and \ r_2 = r^{high} \ with \ prob \ \pi_2, \ \pi_1 + \pi_2 = 1 \qquad (4)$$

The variable c denotes consumption, s savings, τ_1^{ss} the social security payroll tax, w the wage, r the (international) interest rate, and TR the social security benefits. We keep track of the agent's age through the subscripts 1 (young) and 2 (old). Additionally, the international interest rate is an identically and independently distributed random variable taking two possible values with probabilities given by π_1 and π_2. We assume perfect capital markets so that agents face no frictions in reshuffling resources between periods.

2.2 Firms

We assume constant returns to scale technology and perfectly competitive markets so that the firm's maximization problem can be portrayed as the following static one.

$$\underset{K(t),L(t)}{Max} \ A(t)K(t)^{\alpha}L(t)^{1-\alpha} - w(t)L(t) - r(t)K(t) \qquad (5)$$

Where A is a technological parameter (which we assume to be fixed), K is capital input, L is labor input, and α denotes the factor shares. The variable t indexes time. Unlike the household problem, we do not need to keep track of the firm's age.

Optimality implies that the marginal product of labor must be equal to the wage, and that the marginal product of capital must equal its rental cost. Working with the intensive form of the production function above, one can show that the first-order conditions of the problem yield:

$$(1-\alpha)A(t)k(t)^{\alpha} = w(t), \quad k(t) = K(t)/L(t) \qquad (6)$$

$$A(t)\alpha k(t)^{\alpha-1} = r(t), \quad k(t) = K(t)/L(t) \qquad (7)$$

Given our frictionless environment, the firm will instantaneously adjust its level of inputs in response to any exogenous shock. At the same time, absence of arbitrage opportunities implies that the rental cost of capital must always equal the international interest rate. Thus, to the extent that interest rate changes over time, the domestic capital stock itself (and thus the wages) will also fluctuate.

2.3 Opposing effects of interest rates and the role of the government

An increase in the international interest rate benefits those agents with accumulated savings (retirees) collecting financial returns on their investment, but it harms workers as wages decrease in response to a lower domestic capital stock. So changing interest rates have opposing effects on workers and retirees. In this context, economic theory suggests that the potential room for risk sharing between young and old agents will eventually give rise to institutions capable of performing such task. Economic theory also suggests many informational problems that may prevent these institutions from spontaneously arising. Within this context, we investigate how a government-run PYG system that conducts intra-temporal transfers between workers and retirees can affect the dynamic properties of this economy.

A first question that one may ask is whether PYG schemes are pareto-improving in this context. Even though this is an interesting issue, we postponed it to future work. Our main focus here is not whether there are efficiency gains to be achieved by government intervention, but rather how the dispersion of income histories across generations will be affected by different degrees of SS capitalization. It is clear from the outset that each generation will have different earning experiences just because the international interest rate is a random variable - that is, some generations are going to be luckier than others. Nevertheless, we show that the choice of the SS regime matters for how volatile these income histories can be.

Ultimately, we want to evaluate to what extent intra-period transfers confer to the PYG regime an edge over full capitalization when it comes to the reduction of income dispersion across generations. In order to isolate this intra-period component we shut down two other channels that generally enhance the PYG payoff. The first one is population growth/ technological progress. Indeed, by assuming zero population growth/ technological progress we are setting at zero the rate of return of the PYG system. The second channel we shut down is government financing, which means that the social security budget must balance at each point in time.

In our model, government levies payroll taxes on young agents and makes transfers to contemporaneously alive old individuals. Because we assume that the SS budget is always balanced, we have that government transfers to old agents at any point in time must be equal to the social security tax times the wages received by the young agents. The payroll tax parameterizes the degree of capitalization in the system by affecting incentives to save.

2.4 Equilibrium

The SOE assumption breaks the general equilibrium link between savings and domestic capital stock that is present in the original Diamond (1965) model. It is possible to see from equation (7) that the domestic capital stock will be determined by the international interest rate, irrespective of the saving behavior.[3] Once the interest rate is given, the wage rate can be inferred from the price factor frontier associated with the firm's problem, and the household decides its optimal saving behavior having knowledge of its first-period income.

3. SIMULATION EXERCISE

In order to generate numerical assessments from our framework we start by characterizing the entire behavior of 20 generations given a randomly drawn sequence of 40 observations for the international interest rate. We solve the model for each point in time to obtain a sequence of equilibrium values for the endogenous variables, which enables us to compute the total income for any generation *p* as follows:

$$TI_p(\tau_1^{SS}) = (1-\tau_1^{SS})w_{1,p} + \tau_1^{SS} w_{1,p+1} + (1+r_{2,p})s_{1,p} \qquad (8)$$

Equation (8) implies that the total income for an individual belonging to generation *p* must equal to his net wage income generated when young plus the SS benefits received when old (coming from payroll taxes levied on workers of generation *p+1*) plus the interest collected on savings he accumulated when young. Note that our formula above does not contain any discounting factor or expectation term in the right-hand side. Indeed, our intention is not to capture the *expected* present discounted value of lifetime income resources. Instead, we want a measure of "generation's income" that fluctuates in response to the history of international interest rate shocks, allowing us to study how different levels of capitalization in the SS system may impact its dispersion across time.

In order to assess the dispersion among elements of the sequence $\{TI_p\}_{p=1}^{20}$, we need to parameterize the model. Given the already simplified structure we are working with, we make no attempt to carry out a serious calibration exercise.[4] Instead, we pick arbitrary values for the parameters and focus on a more primitive message that is qualitatively robust to alternative parameterizations of the model.

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[3] This is only possible because we are assuming that capital flows will adjust instantaneously to cover the difference between savings and the capital stock.

[4] Markov-switching techniques could be used in a future extension of this paper to pin down interest rates and transition probabilities.

Parameters

r^{low} **= 0.05**	π_1 **=.5**	σ **= 2**	A **=1**
r^{high} **= 0.15**	π_2 **=.5**	$\beta = 1/(1+E(r))$	α **=.3**

Given the set of parameters above and a randomly drawn sequence of international interest rates, we obtain sequences of endogenous variables across 20 generations allowing the payroll tax (τ_1^{SS}) to assume eleven different values ranging from 0 to 100% for each different simulation. The case in which the SS tax is zero corresponds to full capitalization, as agents have to rely entirely on their private provision for retirement; whereas full taxation represents an extreme case in which the government transfers all wage income from workers to retirees, and young agents are forced to finance all their current consumption through negative savings. For each level of payroll tax z we calculate the following measure of dispersion across generations:

$$DI^{\tau^{SS}=\tau^z} = \frac{\sqrt{\left[\sum_{p=1}^{20}\left[TI_p(\tau_1^{SS}) - \sum_{p=1}^{20} TI_p(\tau_1^{SS})\Big/20\right]\Big/20\right]^2}}{\sum_{p=1}^{20} TI_p(\tau_1^{SS})\Big/20}, \quad \tau^z = [0,.1,.2,...,1]$$

The numerator of the expression above - equation (9) - is simply the standard deviation of the sequence $\{TI_p\}_{p=1}^{20}$ and the denominator normalizes that measure by its mean so that level effects associated with different social security taxes do not prevent comparability across alternative regimes. The *DI* index can be interpreted as giving the "size" of the inter-generational dispersion as a percentage value of the mean income across generations.

The last stage of the simulation exercise is to repeat all the steps above 50 times (drawing a new sequence of international interest rate each time) and then calculate averages across all iterations. The summary table below describes the algorithm used.

Algorithm

Step 1	*Draw a sequence of 40 observations for the international interest rate*
Step 2	*Set payroll taxes (τ^z) to 0*
Step 3	*Solve the model for 20 generations and calculate* $DI^{\tau^{SS}=\tau^z}$
Step 4	*Increase* τ^z *by 0.1 and return to step 3 or move to step 5 if* $\tau^z = 1$
Step 5	*Return to step 1 until 50 complete iterations (from 1 to 5) are performed*

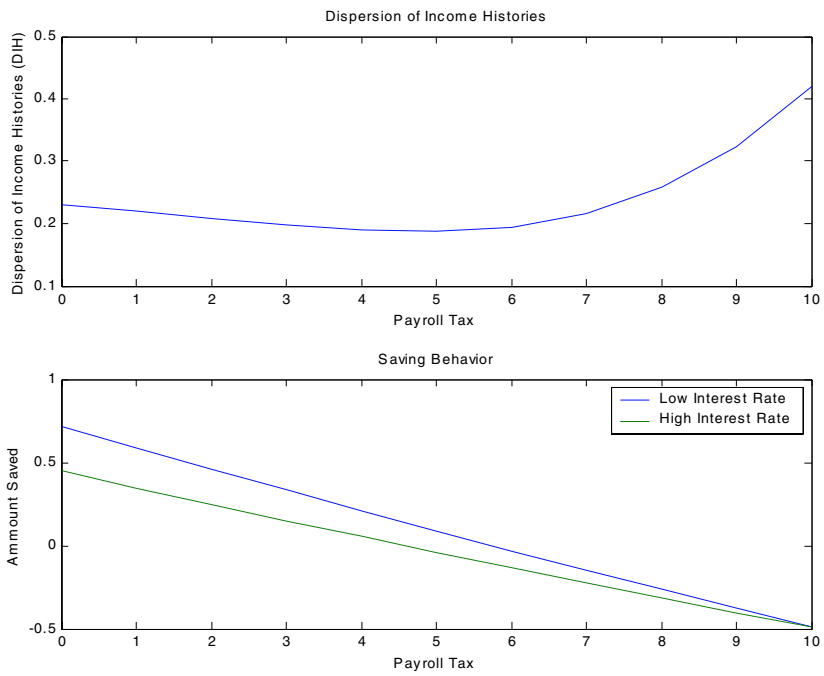
4. RESULTS AND DISCUSSION

The simulation results summarized in figure 1a deliver a U-shaped relationship between SS taxes and the *DI* index, implying that a PYG system can successfully reduce the dispersion of income histories across generations, but too much of it can cause the opposite effect.

To understand the intuition behind this result, note that a SOE with a full capitalization SS system and fluctuating interest rates is characterized by a dichotomous structure of risk exposure based on age. Indeed, young individuals are negatively affected by high interest rates (low wages) while old ones suffer with low interest rates (low returns on savings). The introduction of a PYG scheme breaks down this dichotomy by allowing retirement income to be affected in a more complex way. From one hand, old agents can now benefit from low interest rates given that better wages will imply higher SS transfers; but from the other, payroll taxes reduce their savings in the first period. Ultimately, the PYG system creates inter-cohort linkages across earning histories of adjacent generations.

The economic variable embodying such linkage effects is savings. Figure 1b pictures the average amount saved by young agents under high and low interest rates for each level of payroll tax. As the economy moves from a fully capitalized system to the extreme 100% tax, the savings gap shrinks. This result is intuitive since government-enforced intra-period transfers displace private savings as a mechanism for financing retirement consumption.

Figures 1a, b



The simulation also points to a strong asymmetry in the U-shaped relationship between SS taxes and the *DI* index, indicating that generational inequality is worse when taxes are very high than when they are very low. The picture shows that raising payroll taxes from 0% (fully-funded SS system) to 50% can reduce the standard deviation of generational earnings by approximately 5% of its mean value across 20 generations. On the other hand, moving from a fully funded scheme (that is, 0% payroll taxes) to the extreme case of 100% payroll taxes actually increases the standard deviation of generational earning histories by approximately 20%.[5]

5. FUTURE WORK AND EXTENSIONS

This paper develops a model of a SOE subjected to fluctuating international interest rates in which alternative SS arrangements impact the dispersion of income histories across different generations. Despite its simplifying assumptions, the model was able to generate some interesting insights with regard to the benefits and limitations of the PYG system as an instrument to reduce inequality across generations. A central message of paper is that PYG can reduce income dispersion across generations, but it can also produce the opposite effect if pushed too far. Future extensions of this work should address some of the simplifying assumptions made, and evaluate how the U-shape relationship reacts when the economic environment is modeled in greater detailed. We list below some of the assumptions to be relaxed.

Endogenous labor supply

The introduction of labor supply distortion effects is probably the number one assumption to relax. Indeed, high level of payroll taxes is likely to reduce wage income by reducing incentives to work, and it will ultimately reduce the effectiveness of intra-period transfers.

Technological Progress/Population growth

The rate of return of a PYG scheme is tied to population growth and technological progress. We assumed both are zero in this paper and focused solely on distributional issues arising from alternative SS arrangements. By departing from this assumption we may assess the role of a PYG regime as a welfare enhancing mechanism as we equip it with a non-zero average rate of return.

Persistence of international shocks

We have assumed a very simple structure for the interest rate shock where high and low interest rates have equal probability to occur. Reality suggests that a SOE undergoes spells of high (or low) interest rates, and it would be interesting to evaluate how persistence of shocks would affect our results. This point is linked to the next one.

Government debt

We have not allowed the government to issue debt for financing temporary deficits in the SS budget. This may be a particularly powerful instrument for reducing the dispersion of income histories across generations particularly when there is persistence of bad times and the government may want to smooth private income throughout time.

[5] These numbers are certainly affected by our simplifying assumption and one must not believe they provide an accurate quantitative assessment. The main objective of the paper is to expose a central element associated with SS-system design in a SOE subjected to fluctuating international interest rates.

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