Social Security Reform: Funding Paygo with Investments in Human Capital

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Abstract

A reform of Social Security motivated by investment in human capital is shown to have the potential to reduce social security taxes and strengthen the economy, while putting the system on a sound economic and actuarial footing.

1 Introduction

There is an extensive volume of research in the macroeconomics literature concerning Social Security and its effect on the macroeconomy.[1] As a result, we have a sound understanding of many issues related to Social Security. It is an indication of the inherent complexity of Social Security in the political economy, that even with this broad understanding there is still not a corresponding consensus as to the best way to address the financial and demographic problems associated with Social Security.

Till now, there have been two basic strategies for reforming Social Security. One strategy is for individuals to take responsibility for their own retirement. A version on this theme would require each individual to build up a Personal Retirement Account through mandated contributions. The distinguishing characteristic of this approach is individual responsibility, ownership and freedom of action for their own retirement income. The other basic approach is for the government to continue to have sole responsibility for providing a retirement pension. Given the current actuarial imbalance, reform proposals under this approach necessarily involve some variation of tax increase, or benefit reduction to "fix" Social Security. But the distinguishing characteristic of this approach is government action with no choice or responsibility on the part of the individual.

Neither of the two basic strategies is without flaws. A system funded by individual accounts would be pro-cyclical, increasing benefits in good times and decreasing benefits in hard times. One of the strengths of the present approach

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[1] For this paper, Social Security will only refer to old age pension benefits and exclude disability and survivor benefits.

is the counter-cyclical role it plays in stabilizing the economy. On the other hand, the present paygo system is shown under reasonable hypotheses to result in systemic declines in both capital formation and family formation, repressing the long term standard of living. Any increase in taxes to "fix" social security will only exacerbate these issues. Cutting benefits will alleviate the disincentive for capital and family formation, but would be politically unpopular.

This paper proposes a third way to reform social security, a shared responsibility between the individual and the government to provide for old age security. This approach builds on the current paygo system, and puts it on a sound actuarial footing. The reform proposal may also have demographic and educational spillover effects which can improve both the economy and society.

The usual meaning attached to a funded social security system is that assets are accumulated during one's working years, invested in physical capital, and earn a return to provide income during one's retirement. This requires that the worker reduce consumption during working years in order to consume more in retirement. In this paper, we will explore an alternative meaning of the term funding. In this paper workers reduce their consumption to invest in raising children, who earn a return to provide income to their parents in their retirement.

A productive economy needs both physical capital and human capital.[2] There is no reason to focus solely on the accumulation of physical capital as the funding source for retirement income. Human capital will also do the job. The present Social Security system already relies on population growth (a necessary input to human capital) for its viability. But the present system generates disincentives for a worker to have children, or to invest in the education of the children they do have. The present system depends on future generations to pay benefits for current workers. But Social Security is free-riding on whatever other motivations exist for workers to raise children and invest in their education.

In the all-important formative years of childhood, human capital is developed by the joint contributions of the child and the child's parents. (Obviously teachers too, but we can consider teachers to be agents of the parents) During these years, parents voluntarily reduce their consumption of other goods and countless hours of their time, to invest in the production of human capital through their children.[3] To the extent that workers invest greater amounts of time and resources in the production of human capital,it is reasonable to expect more productive children to be the result. The reward to parents for this investment is the altruistic satisfaction that it produces. But raising children (or not) has no effect on their Social Security benefit, which depends only on their own earnings In fact, for many workers their earnings may be negatively affected as the worker devotes time and energy to child-rearing rather than career-building.

The main idea of this paper is to explore the implications of a reformed

[2] Human capital refers to acquired skills and knowledge embodied in workers through education and experience.

[3] According to the 2011 annual report by the US Department of Agriculture, the cost in 2011 for a middle income two parent family to raise a child from birth to age 18 was estimated to be $234,900.

Social Security system in which workers get a basic pension based on a paygo tax on their own earnings, plus a supplemental pension based on the earnings of their chidren. There are two parts to the idea. The first part (the government's responsibility) is that workers are taxed to provide a basic paygo benefit. The amount of the basic benefit is based on the worker's own earnings,like the present system, but the basic benefit is necessarily lower than the present benefit. Conceptually, this basic benefit is sourced from the taxes themselves and from taxes paid by those of their generation who do not survive to retirement. While still a paygo system, the basic benefit does not actuarially rely on population growth to meet future benefits. (Of course, the mechanics of Paygo still involve the interaction of generations.)

The second part (the individual's responsibility) provides an additional retirement benefit based on the earnings of the worker's own productive children. Childless workers would only receive the basic benefit. Workers who do not have children, anticipating a lower pension benefit, could voluntarily increase private investment in physical capital (a part of that shared responsibility idea). Since they do not have the financial burden of raising children, this option is more accessible to them than it is to workers with children. The result is a greater fairness between workers with children, and workers without children, in providing for retirement security.

A social security system funded by investment in one's children is an echo of the old-age security system of the pre-modern era. Before social security, there were large families, and strong inter-generational bonds within families, to provide old-age security. Once social security appeared, the motivation for a large family to provide old-age security decreased, while the means to raise a large family also decreased, due to social security taxes. As a result (and also due to other combined forces too complex to fully sort out ; e.g. urbanization, increased education levels, increased wealth, cultural shifts, etc.), fertility declined sharply in the second half of the twentieth century. In fact, Demeny (1987) proposed re-linking social security to fertility as a possible channel to reverse declining fertility trends in Europe. This paper expands on Demeny's proposal from a purely demographic argument to an actuarial and economic argument, and to explore how it would effect the economy.

Our main results can be summarized as follows. The policy change, (as specified in the paper, childless workers receive two thirds the benefit of present policy) by itself has a modest effect on social security tax rates due to lower benefits paid to childless retirees.. If there are no behavior effects, the tax required under the reformed policy is 93.1% of the tax required under present policy. However, if the policy change results in behavior changes in the number of children per family, and in investment in education, then the effects in the economy are large. For example, if fertility increases by 10% (from 2.1 to 2.3 children per woman, still well below historical levels), then the required tax under the reform policy is reduced 35% from the tax required under current policy. More importantly perhaps is that if the reform results in parents taking a greater interest in the education of their children, the standard of living rises in the long run.

2 Related Literature

This paper contributes to the literature on funded and unfunded public pension systems. A significant part of this literature has revealed that the overall welfare effect of introducing such a system crucially depend on the importance of two opposing effects: a higher intergenerational risk sharing and a lower capital intensity. On the one hand, an unfunded social security system reallocates the impact of shocks across generations, reducing the consumption risk of the old aged relative to the risk they would face with private markets (Bohn 1999). This provides a welfare improvement for all generations alive and for the ones to be born in the future. On the other hand, such a system redistributes income away from younger agents with lower marginal propensities to consume, toward older agents with higher marginal propensities to consume. This lowers aggregate savings and aggregate capital formation (Feldstein 1974, Diamond 1977). The so-called "crowding-out" effect on capital from unfunded social security has been noted by many researchers over the years (see, for example, Auerbach and Kotlikoff 1987; Imrohoroğlu, Imrohoroğlu and Joines 1998b and 1999). This crowding out effect arises in life-cycle models, in which social security substitutes for precautionary savings to guard against an uncertain length of life. The net effect of lower capital intensity (due to crowding-out) is that agents would be better off in the long run if they were born into an economy without Social Security.[4]

There is also a significant literature in the field of demography related to the depressing effect of Social Security on fertility. Hohm (1975) examines evidence from 67 countries and finds a measurable negative effect on fertility. He recommends that social security be a policy tool for countries to implement in order to reduce fertility. Caldwell (1978) advances a theory of fertility based on the nature of economic relations within the family. By the 1980s however, declining fertility in some developed countries had advanced to a point that Demeny (1987) proposed relinking social security benefits to fertility as a way to increase fertility rates.

Economists were not idle during this period. Becker and Barro (1988) found that social security discouraged investment in children. Ehrlich and Lui (1991) develop an intergenerational model of intra-family economic transfers, and study the impact of such family insurance on economic growth. Their paper "assigns an important dynamic role for the family as a social institution" and they find that Paygo social security "can reduce an economy's growth potential by providing an inefficient substitute for voluntary family insurance". Ehrlich and Lui (1998) get even closer to the spirit of this paper. They find significant adverse effects from Paygo social security on fertility, savings and investment in human capital. Here is a prescient quote from their 1998 paper:

> The spector of financial collapse, sometime in the next century,

[4] Subsequently, Fuster (1999) and Fuster, Imrohoroğlu and Imrohoroğlu (2002) have analyzed Social Security in a dynastic framework. In this setting, the household can undo the effect of Social Security through its altruistic motives, so that there is much less crowding-out.

> of many Western-style social security systems (at current defined benefits) is an inevitable outcome of persistent secular reductions in fertility, labor productivity, and the aging of the population, given the mechanics of the PAYGO scheme. Our model suggests that these difficulties may be exacerbated by the adverse effects on fertility and growth generatd by the systems themselves. An intriguing, though politically unlikely remedy would be to increase the link between old-age benefits to parents and the social security contributions of their children... which would bolster parental incentives to raise productive and successful children.

That, of course is exactly the intriguing remedy this paper is about.

Literature on Human Capital development and social security is also extensive. Some papers are related to investment in one's own human capital, which is not the focus of this paper. Several researchers find that Social Security provides disincentives for human capital development (see for example, Becker and Barro (1998), Ehrlich and Lui (1998), Ehrlich and Kim (2005)). A different take on investment in human capital is from Kaganovich and Meier (2008). They find that a Paygo social security system is likely to put the public in a mind to fund public education more generously.

David Romer(2001) presents a simplified growth model, based on models developed by Paul Romer, Grossman and Helpman , and Aghion and Howitt ,.in which the production of output also depends on the production of knowledge, or human capital. The model demonstrates interdependence between the growth of capital and the growth of knowledge. This growth interdependence impliess that it is as appropriate to fund social security with investments in human capital as it is to fund the system with investments in physical capital.

The paper is organized as follows. Section 3 presents the overlapping generations model which is used in this paper. The framework for our analysis is a large-scale general equilibrium overlapping generations (OLG) model. This setting, in various permutations has been used extensively since Auerback and Kotlikoff (1987) first analyzed labor supply and capital stock with a 55-period deterministic OLG model.[5] Section 4 discusses the calibration and solution method. Section 5 presents the results of the various experiments in the general equilibrium. Finally, Section 6 summarizes and concludes.

3 The Overlapping Generations Model

The OLG model used in this paper is based on the 65-period (ages 20-85) model used by Imrohoroğlu, Imrohoroğlu and Joines (1997). It has been modified in three significant dimensions. First, the model has been extended to 85 periods (ages 20-105) to enable it to better capture advanced old age dynamics. Second,

[5] Imrohoroğlu, Imrohoroğlu and Joines (1998a) discuss the main features of the model, used in many papers over the last twenty-five years.

there are two types of workers in the model of this paper, distinguished by labor efficiency (human capital). Fuster, Imrohoroğlu and Imrohoroğlu (2002) also study a model with heterogeneous ability types, and this paper borrows the split by type from their setup. The third modification is that an asumption of constant population growth has been replaced with population which evolves from fertility and mortality rates which differ by type of worker (level of human capital).

3.1 Demographics

Time is discrete, and each period represents one year. Age 0 corresponds to age 20. The oldest possible age is age J , where $J = 85$ (age 105). Death is certain after age 105.

There are two types of agents indexed by z, where $z \in \{1, 2\}$. An agent's type is revealed at age 0 (real age 20) and this determines lifetime ability (human capital), which can be either high ($z = 1$) or low ($z = 2$). The realization of ability follows a first-order Markov process with transition matrix Π:

$$\begin{aligned} \Pi(z, z') &= [\pi_{ij}]; i, j \in \{1, 2\} \\ \pi_{ij} &= \Pr(z' = j | z = i). \end{aligned}$$

where z is the ability type of the parent and z' is the ability type of the child.

The ability type determines the endowment of efficiency units an agent receives. In a given period, the cross-sectional labor efficiency $\varepsilon_j(z)$ is indexed by ability type z and age j. For simplicity, we assume throughout this paper that the rate of technological growth is zero. Under this assumption, the longitudinal efficiency units of a particular agent equal the cross-sectional efficiency factors, $\varepsilon_j^l(z) = \varepsilon_j(z)$.

Agents have uncertain lifetimes. Survival probabilities are correlated with ability type, so that high ability agents have longer expected lifetimes than low ability agents. Thus survival probabilities are indexed by age and type. The probability that an agent age j and ability type z survives to age $j+1$ is denoted by $\psi_j(z)$. The probability that an agent age j and ability type z survives to age $j + t$ is denoted by $\Psi_{j,t}(z)$, where:

$$\begin{aligned} \Psi_{j,t}(z) &= 1, \text{ if } t = 0 \\ \Psi_{j,t}(z) &= \Pi_{s=1}^{t} \psi_{j+s-1}(z), \text{ if } t > 0. \end{aligned}$$

Fertility ($F(j, z)$) is assumed to vary by type and age, in accord with empirical data.

Like much of the social security literature, this paper analyzes the steady state of a stationary population distribution, with time invariant cohort shares. Each cohort share ($\mu_j(z)$) represents the share of the total population at age j and type z. The evolution of the population to stable growth and stationary distribution of cohort shares derives from the inter-relationship over time of fertility and mortality by type. The model uses a modified Leslie Matrix to compute the stationary cohort shares.[6]

The sum of all cohorts must equal 100% so that,

$$\sum_{z=1}^{2}\sum_{j=1}^{J}\mu_j(z) = 1. \tag{1}$$

Given the Markov process, survival rates, and fertility rates, the above relationships over time uniquely determine time invariant cohort shares, $\{\mu_j(z)\}$.

3.2 Technology and Factor Prices

There is a single good in the economy, produced by one or more firms using a constant returns to scale Cobb-Douglas production function:

$$Y = AK^{1-\alpha} \cdot L^{\alpha}, \text{ where } \alpha \in (0,1). \tag{2}$$

Total factor productivity A is normalized to 1. The labor share is α, and K and L are aggregate capital and labor supplied as inputs. Capital is assumed to depreciate at the constant rate δ. Therefore, in a competitive equilibrium, we get factor prices for capital and labor:

$$\begin{aligned} r &= (1-\alpha) \cdot K^{-\alpha} \cdot L^{\alpha} - \delta \\ w &= \alpha \cdot K^{1-\alpha} \cdot L^{\alpha-1} \end{aligned} \tag{3}$$

K represents the aggregate asset holdings over the population in a given period. The size of L is determined by the workers up to retirement age j^*. Workers are assumed to supply labor inelastically to age j^*, and do not work thereafter. The actual supply of efficient labor depends on the ability type of agents in the working age population.

$$L = \sum_{z=1}^{2}\sum_{j=1}^{j^*-1}\varepsilon_j(z) \cdot \mu_j(z). \tag{4}$$

3.3 Government Policy and Social Security

Present Policy A social security program provides a public pension to retirees. Average lifetime earnings for a worker of ability type z, denoted by $w^{SS}(z)$, is given by:

$$w^{SS}(z) = \frac{1}{j^*-1} \cdot \sum_{j=1}^{j^*-1} w\varepsilon_j(z)$$

[6]Details of the modified Leslie Matrix are available from the author.

The social security benefit, $b^{SS}(z)$, is determined as a formula of average lifetime earnings. Let $\bar{w}$ denote the average lifetime earnings over all workers. The social security benefit formula is based on the formula used by the current Social Security Administration.

For low income workers ($z = 2$),

$$b^{SS}(2) = .9 * (.2 * \bar{w}) + .33 * (w^{SS}(2) - .2 * \bar{w}) \tag{5}$$

For high income workers ($z = 1$),

$$b^{SS}(1) = .9 * (.2 * \bar{w}) + .33 * ((1.25 - .2) * \bar{w}) + .15 * (w^{SS}(1) - 1.25 * \bar{w})$$

The set of breakpoints (20% and 125%), together with the factors .9, .33, .15, are collectively referred to as present policy choice θ.

Reform Policy *It is necessary to specify how a human capital based funding program might work. There are many possible choices. The ad hoc policy choices defined here are intended only to reflect the spirit of the idea, and are not meant to be anything more than illustrative. Alternatives are certainly possible and very likely preferable.*

The reform policy provides a social security pension in two parts. Part one is a basic benefit for all workers. The amount of the basic benefit is specified to be 67% of the amount determined by the formula under the present policy.

Part two of the reform policy calculates an alternative pension for retirees whose children are themselves working and contributing to the social security system. To calculate the alternative benefit, one first calculates the average lifetime earnings of the retiree. Then one computes the lifetime earnings (to date) of the two oldest working children of the retiree. (There is no incremental benefit for more than two children; this eliminates the incentive for excessively large families.) The alternative benefit is computed based on the weighted average lifetime earnings of the retiree and the working children. The retiree's own wages count for two thirds of the weighted average, and the children combined account for the remaining third. The social security benefit is computed using 100% of the the present policy benefit formula if there are two children, and 83% of the present policy formula if there is only one child. These rules modify the calculation of the social security benefit as follows:

$$\begin{aligned} b_c^{SS}(z) &= .67 * b^{SS}(z), c = 0 \\ b_c^{SS}(z) &= .83 * b^{SS}(z), c = 1 \\ b_c^{SS}(z) &= 1.00 * b^{SS}(z), c = 2+ \end{aligned} \tag{6}$$

(In using the above formulas for $b_c^{SS}(z)$, the model is implicitly assuming that children have the same average indexed earnings as the parent. This is not generally the case, but this makes the model much simpler to build. As such,

it reduces the effect that education will play in the model, but I believe it to be a second order influence in this particular point in the model. The important policy choice is that investment in education can increase the social security benefit, not merely having children.)

The breakpoints, benefit factors and alternative benefit formulae are collectively referred to as reform policy choice, θ'.

Taxes The role of the government is to collect a tax on labor income to exactly provide the social security pension to retirees. The necessary tax rate, τ_{SS}, in the model of present policy is:

$$\tau_{SS} = \frac{\sum_{z=1}^{2} \sum_{j=j^*}^{J} b^{SS}(z) \cdot \mu_j(z)}{w \cdot \{\sum_{z=1}^{2} \sum_{j=1}^{j^*-1} \varepsilon_j(z) \cdot \mu_j(z)\}} \tag{7}$$

The numerator is the total benefit paid under social security and the denominator is the total wage base over which the tax is applied in a given period.

For the reform policy, the necessary tax rate is:

$$\tau_{SS} = \frac{\sum_{c=0}^{2} \sum_{z=1}^{2} \sum_{j=j^*}^{J} b_c^{SS}(z) \cdot \mu_j(z)}{w \cdot \{\sum_{z=1}^{2} \sum_{j=1}^{j^*-1} \varepsilon_j(z) \cdot \mu_j(z)\}} \tag{7R}$$

3.4 Constraints and Bequests

During the working years, the agent receives after-tax labor income based on their age/ability profile of labor efficiency. Upon retirement, the agent receives social security benefits. Each period, the agent must choose the amount of consumption and the amount of voluntary saving. Savings earn the rate of return on capital r. We assume that agents are subject to a no-borrowing constraint.

Because lifetimes are uncertain, some agents will die with positive amounts of assets (aka accidental bequests). Accidental bequests are redistributed to surviving agents, in such a way that each type of agent receives an equal share based on the expected bequest of that agent, given their ability type. The amount of the bequest distributed to agents of ability type z is denoted by $\xi(z)$.

The budget constraint faced by an agent of age j and ability type z, is given by:

$$c_j(z) + a_{j+1}(z) = [a_j(z) + \xi(z)] \cdot (1 + r) + Q_j(z) \tag{8}$$

Further, Q_j is defined as follows:

$$\begin{aligned} Q_j(z) &= w \cdot \varepsilon_j(z) \cdot (1 - \tau_{SS}) \text{ for } j < j^* \\ Q_j(z) &= b^{SS}(z) \text{ for } j^* \leq j \end{aligned}$$

The left hand side of the equation is the allocation of that period's wealth to consumption and savings, while the right hand side is the total of the resources available from prior savings and returns, bequests, wages and benefits from social security   In all economies, $a_1(z) = 0$ and $a_{J+1}(z) = 0$.

In all economies, households face a borrowing constraint:

$$a_j(z) \geq 0, \ \forall \ j$$

The bequest $\xi(z)$ is defined below.

3.4.1 Expected Bequests

Since ability type determines labor earnings, then the average size of an accidental bequest differs by type. It is reasonable to assume that children receive the accidental bequest left by the parent. The problem is how to allocate accidental bequests to agents of type 1 and type 2 so that the allocation is consistent with a presumption that the bequest stay in the family. To do this, let $Beq(z)$ denote the average bequest of agents of type z that die in a given period:

$$Beq(z) = \frac{\sum_{j=1}^{J} \{a_j(z) \cdot \mu_j(z) \cdot (1 - \psi_j(z))\}}{\sum_{j=1}^{J} \mu_j(z) \cdot (1 - \psi_j(z))}$$

The numerator is the sum of assets owned by the type z agents who die in a given period, while the denominator is the number of such agents.

Recall that $\pi_{ij} \in \Pi$ is the probability that a parent of type i has a child of type j, and that $\lambda(z)$ is the probability that a newborn is type z. It turns out that the probability that a child of type z has a parent of a given type produces exactly the same Markov probability matrix Π. We then allocate accidental bequests as follows:

$$\begin{aligned} \xi(z) &= \frac{\pi_{z1} \cdot Beq(1) + \pi_{z2} \cdot Beq(2)}{\sum_{z=1}^{2} \lambda(z) \cdot (\pi_{z1} \cdot Beq(1) + \pi_{z2} \cdot Beq(2))} \cdot Beq \qquad (9) \\ \text{where } Beq &= \sum_{z=1}^{2} \sum_{j=1}^{J} \{a_j(z) \cdot \mu_j(z) \cdot (1 - \psi_j(z))\} \end{aligned}$$

3.5 Preferences and Individual Optimization Problem

To streamline notation, we let a denote $a_j(z)$, where age and type are defined by the context of the usage. Likewise, we will make the same notational shortcut for c , Q and ξ. The prime symbol denotes the next period value.

3.5.1 Preferences

Preferences are defined over a lifetime sequence of consumption $\{c_j(z)\}_{j=1}^{J}$. The individual agent's objective for an agent age j is to maximize expected discounted lifetime utility:

$$U_j = \sum_{t=0}^{J-j} \beta^t [\Psi_{j,t}(z)] \cdot u(c_{j+t}(z)) \qquad (10)$$

where $u(c) = \frac{c^{1-\gamma}}{1-\gamma}$, γ is the constant coefficient of relative risk aversion and β is the discount factor. The term in brackets is the probability of survival to age $j+t$ for an agent of age j and type z.

3.5.2 The Individual's Problem

An agent of age j and type z starts a given period with initial asset holdings a. The individual's dynamic problem is to choose how much to consume now c, and how much to save for future consumption a', in order to maximize the Bellman equation:

$$W_j(a) = \max_{c,a'} \{u(c) + \beta\psi_j(z)W_{j+1}(a')\} \tag{11}$$

subject to the budget constraint, the borrowing constraint, the initial and optimality conditions, and taking the factor prices as given.

3.6 The Steady State Equilibrium

Let $D = \{d_1, d_2, ..., d_m\}$ represent the discrete set of values that asset holdings are permitted to take. The feasible set for an age j agent of type z and asset holdings a is denoted by $\Omega(j,a,z)$. The possible choices for a using standard preferences satisfy $a' \in \Omega(j,a,z)$, $a' \geq 0$, and the budget constraints.

A steady state equilibrium for a set of policy parameters $\{\theta, \tau_{SS}\}$ is a collection of value functions $\{W_j(a)\}$; decision rules $R^c_{a,j,z} : D \times \{1,2,...,J\} \times \{1,2\} \rightarrow \mathbb{R}_+$ and $R^{a'}_{a,j,z} : D \times \{1,2,...,J\} \times \{1,2\} \rightarrow D$; a stationary distribution of types of newborns, $\{\lambda(1), \lambda(2)\}$; a time invariant distribution of agents by type, $\{\mu_j(z) | \forall j \in \{1,2,...J\}, \forall z \in \{1,2\}\}$; a set of prices for capital and labor $\{r, w\}$; and a set of lump sum transfers of accidental bequests to agents $\{\xi(z)\}$; such that

1. Given factor prices, government policy and the lump sum transfers, the decision rules solve the individual optimization problem.

2. Factor prices solve the optimization problem of the firm

3. Markets clear, implying that:

$$K = \sum_{z=1}^{2} \sum_{j=1}^{J} [a_j(z) + \xi(z)] \cdot \mu_j(z) \tag{12}$$

$$L = \sum_{z=1}^{2} \sum_{j=1}^{j^*-1} [\varepsilon_j(z) \cdot \mu_j(z)] \tag{13}$$

$$Y = \sum_{z=1}^{2} \sum_{j=1}^{J} \mu_j(z) \cdot [c_j(z) + a_{j+1}(z) - (1-\delta) \cdot (a_j(z) + \xi(z))] \tag{14}$$

Thus, aggregate capital is the sum of individual asset holdings, aggregate labor is the sum of effective workers and output equals aggregate consumption plus the increase in aggregate capital.

4. The invariant population distribution conditions are satisfied.

5. Government pensions are fully financed by the labor tax.

6. The lump sum transfers satisfy:

$$\sum_{z=1}^{2}\sum_{j=1}^{J}\xi(z)\cdot\mu_j(z)=\sum_{z=1}^{2}\sum_{j=1}^{J}\{a_j(z)\cdot\mu_j(z)\cdot(1-\psi_j(z))\} \tag{15}$$

4 Calibration and Solution Method

4.1 Calibration

4.1.1 Demographic and Labor Parameters

The model is calibrated following some of the previous literature. Each period represents one year. The probabilities that make up the transition matrix Π are taken from the calibration used by Fuster, Imrohoroğlu and Imrohoroğlu (2002). As they explained, the values of Π were chosen to match 1991 Bureau of the Census data on the proportion of college graduates in the work force, and to match an observed correlation between the permanent component of income of parents and children, based on estimates by Zimmerman (1992) and Solon (1992). Thus:

$$\Pi=\begin{bmatrix}\pi(1,1) & \pi(1,2)\\ \pi(2,1) & \pi(2,2)\end{bmatrix}=\begin{bmatrix}.57 & .43\\ .17 & .83\end{bmatrix}$$

Mortality is assumed to be different between high ability agents and low ability agents. Mortality rates from based on tables from the Social Security Administration. The aggregate mortality rates are then split into two sets of mortality rates; one for the high ability workers and one for the low ability workers. The method used to split aggregate mortality rates by type is available from the author.

The model also splits the aggregate labor efficiency factors into two sets, one for each type. The aggregate factors are the age-related factors used by Imrohoroğlu, Imrohoroğlu and Joines (1999), based on research by Hansen (1993). The aggregate efficiency factors are then split into type specific efficiency factors in a manner similar to that used to split the mortality rates. Again, the details are available from the author. Labor is supplied inelastically to retirement age, which is fixed at $j^*=45$, corresponding to real age 65. Thereafter, $\bar{\varepsilon}_j=0$.

The total fertility rate is allocated by age and type based on data from the National Health Statistics Report Number 51, April 12, 2012. This report is also the source for data about number of children per household by type, which is needed to calculate social security benefits under the reform. The benchmark case assumes total fertility is 2.1 live births per woman. The actual rate fluctuates quite widely on a year to year basis, but this rate is close to the current level, and it results in population growth close to zero. With these assumptions and data, we get the following specification for fertility, $F(j, z)$:

$F(j, z)$	Age 20-30	Age 30-35	Age 35-40
Type 1	.12032	.10933	.05472
Type 2	.1391	.1264	.06326

The distribution of family size is specified as follows:

Number of children	None	One	Two	Three or more
Type 1	7.14%	4.56%	8.51%	5.34%
Type 2	8.26%	10.64%	26.49%	29.12%

4.1.2 Technology Parameters

The model uses a Cobb-Douglas production function with constant returns to scale, $Y = AK^{1-\alpha}L^{\alpha}$. Total factor productivity A is normalized to one. Labor's share α is set to 0.64. These values are often used in a simple model, as they approximate the observed patterns in the US over a long period. The value of L is determined by the demographic assumptions.

Depreciation is set at a constant rate of 6.9%, following Imrohoroğlu, Imrohoroğlu and Joines (1999), in which they calculated their technology parameters based on annual US data since 1954. The rate of exogenous technological growth is set to zero.

4.1.3 Preferences

The parameters that specify standard preferences in the model are the coefficient of relative risk aversion, γ, and the time preference discount rate, β. The coefficient of relative risk aversion, γ, is set to 2, and the time preference discount rate, β, is set to .978. These values match the values used by Imrohoroğlu, Imrohoroğlu and Joines (1999), which they chose to produce a capital intensity ratio close to 2.5, which is the empirical average in the US since 1954, according to their analysis. In this paper, under present policy, this parameterization produces a capital intensity of 2.04.

4.2 Solution Method

The model is solved using a recursive method applied on a discretized state space. The solution we seek is a steady state of the economy. Starting from an initial guess as to the value of aggregate capital, K, and a guess as to the value of aggregate bequests, B, the solution algorithm computes optimal saving and consumption decisions for all agents in the invariant population distribution for a given period. New aggregate capital and aggregate bequests are calculated, given the optimal policies, and the new values for K and B are compared to the starting values. If they differ by more than a tolerance amount defined in advance, the starting guess is updated, and the algorithm is repeated. The process repeats until the aggregate capital and aggregate bequests reach a steady state.

To solve the individual problem under standard preferences, we use a backwards induction algorithm, starting in the last period of life.

5 Numerical Results

First, we consider the reform policy and the cost to the individual in the form of the social security tax. To gain better insight, we establish a baseline with respect to present policy. Table 1 presents the required social security tax rate for the benchmark economy and for an economy which isolates these areas of interest.

Table 1. Required Social Security Tax Rates for Selected Economies

	SS tax rate	% of Benchmark	Change per Unit
Benchmark	10.2%	100.0%	NA
Fertility (+10%)	7.09%	69.5%	−3%/1%ΔFert.
Educ.(+10%)	10.89%	106.8%	+.68%/1%ΔEd. odds
Policy Chng only	9.50%	93.1%	−.21%/1% ben. red.

The "Benchmark" economy is calibrated as described above, with the present level of Social Security benefits. "Fertility (+10%)" is the same, except that in the Fertility (+10%) economy, fertility rates are 10% higher. "Education(+10%)" is also based on present benefit levels, but with an economy in which the odds of starting working life as a Type 1 worker (i.e., having received a college education) are 10% higher than in the benchmark economy. (The odds are exogenous in the model) "Policy Change only" is the same economy as the benchmark, except that social security benefits are based on the reform policy.

Certain results stand out from Table 1. If fertility rates were to increase, the required tax rate would drop significantly, even under the present policy benefits. Each percentage increase in fertility rates allows a 3% reduction in tax rate. But without reform, there is no reason to expect an increase in fertility, and every reason to think fertility may continue to decline. Some European countries, with fertility rates well below 2 have implemented policies to reduce the burden of child-raising through government assistance, but these policies do not seem to be that effective in raising fertility.

The economy with more human capital (education) needs a higher tax rate than the benchmark economy, 6.8% higher in the Table 1 scenario. One might have expected a lower tax rate from a more productive economy. The model outcome is due to the fact that there is a cross-subsidization built into the present social security program. Low income workers, due to higher mortality rates, live shorter lives on average in retirement than high income workers; several years less. So even though low income social security workers get a disproportionately higher benefit through the benefit formula, it is not enough to fully offset their shorter lives live in retirement. With more workers getting a good education, and experiencing better mortality, the cost of pensions go up and taxes have to go up too.

The Policy Change only economy shows the impact of a 33% benefit reduction for childless workers and about a 17% benefit reduction for workers with only one child, holding everything else the same. Lower benefits mean lower taxes, 6.9% lower than the benchmark economyl. A reasonable test confirms this result. About 15% of retirees are childless, and another 15% have only one child. So the benefit reduction is roughly 7.3%. The model result is a 6.9% reduction.

The real impact of the reform comes from potential behavior changes, motivated by the changed incentives of the reform policy Whereas the current policy contains disincentives to family formation, and does not reward investment by parents in the education of their children, the reform policy explicitly rewards workers who raise productive children, with larger rewards for more productive children. So it is credible to assume some increase in fertility and educational attainment. How much of a behavioral response is an open question. So the approach here is to show what a fertility increase of 10% would mean for the tax rate, and what the effect of an increase of 10% in the chances of getting a good education would be. Then simple arithmetic would let the reader estimate their own expectation for behavior change that might result from such a reform of social security policy. Table 2 presents the results, starting again with the Benchmark economy and the Policy Change only economy for comparison.

Table 2. Required Taxes under Polcy Reform

	SS tax rate	As % of Benchmark
Benchmark	10.2%	100.0%
Policy Change only	9.50%	93.1%
Δ Policy, +5% Fertility	7.92%	77.6%
Δ Policy, +10% Fertility	6.63%	65.0%
Δ Policy, +10% Education	10.1%	99.0%
Δ Policy, +10% Fert., +10% Ed.	7.06%	69.2%

Fertility once again is the big reason for lower tax rates.

Education will improve one's living standard, but not the required tax rate, thanks to the longer life and associated higher cost of pensions.

The reform may motivate both higher fertility and increased education. Overall, if one thinks a 10% increase in fertility and a 10% increase in the odds of getting a good education are credible then the model indicates that tax rates under the reform policy would be 7.06%, almost 30% lower than under present policy, with only a 6.5% reduction in overall paid benefits . (When fertility is higher, there will be fewer childless families, and some families with one child will have two children. The model produces a 6.5% reduction in benefits, relative to the benchmark, versus 6.9% when fertility is not assumed to increase.)

So far our analysis has focused on social security tax rates, but what about the economy overall? Is the economy stronger, are workers better off with the reform policy? For that we look to key economic indicators, such as Wages, Consumption, and Output. Table 3 presents these key indicators for various economies.

Table 3. Key Economic Indicators Under the Reform Economies

	Wages	Output	Consumption	Tax Rate
Present Policy Benchmark	.957	1.166	.982	10.2%
Policy Change only	.957	1.166	.982	9.50%
Δ Policy, +10% Fertility	.918	1.157	.964	6.63%
Δ Policy, +10% Education	.949	1.233	1.045	10.1%
Δ Pol., +10% Fert., +10% Ed.	.910	1.229	1.032	7.06%

The policy change itself, without any behavior change, has no effect on the economic indicators. There is no change in the labor force, so wages are unaffected, and output is unaffected. Consumption is shifted at the margin from childless workers to workers with children, but in total, consumption is the same.

However, behavior changes do affect the economy. An increase in fertility increases the cohort share of active workers, and the increased supply of labor depresses wages. Consumption is also reduced, as a relative rise in interest income is not sufficient to offset the lower wages. Output (per effective worker) is also lower. This is a consequence of the assumption that Type 2 workers have a higher fertility rate than Type 1 workers. An increase in fertility results in an increase in the cohort share of Type 2 workers, who are not as productive.

The picture changes if the policy change results in higher investment in education. An increase in education, with no change in fertility, still causes a decrease in wages, since there is an increased supply of "effective labor". However the cohort share of Type 1 workers increases, causing an increase in output per effective worker. Thus consumption increases, even with lower wages.

The combined impact of both fertility change and a change in investment in education depends on which behavior is more responsive to this policy change. The model illustrates the case with a 10% increase in fertility and a 10% increase in the chance for a good education. Wages are lower, since both changes increase the supply of effective labor. Output increases due to the increased cohort share of educated workers, thus causing an increase in consumption. In this happy scenario, there is a 5% decrease in wages, a 5% increase in output and a 5% increase in consumption, all with a 30% decrease in social security taxes.

6 Conclusion

This paper presents the case for a different approach to reforming the present Social Security system. Investment in human capital is an alternative to investment in physical capital as a path for funding Social Security. Our approach to funding Social Security via human capital is actuarially sound. For illustration of the concept , we modeled a 33% reduction in basic benefits. Basic benefits are therefore close to the level sustained by taxes themselves plus the tontine effects of survivorship. Supplemental benefits are then provideded to those who invest in human capital, so that the system becomes demographically self-funding.

Analysis of the reform indicates that the reform itself, without behavioral changes, has only a modest effect on closing the actuarial deficit of the present system. But it would increase equity in funding retirement security between workers with children and workers without children.

However, behavior changes in both fertility and education are reasonable to expect as a consequence of the reform policy. These behavior changes both have a significant effect in the economy. Changes in fertility reduce the required tax rate for social security, with a 3% decrease in the tax rate or every percent increase in fertility rates. An increase in education, the other major component of human capital, does not decrease the required tax rate. However, educated workers produce an economy with a higher standard of living.

7 References

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