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Social Security Reform with Self-Control Preferences*

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Abstract

This paper analyzes a fully funded social security system under the assumption that agents face temptation issues. Agents are required to save through individually managed Personal Security Accounts without, and with mandatory annuitization. When the analysis is restricted to CRRA preferences our results are congruent with the literature in indicating that the complete elimination of social security is among the reform scenarios that maximize welfare. However, when self control preferences are introduced, and as the intensity of self control becomes progressively more severe the "social security elimination" scenario loses ground very rapidly. In fact, in the case of relatively severe temptation the elimination of social security becomes the least desirable alternative. Under the light of the above findings, any reform proposal regarding the social security system should consider departures from standard preferences to preference specifications suitable for dealing with preference reversals.

JEL Classification: E6; H55

Keywords: funded social security; unfunded social security; self-control preferences

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1 Introduction

There is an abundance of studies related to the importance of social security and its impact on welfare. The primary reason for this is its dramatically growing scale which has triggered a renewed academic debate regarding the optimal allocation of the available resources. This controversy stems from the huge monetary burden that the mere presence and administration of a social security system entails for the society and the associated budget implications: Old age, disability, unemployment and health insurance policies have evolved into the most expensive items on government budgets.

Most of the studies that seem to emerge as a direct or implicit offspring of this debate focus on the welfare implications of alternative social security schemes in an economy. In the very core of this debate one can clearly identify the dilemma between an "unfunded" (Pay-As-You-Go) versus a "funded" social security system. In an unfunded system, resources are transferred statically from the working population to the concurrent retirees (inter-generational transfers). In contrast, a funded system prescribes a dynamic allocation of resources within the same generation (inter-temporal within the same generation transfers). While the implementation of both systems relies on an external institution (e.g. government), their different logic and mechanics eventually induce entirely different risk-sharing properties as well as savings incentives. Therefore, their welfare implications may significantly diverge because of this difference.

Population ageing as a result of the declining population growth rate and decreasing birth rate have challenged enormously the sustainability of a *PAYG* system and called for a minimization of the fiscal burden through tax reforms and benefits restructuring. As a result, there are numerous studies suggesting alternative institutional arrangements that could be more robust to adverse demographic shocks. However, as much as converting an unfunded system to a fully (or partially) funded one may seem a plausible solution, in most cases the transition costs associated with such a reform make it prohibitively costly [DeNardi *et al.* (1999)].

The welfare implications of social security are well identified in the relevant literature.¹ Several studies [e.g. Storesletten *et al.* (1999)] comparing different social security systems typically compare welfare across alternative steady states, each corresponding to a stationary equilibrium with a different social security system. Focusing only on unfunded social security, Imrohoroglu *et al.* (1995) emphasize the detrimental effects that such an arrangement has to the overall welfare in a country.

However, all the above studies ignore alternative preference specifications that may be binding in several cases: Imrohoroglu *et al.* (2003) and Fehr *et al.* (2008) use time-inconsistent preferences while Kumru & Thanopoulos (2008) use self-control preferences to highlight that in a context of unfunded social security welfare may be critically affected by the preference specification.² In a recent paper, Fehr & Kindermann (2009) study the implications of individual

¹The interest in the welfare implications of a social security system has been sparked with the seminal work of Diamond (1965). The first quantitative model that assessed the welfare implications of the system was created by Auerbach & Kotlikoff (1987).

²For a detailed introduction to the mechanics of the hyperbolic consumption model and dynamically inconsistent preferences see Angeletos *et al.* (2001).

retirement accounts (IRA) on economic aggregates and welfare in the context of a general equilibrium model populated by either rational agents or agents with time-inconsistent preferences. Furthermore, the experimental economics literature documents some evidence that preferences show some degree of time inconsistency and agents suffer from temptation, a fact that further supports the results in the aforementioned studies.³

In this study, we would like to quantitatively assess the welfare implications of the reform of the current *unfunded* social security system into a partially funded or fully privatized one, under the assumption that agents face self-control problems. We proceed by assessing in terms of welfare a hybrid (partially funded) and a fully funded social security system under the alternative hypotheses of self-control or CRRA preferences. The apparatus by means of which we model departures from unfunded social security is a Personal Security Account (PSA). Within that class of "funded" models, we investigate two competing scenarios involving PSAs: one *without* annuitization and an alternative one that prescribes a mandatory annuitization of retirement benefits. More precisely we compare and contrast the implications of five different social security reforms:

- The first reform proposal (PSA) postulates the substitution of the current social security system by a two-tier scheme: a universal PAYG-financed basic pension combined with a Personal Security Account that does not require annuitization of benefits at retirement.
- The second reform proposal (PSAA) is similar to the first one except that it prescribes a mandatory annuitization of the funds accumulated in PSA accounts.
- The third reform proposal (PSAwoFT) postulates the removal of the PAYG-financed basic pension plan existing in the first reform proposal.
- Similarly, the fourth reform proposal (PSAAwoFT), suggests the removal of the PAYG-financed basic pension plan existing in the second reform proposal.
- Finally the fifth proposal (elimination) suggests the complete removal of the social security system.

Moreover, in order to capture our agents' temptation towards current consumption, our model economies make use of the preference structure pioneered by Phelps & Pollak (1968) and further elaborated by Gul & Pesendorfer (2004) to model self-control issues. Gul & Pesendorfer (2004) identified a particular class of utility functions that provide a *time-consistent* model suitable for addressing the preference reversals that motivated the time inconsistency literature. The key theme here is that self-control preferences assume that agents maximize a utility function that is a 'compromise' between the standard utility (or 'commitment' utility) and a 'temptation' utility. The conflicting ways by which agents derive utility in this setting, is the device through which the trade-off between the temptation to consume on the one hand,

³For a recent overview of studies that provide evidence that individuals indeed exhibit bias toward immediate gratification see Frederick *et al.* (2002).

and the long-run self interest of the agent on the other is captured. The main benefit is that self-control preferences remain perfectly time-consistent and, contrary to time-inconsistent preferences, allow agents in our model to commit.

With the exception of the aforementioned difference in the specification of preferences, our model specification follows that of Imrohoroglu *et al.* (2003) and Fuster *et al.* (2005). Furthermore, our economic environment features uninsurable individual income shocks, borrowing constraints and missing annuity markets.

We aim to contribute to the debate on the reform of social security. Our augmented model allows us to look at the welfare gains or losses due to the reforms from a different angle. In particular, it allows us to assess the welfare-enhancing potential of mandatory savings versus mandatory annuitization of accumulated PSA wealth at retirement. For the sake of comparability of our results, the particular specification of those alternative policies is purposely chosen to match the proposals analyzed in the literature (Storesletten *et al.* (1999) and Fuster *et al.* (2005)), as well as those featuring in the reform recommendations made by the 1997 Advisory Council on Social Security.

Moreover, changing the preference structure is very important for theoretical purposes because it enhances our understanding of the mechanics of similar models in the literature by providing an additional channel through which capital accumulation is distorted. Equally importantly, an augmented preference structure is also essential for providing a comprehensive comparison framework for policy makers in their evaluation of various proposals. As shown in Imrohoroglu *et al.* (2003), Kumru & Thanopoulos (2008), and Fehr *et al.* (2008) the presence of slightly far-sighted or current consumption favored agents changes substantially the welfare implications of the system.

Our results in this paper highlight the important role that self control preferences play, especially with regards to the kind of reform that could generate the highest welfare. When the analysis is restricted to CRRA preferences our findings initially are congruent with those obtained in other studies (e.g., Fuster *et al.* (2005)): we also find that the complete elimination of any social security ranks highly with regard to welfare maximization, although it turns out that one of our fully funded scenarios (not analyzed in Fuster *et al.* (2005)), namely *PSAAwoFT* is the reform scenario that generates the highest welfare. When self-control preferences are introduced instead, we come across a drastic alteration of these results: the *elimination* of social security becomes the least desirable policy reform from a welfare maximization standpoint, i.e. *PSAA* and *PSAAwoFT* reforms give rise to larger welfare improvements under self-control preferences.

Along the same lines, our research indicates that the clear-cut advantage of the *elimination* scenario under CRRA preferences (even if it is not the welfare maximizing alternative) fades away as self control becomes gradually more severe. Our robustness tests confirm this finding: in the case of relatively severe temptation the elimination of social security becomes the least desirable scenario.

Under the light of the above findings, any reform proposal regarding the social security sys-

tem should consider departures from standard preferences to preference specifications suitable for dealing with preference reversals.

The remainder of the paper is organized as follows. Section 2 provides a concise introduction to self-control preferences and time inconsistency. We briefly present and compare the two theories and attempt to shed light on the different implications they have for the question at hand. Section 3 presents our model economy. In section 4, we outline the parameter values. We present the results of our experiments and conduct sensitivity analysis in section 5. Finally, section 6 concludes.

2 Temptation and self-control preferences

In this section we briefly highlight the similarities and differences between time-inconsistent and self-control preferences, as well as motivate the use of the latter in this paper.

2.1 Time inconsistent preferences

In the standard OLG models, preferences are defined over sequences of lifetime consumption, $\{c_1, c_2, \dots, c_j, \dots, c_J\}$. If individuals in the economy have time consistent preferences, and a deterministic life-span is equal to J , the utility ranking of the lifetime consumption sequences will not depend on their standpoint j : ranking of these sequences will be invariant with respect to the time the ranking took place.

The essence of the time inconsistent preferences is that the aforementioned invariance result no longer holds: The discounting structure sets up a conflict between today's preferences and the preferences that will be held in the future, commonly labeled as a "preference reversal." For example, from today's perspective, the discount rate between two far-off periods, j and $j + 1$, is the long-term low discount rate, while from the time j perspective, the discount rate between j and $j + 1$ is the short-term high discount rate. This can be modeled by the following preference structure adapted to the purposes of our model from Laibson (1997):

$$U_j = E_j \left[u(c_j) + \delta \sum_{i=1}^{J-j} \beta^i u(c_{j+i}) \right].$$

When $0 < \delta < 1$, the above discounting structure can mimic the qualitative property of the generalized hyperbolic discounting function (namely a function implying discount rates that decline as the discounted event moves further away in time) but at the same time maintain most of the analytical tractability of the exponential discounting function. The preferences given in the above equation are dynamically inconsistent, in the sense that preferences at date j are inconsistent with preferences at date $j + 1$.⁴

⁴To check this note that the MRS between periods $j + 1$ and $j + 2$ consumptions from the standpoint of the decision maker at time j is given by $\frac{u'(c_{j+1})}{\delta u'(c_{j+2})}$, which is not equal to the MRS between those same periods from the standpoint of the decision maker at $j + 1$: $\frac{u'(c_{j+1})}{\beta \delta u'(c_{j+2})}$.

Note that a major consequence of the time inconsistent preferences is that the optimal policy functions derived at age j for ages $j' > j$ will no longer be optimal when the individual arrives at age j' ; and in the absence of any commitment technology, the individual's future behavior will deviate from that prescribed by the earlier policy functions.

2.2 Self-control preferences

An alternative way of modelling self-control issues is to use a class of utility functions identified by Gul & Pesendorfer (2004). They provide a time-consistent model that addresses the preference reversals that motivate the time inconsistency literature.

Consider a set B of consumption lotteries, and a two-period setting. Gul & Pesendorfer (2004) have shown that under a specific assumption on choice sets (set betweenness) combined with other standard axioms that yield the expected utility function $U(\cdot)$ defined as

$$U(B) := \max_{p \in B} \int (u(c) + v(c)) dp - \max_{p \in B} \int v(c) dp$$

that represents the preference relation implied by the above axioms. The function $u(\cdot)$ represents the individual's ranking over alternatives when she is committed to a single choice while when she is not committed to a single choice, her welfare is affected by the temptation utility represented by $v(\cdot)$. Note that when B is a singleton, the terms involving $v(\cdot)$ will vanish leaving only the $u(\cdot)$ terms to represent preferences. However, if it is e.g. $B = \{c, c'\}$ with $u(c) > u(c')$ an individual will succumb to the temptation (that is, she will pick the commitment utility-reducing alternative, c') only if the latter provides a sufficiently high temptation utility $v(\cdot)$ and offsets the fact that $u(c) > u(c')$, i.e., when

$$u(c') + v(c') > u(c) + v(c).$$

In this case the individual wishes she had only c as the available alternative, since under the presence of c' , she cannot resist the temptation of choosing the latter.

When the above inequality is reversed, however, the individual will pick c in the second period, albeit at a cost of $v(c') - v(c)$.⁵ We call the latter difference the “*cost of self-control*.”

In terms of the setting in the present paper, in every period an individual faces a consumption-savings problem. Each period, our individuals make a decision that yields a consumption for

⁵To see that, note that for $B = \{c, c'\}$ and $u(c) > u(c')$ we would have that

$$\begin{aligned} U(\{c, c'\}) &= \max_{c \in \{c, c'\}} u(c) + v(c) - \max_{\tilde{c} \in \{c, c'\}} v(\tilde{c}) = \\ &= u(c) + v(c) - v(\tilde{c}) \end{aligned}$$

and since by assumption $v(c') > v(c)$ this means that

$$U(\{c, c'\}) = u(c) - [v(c') - v(c)]$$

i.e. the utility of the choice c gets penalized by a positive number, the “cost of self-control.” Note that in the case $v(c') < v(c)$ i.e. when there is congruence of the utility functions as to which alternative is the best, there is no temptation issue anymore; c is chosen at no penalty since the $v(\cdot)$ terms in $U(\{c, c'\})$ cancel out.

that period and wealth for the next. However, each period these individuals face the temptation to consume all of their wealth, and hence, resisting to this temptation results in a self-control-related cost.

Under standard assumptions combined with the multi-period version of “set betweenness,” we can represent self-control preferences in a recursive form for the purposes of our J period model which is delegated to section 3.

The main difference between the above models is that the self control preferences do not imply dynamic inconsistency. Preferences are perfectly consistent. Moreover, it allows agents to exercise self-control, an option not existing in the time-inconsistent preferences. The difference in discounting was the source of preference reversals in the time-inconsistent preferences and the explanation of why individuals find immediate rewards tempting. Instead, Gul & Pesendorfer (2004)’s explanation assumes that agents maximize a utility function that is a “compromise” between the standard utility (or “commitment” utility) and a “temptation” utility.

Imrohoroglu *et al.* (2003) consider a setting similar to ours and analyze the consequences of time inconsistent preferences, while we follow the self-control paradigm in a similar finite-horizon setting. Gul & Pesendorfer (2004) show that for finite decision problems a time inconsistency model can be re-interpreted as a temptation model.

3 A Model of Social Security

The model we consider in this section is quite standard in the social security literature. In particular, our model follows that of Imrohoroglu *et al.* (2003).

3.1 The Environment

We consider a stationary overlapping generations economy in discrete time. Each period a new generation is born which is modeled to be n percent larger than the previous generation. Agents face lives of uncertain duration and some live through the maximum possible life span, denoted by J . At any given time j within their life-span, all agents have a (time-invariant) conditional probability $s_j \in (0, 1)$ of surviving from age $j - 1$ to j , conditional on having survived up to age $j - 1$. Our stationary population assumption implies that age j agents constitute a fraction μ_j of the population at any given date. The cohort shares $\{\mu_j\}_{j=1}^J$ are given by

$$\mu_{j+1} = \frac{\mu_j s_{j+1}}{1 + n},$$

while their sum is normalized to 1.

3.2 Preferences

Agents in our economy feature self-control preferences. That is, their preferences are such that in every period they induce a temptation to consume their entire wealth. Resisting temptation gives rise to a self-control cost; note that the latter feature is absent in models with CRRA

and quasi-hyperbolic preferences. We follow Gul & Pesendorfer (2004) and DeJong & Ripoll (2007) and proceed to model self-control preferences recursively.

Let $W(x)$ denote the maximized value of the expected discounted objective function with state x . The utility function of an agent is as follows:

$$W(x) = \max_c \{u(c) + v(c) + \beta EW(x')\} - \max_{\check{c}} v(\check{c}), \quad (1)$$

where E is the expectation operator; $u(\cdot)$ and $v(\cdot)$ are von Neumann-Morgenstern utility functions; $0 < \beta < 1$ is a discount factor; c represents the "commitment" consumption; \check{c} is the "temptation" consumption; and x' denotes next period state variable. As in the section above, $u(\cdot)$ represents the momentary utility function and $v(\cdot)$ represents temptation.⁶ In particular, $v(c) - \max_{\check{c}} v(\check{c})$ denotes the disutility from choosing consumption c instead of \check{c} .

The momentary utility and temptation functions are assumed to take the following forms respectively:

$$u(c) = \frac{c^{1-\gamma} - 1}{1-\gamma}; \quad (2)$$

$$v(c) = \lambda \frac{c^\rho}{\rho}. \quad (3)$$

In the specification above, higher values of the scale parameter $\lambda > 0$, imply an increase in the share of "temptation" utility, i.e. a higher λ increases the importance of current consumption for an agent. The momentary utility function $u(\cdot)$ is a standard Constant Relative Risk Aversion (CRRA) form, $\gamma > 0$ measures the degree of relative risk aversion (and $1/\gamma$ the inter-temporal elasticity of substitution).

3.3 Production Function

Firms have access to a constant returns-to-scale Cobb-Douglas technology that produces output (Y_t) by using labor input (L_t) and capital input (K_t) which is rented from households:

$$Y_t = F(K_t, L_t) = A_t K_t^\alpha L_t^{(1-\alpha)}, \quad (4)$$

where A_t represents the state of technology; $\alpha \in (0, 1)$ is the capital's share of output.⁷ Defining the capital-labor ratio as $\frac{K_t}{L_t}$, we can write the production function in the intensive form as follows:

$$y_t = f(k_t) = A_t k_t^\alpha.$$

⁶Notice that when $v(\cdot)$ is convex, we need to make sure that $v(\cdot) + u(\cdot)$ is strictly concave. In particular, $\gamma > 0$, $\rho > 1$ and $0 < \lambda < \gamma/(c^{\gamma+1}c^{\rho-2})$ guarantee that $u(\cdot)$ is concave, $v(\cdot)$ is convex and $u(\cdot) + v(\cdot)$ is strictly concave.

⁷Note that $L_t = 0.94 \sum_{j=1}^{j^*-1} \mu_j \epsilon_j$, where j^* denotes the compulsory retirement age and ϵ_j denotes the efficiency index of an age j agent.

The technology parameter A_t grows at a constant rate g and capital depreciates at a constant rate δ . Competitive firms in this economy maximize their profits by setting the real rate of return from asset holdings r and the real wage rate w according to the following:

$$r_t = A_t \alpha k_t^{\alpha-1} - \delta; \quad (5)$$

$$w_t = A_t (1 - \alpha) k_t^\alpha. \quad (6)$$

Since we are concerned only with the behavior of steady-state equilibria, we will henceforth drop the time subscript for the rest of the analysis.

3.4 Budget Constraints

The exogenously given mandatory retirement age is j^* . Agents who are younger than age j^* face a stochastic employment opportunity at each period $j < j^*$. Agents who find an employment opportunity, supply inelastically one unit of labor.⁸ We denote the employment state variable by $e \in \{0, 1\}$ where 0 and 1 denote unemployment and employment states respectively. Furthermore, we postulate that the employment state follows a first-order Markov process. The transition probability distribution between the current employment state e and next period's employment state e' is represented by the 2×2 matrix $\Pi(e', e) = [\pi_{k'k}]$ where $k', k = 0, 1$ and $\pi_{k'k} = \Pr\{e' = k' | e = k\}$.

An employed ($e = 1$) agent earns $w\epsilon_j$ where w denotes the wage rate per efficiency unit of labor in terms of the consumption good and ϵ_j denotes the efficiency index of an age j agent. If, on the other hand, an agent is unemployed ($e = 0$), he receives an unemployment insurance benefit equal to a fraction ϕ of the wage of an employed agent, resulting in the amount $\phi w\epsilon_j$; ϕ is the unemployment insurance replacement ratio.

The disposable (after-tax) income of an agent at age j can be written as

$$q_j = \begin{cases} (1 - \tau_s - \tau_u - \kappa)w\epsilon_j & \text{for } j = 1, 2, \dots, j^* - 1, \text{ if } e = 1; \\ \phi w\epsilon_j & \text{for } j = 1, 2, \dots, j^* - 1, \text{ if } e = 0; \\ b_j & \text{for } j = j^*, j^* + 1, \dots, J, \end{cases}$$

where τ_s , τ_u , κ represent the social security payroll tax rate, the unemployment insurance tax rate, and compulsory contribution deposit rate for personal security accounts respectively. The parameter κ is greater than zero for employed agents if PSAs exist in the economy, otherwise, $\kappa = 0$. The details for the law of motion of PSAs are given in the next section.⁹

We assume away any private insurance markets against unemployment risk and private annuities' markets against the risk of outliving one's own resources.¹⁰ The only available

⁸ Adding labor-leisure choice into the model requires the modification of preferences in a way that agents are not only tempted by current consumption but also by current leisure.

⁹ Note that in the US social security system both retirement and unemployment benefits are taxed (Diamond & Orszag (2005)). For the sake of less cumbersome notation we refrain from incorporating those taxes in our analysis.

¹⁰ Although a market for private annuities exists in the U.S. it is nevertheless very thin (Feldstein & Liebman

device to smooth consumption across one's lifetime is the accumulation of assets in terms of physical capital. Agents cannot hold negative assets at any period.¹¹ Since death is certain at J and there is no bequest motive, the borrowing constraint can be stated as:¹²

$$\begin{cases} a_j \geq 0 & \text{for } j = 1, \dots, J-1; \\ a_j = 0 & \text{for } j = J. \end{cases}$$

We can now proceed to write the budget constraint of an agent as follows:

$$a_j + c_j = (1+r)a_{j-1} + q_j + \eta; \quad (7)$$

$$a_j + \check{c}_j = (1+r)a_{j-1} + q_j + \eta, \quad (8)$$

where r is the rate of return from asset holdings and η denotes the amount of accidental bequests, to be distributed equally to all alive members of the society.

3.5 Social Security and Fiscal Policy

We consider five distinct social security arrangements, out of which the first three are: (i) a simple Pay-As-You-Go (*PAYG*) system, (ii) a two-tier hybrid system featuring a Personal Security Account *without* annuitization (*PSA*), and (iii) a two-tier hybrid system featuring a Personal Security Account *with* mandatory annuitization (*PSAA*). Systems (ii) and (iii) bear an unfunded component (as their first tier) in their structure.

In contrast, the latter two systems have a fully-funded structure, but their construction merely entails the shutting down of the unfunded component from the aforementioned two-tier constructs. We henceforth label the fully-funded scenarios stemming from scenarios (ii) and (iii) by just stripping them of their unfunded feature, as (iv) *PSAwoFT* and (v) *PSAAwoFT* respectively.

We follow Fuster *et al.* (2005) as far as our modelling of Personal Security Accounts is concerned.

(2002), Imrohoroglu *et al.* (1995)). Hence, our assumption seems innocuous. In our model, social security partially fulfills the role of the missing annuities' market (it can be considered as mandatory annuitization). Diamond *et al.* (2005) analyze thoroughly the relationship between annuities and individual welfare. He shows that full annuitization of wealth is optimal under certain conditions.

¹¹In other words, an agent faces a borrowing (or liquidity) constraint. Given the size of private credit markets, this assumption may not seem so innocuous. There are two main reasons behind this assumption: First, we would like to engage in a careful comparison of our results with those of the existing social security literature where this assumption is a standard one. Second, the fact that agents are not allowed to borrow against their future income induces an additional boost in (private) savings for precautionary purposes, since they may become/remains unemployed with a positive probability. It would be a fair question to explore the consequences of alleviating this constraint in our environment and allow borrowing against future income. In that case however, the ability to borrow would lower agents' marginal propensity to save (for precautionary reasons), thus implying that the effects of self-control and ability to borrow against future income are highly correlated; consequently, the effect of social security on savings due to self-control will be non-identifiable. In a recent paper, Rojas & Urrutia (2008) show that adding an endogenous borrowing constraint reduces the welfare cost of having a social security.

¹²Allowing a bequest motive does change the welfare implications of a social security system. Fuster *et al.* (2003) make a welfare analysis of social security in a dynastic framework and show that steady state welfare increases with social security.

3.5.1 PAYG

A *PAYG* system in our model economy resembles to that of the US Economy. Agents retire at age j^* and receive social security benefit b . The social security benefit b is defined as a fraction θ of an average life-time employed income, which is, notably, independent of a particular agent's employment history.

$$b_j = \theta \frac{\sum_{j=1}^{j^*-1} w\epsilon_j}{j^*-1} \quad \text{for } j = j^*, j^* + 1, \dots, J.$$

The social security system is self-financing and the government administers the program. We restrict our attention to social security arrangements that are described by the pair (θ, τ_s) . The self-financing condition is as follows:

$$\tau_s \sum_{j=1}^{j^*-1} \sum_a \mu_j \Lambda_j(a, e=1) w\epsilon_j = \sum_{j=j^*}^J \sum_a \mu_j \Lambda_j(a, e) b_j, \quad (9)$$

where $\Lambda_j(a, e)$ is the set of age dependent, time invariant measures of agents.

If agents in this economy die before age J , their remaining assets will be distributed evenly to all of the survivors in a lump-sum fashion as follows:

$$\eta = \sum_j \sum_a \sum_e \mu_j \Lambda_j(a, e) (1 - s_{j+1}) a_j(a, e). \quad (10)$$

3.5.2 Personal Security Accounts without Annuitization (*PSA*)

In this section, we consider a two-tier social security system. The first tier is a *PAYG*-financed universal flat pension benefit. The amount of benefit is set as 18% of the per capita gross domestic product (GDP). As in the above benchmark case, the first tier is self-financing and administered by the government.

$$\tau_s \sum_{j=1}^{j^*-1} \sum_a \mu_j \Lambda_j(a, e=1) w\epsilon_j = \sum_{j=j^*}^J \sum_a \mu_j \Lambda_j(a, e) b^*,$$

where $b^* = 0.18y$ and $y = w/(1 - \alpha)$.

Hence, the equilibrium tax rate can be found by using the equation below:

$$\tau_s = \frac{0.18}{1 - \alpha} \frac{\sum_{j=j^*}^J \sum_a \mu_j \Lambda_j(a, e)}{\sum_{j=1}^{j^*-1} \sum_a \mu_j \Lambda_j(a, e=1) \epsilon_j}.$$

The second tier of retirement benefits is financed through mandatory savings. In this setting, employed agents are required to deposit 5% of their earnings into their privately managed personal savings account. The funds on *PSA* earn the tax-free rate of return on capital and

they cannot be withdrawn until the mandatory retirement age. Agents' second-tier benefits depend on the funds accumulated in their PSAs. The law of motion for the PSA is the following:

$$\begin{aligned}(1+g)\varkappa_{j+1} &= (1+r)\varkappa_j + \kappa w \epsilon_j; \\ \varkappa_1 &= 0,\end{aligned}\tag{11}$$

where $\kappa = 0.05$ is the required deposit rate and \varkappa_{j+1} denotes an age $j+1$ individual's accumulated PSA funds. agents receive a lump-sum transfer of funds accumulated in their PSAs when they are retired at age j^* . Hence, retirement benefits can be written as follows:

$$b_j = \begin{cases} b^* + (1+r)\varkappa_{j^*}, & \text{for } j = j^*; \\ b^*, & \text{otherwise.} \end{cases}$$

If an individual dies before one's retirement, the accumulated funds in his PSA account are distributed to the remaining members of the society in a lump-sum fashion along with their assets:

$$\eta = \sum_j \sum_a \sum_e \mu_j \Lambda_j(a, e) (1 - s_{j+1}) [a_j(a, e) + \varkappa_j(e)].\tag{12}$$

3.5.3 Personal Security Accounts with Mandatory Annuitization (*PSAA*)

We consider a two-tier pension system here as well. While the first tier is exactly the same as that of the previous section, the second tier differs. The government annuitizes funds accumulated in agents' PSAs and hence, agents receive annuity payments equal to $b' = p(1+r)\varkappa_{j^*}$, where p denotes the proportion, i.e. the amount of an annuity payment received by an individual, which is obviously proportional to the accumulated funds in his PSA account, and is determined endogenously.

The government sets the proportion p in such a way that the expected present value of the aggregate annuity payments of the generation that retires now (\bar{E}) is equal to the funds held in PSAs, including the funds of agents from the same generation who died before their retirement. The expected present value of the aggregate annuity payments of the generation that retires now is equal to the following:

$$\bar{E} = p(1+r)\varkappa_{j^*} \sum_{j=j^*}^J \left(\frac{1+g}{1+r}\right)^{j^*-j} \prod_{i=1}^{j-1} \mu_i.$$

The aggregate funds of the agents from the same generation who survived to retirement and who died before their retirement are given as

$$(1+r)\varkappa_{j^*} \prod_{i=1}^{j^*-1} \mu_i$$

and

$$(1+r) \sum_{j=2}^{j^*} \left(\frac{1+r}{1+g} \right)^{j^*-j} \varkappa_j (1 - \mu_{j-1}) \prod_{i=1}^{j-2} \mu_i$$

respectively. Hence, the proportion p can be written as follows:

$$p = \frac{(1+r) \varkappa_{j^*} \prod_{i=1}^{j^*-1} \mu_i + (1+r) \sum_{j=2}^{j^*} \left(\frac{1+r}{1+g} \right)^{j^*-j} \varkappa_j (1 - \mu_{j-1}) \prod_{i=1}^{j-2} \mu_i}{(1+r) \varkappa_{j^*} \sum_{j=j^*}^J \left(\frac{1+g}{1+r} \right)^{j^*-j} \prod_{i=1}^{j-1} \mu_i}. \quad (13)$$

Because agents' survival rates do not depend on their types in our model economy, the above return is actuarially fair: It could be offered by private firms and there is no need for government intervention. Yet, in our model, the private annuity market is closed by assumption and hence the government has to administer it. If agents' survival rates were type-dependent, the above equation would yield an actuarially not fair premium. This, in turn, would call for government intervention because adverse selection issues would cause a market breakdown.

The law of motion of the funds aggregated in PSA by the government is the following:

$$(1+n)(1+g)F_{t+1} = (1+r)F_t + \kappa wL - B',$$

where $\kappa = 0.05$ is the compulsory deposit rate, $L = 0.94 \sum_{j=1}^{j^*-1} \mu_j \epsilon_j$ is the aggregate labor supply,

and $B' = \sum_{j=j^*}^J b'(1+g)^{j^*-j} \mu_j$ is the aggregate annuity payment at time t .

Hence, the expression for retirement benefits featuring PSAs under a mandatory annuitization scheme can be written as follows:

$$b_j = b^* + b' \text{ for } j = j^*, \dots, J.$$

In addition to a social security program, the government also runs a self-financing unemployment program. The self-financing condition for the unemployment insurance program is as follows:

$$\tau_u \sum_{j=1}^{j^*-1} \sum_a \mu_j \Lambda_j(a, e=1) w \epsilon_j = \sum_{j=1}^{j^*-1} \sum_a \mu_j \Lambda_j(a, e=0) \phi w \epsilon_j, \quad (14)$$

where ϕ is the unemployment insurance replacement rate.

3.5.4 Fully-funded scenarios: (iv) *PSAwoFT* and (v) *PSAAwoFT*

Scenarios (iv) and (v) are obtained by simply shutting down the unfunded component of scenarios (ii) and (iii) respectively. So essentially, they constitute "fully-funded" social security

systems and hence, naturally, $\tau_s = 0$ in both cases. In what follows our analysis distinctly investigates the welfare implications of those two scenarios and compares them with social security systems that feature an unfunded component (such as (i)-(iii)) as well as with the complete absence of social security.

3.6 An Agent's Dynamic Program

We assume that the temptation function $v(\cdot)$ is strictly increasing, i.e. an agent is tempted to consume his entire wealth in each period. This implies that the agent maximizes the second part of equation (1) by holding zero assets for the next period, i.e. setting $a_j = 0$ in equation (8). In this economy, the agent's state vector x contains the current asset holdings and the employment state. Hence, we can write the agent's dynamic program for any arbitrary two periods as follows:

$$W(x) = \max_c \{u(c) + v(c) + \beta E_{s'} W(x')\} - v((1+r)a + q + \eta) \quad (15)$$

subject to

$$a' + c = (1+r)a + q + \eta, \quad a' \geq 0, \quad a_0 \text{ is given.} \quad (16)$$

$E_{s'}$ denotes the expectation over survival probabilities.

If the agent succumbs to temptation and consumes his entire wealth, the term $v(c) - v((1+r)a + q + \eta)$ in the equation above cancels out. When he resists to temptation and consumes less than his wealth, he faces a self-control cost at the amount of $v(c) - v((1+r)a + q + \eta)$. The agent tries to balance his urge for utility from current consumption $v(c)$ and long-term commitment utility $u(c) + \beta E_{s'} W(x')$.

3.7 Steady State Equilibrium

In our characterization of the steady-state equilibrium, we follow Imrohoroglu *et al.* (2003) and Hugget & Ventura (1999).

Given a set of government policy $\{\theta, \phi, \tau_s, \tau_u, \kappa\}$, a steady-state recursive competitive equilibrium is a set of value functions $\{W_j(x)\}_{j=1}^J$, household policy rules $\{a_j(x)\}_{j=1}^J$, time-invariant measures of agents $\{\Lambda_j(x)\}_{j=1}^J$, wage and interest rate (w, r) , and a lump-sum distribution of accidental bequests η such that all of them satisfy the following:

- Factor prices (w, r) that are derived from the firm's first-order conditions satisfy the equations (5) and (6).
- Given the government policy set $\{\theta, \phi, \tau_s, \tau_u, \kappa\}$, the factor prices (w, r) , and the lump-sum transfer of accidental bequests η , an agent's policy rule $\{a_j(x)\}_{j=1}^J$ solves the agent's maximization problem (15) subject to the budget constraint (16).

- Aggregation holds:

$$K = \sum_j \sum_a \sum_e \mu_j \Lambda_j(x) [a_{j-1}(x) + \kappa_j]. \quad (17)$$

- The set of age-dependent, time-invariant measures of agents satisfies in every period j :

$$\Lambda_j(x') = \sum_e \sum_a \Pi(e', e) \Lambda_{t-1}(x), \quad (18)$$

where Λ_1 is given.

- The lump-sum distribution of accidental bequests η satisfies the equation (10) if the *PAYG* or *PSAA* programs are in use, or else it satisfies the equation (12) if the *PSA* program is in use.
- Both the social security system and the unemployment insurance benefit program are self-financing.
- The market clears:

$$\begin{aligned} & \sum_j \sum_a \sum_e \mu_j \Lambda_j(x) [a_j(x) + \kappa_j(x) + c_j(x)] \\ = & Y + (1 - \delta) \sum_j \sum_a \sum_e \mu_j \Lambda_j(x) [a_{j-1}(x) + \kappa_{j-1}(x)]. \end{aligned} \quad (19)$$

4 Calibration

In this section, we briefly define the parameter values of our model. Each period in our model corresponds to a calendar year.

4.1 Demographic and Labor Market Parameters

Agents are born at a real life age of 21(model age of 1) and they can live up to a maximum real life age of 85 (model age of 65). The population growth rate n is assumed to be equal to the average U.S. population growth rate between 1931-2003 which corresponds, on average, to 1.19% per year.¹³ The sequence of conditional survival probabilities is the same as the Social Security Administration's sequence of survival probabilities for men in the year 2001. The mandatory retirement age is equal to 65 (model age 45). In order to set the efficiency index, we choose the average of Hansen (1993)'s estimation of median wage rates for males and females for each age group. We interpolate the data by using the Spline Method and normalize the interpolated data to average unity. The employment transition probabilities are chosen to be compatible with the average unemployment rate in the U.S. which is approximately equal to 0.06 between 1948 and 2003.¹⁴ The implied employment transition matrix assumes the following

¹³The population data are obtained from the U. S. Census Bureau (U.S. Census Bureau (2006)) .

¹⁴The unemployment data are taken from the U. S. Department of Labor (US Department of Labor (2006)).

form:

$$\Pi(e, e') = \begin{bmatrix} 0.94 & 0.06 \\ 0.94 & 0.06 \end{bmatrix}.$$

4.2 Preference Parameters

We choose the values of preference parameters ρ, γ, λ and β in such a way that our model economy's capital-output ratio matches that of the U.S. economy.

Following Imrohoroglu *et al.* (2003) and DeJong & Ripoll (2007), we let the risk aversion parameter, γ , be equal to 2. When agents have standard CRRA preferences we choose the value of time-discounting factor, β , in such a way that the model economy's capital-output ratio matches with the long-term average of the U.S. economy. When agents have self-control preferences, holding γ constant, we choose different values of ρ *a priori*, and calculate the corresponding values of λ in such a way that $u(.) + v(.)$ stays a strictly concave function. Our parameter value choices for λ are smaller than the estimates made by DeJong & Ripoll (2007) and Huang *et al.* (2007). This allows us to keep the strength of temptation quite low.¹⁵ For every triple ρ, γ and λ , we search over the values of β that deliver the capital-output ratio which is compatible with its empirical counterpart. We assume that the social security replacement ratio is 41% and the unemployment replacement ratio is 25% during our search.

4.3 Production Parameters

The parameters describing the production side of the economy are chosen to match the long-run features of the U.S. economy. Following Imrohoroglu *et al.* (2003), we set the capital share of output α equal to 0.31 and the annual depreciation rate of physical capital equal to 4.4%. The rate of technological progress g is assumed to be equal to 2.1%, which is the actual average growth rate of GDP per capita taken over the time interval from 1959 to 1994 (Hugget & Ventura (1999)). The technology parameter A , can be chosen freely. In our calibration exercises, it is set equal to 1.01. All per capita quantities are assumed to grow at a constant rate g .

4.4 Government

We set the unemployment insurance replacement ratio (ϕ) equal to 25% of the employed wage. In the benchmark case, we set the social security replacement ratio (θ) equal to 41%, which is approximately equal to the average replacement rate of the social security system in the US. Alternatively, we can choose the payroll tax rate (τ_s) and the unemployment insurance tax rate (τ_u) instead of the replacement ratios. Since the social security and the unemployment insurance benefits are self-financing, calibrating the replacement ratios will automatically pin-down the tax rates. This holds true because agents inelastically supply one unit of labor whenever they find an opportunity to work, and changes in tax rates do not affect their supply

¹⁵Note that the theoretical literature on temptation and self-control problems is still developing and hence, there are only a few empirical studies that attempt to estimate the parameters of self-control preferences.

of labor.¹⁶ The first tier universal benefits are set equal to 18% of per capita GDP and the compulsory deposit rate for second tier benefits κ is set equal to 5%.

4.5 Solution Method

We use discrete-time, discrete-state optimization techniques to find a steady-state equilibrium of our hypothetical economy by using the aforementioned parameter values. Our solution method designedly resembles those of previous studies.¹⁷

A discrete set of asset values (containing 4097 points) is created. The lower bound and upper bound of the set are chosen in such a way that the set never binds.¹⁸ While the state space for working age agents comprises 4097×2 points, the state space for retired agents consists of only 4097×1 points (since there is no state transition after j^*). The discrete set of the control variable (consumption) contains 4097×1 points. We start with a guess about the aggregate capital stock and the level of accidental bequests and then solve agents' dynamic program by backward recursion. The time-invariant, age-dependent distribution of agents is obtained by forward recursion. After each loop, we calculate the new values for the accidental bequests and the capital stock. If the difference between the initial values and the new values exceed the tolerance value, we start a new loop with the new values. This procedure continues until we find values for the accidental bequests and the capital stock that are sufficiently close to their beginning-of-loop values.

Demographics	
Maximum possible life span T	65
Obligatory retirement age t^*	45
Growth rate of population n	1.19%
Conditional survival probabilities $\{s_t\}_{t=1}^T$	U.S. 2001
Labor efficiency profile $\{\epsilon_j\}_{j=1}^{t^*-1}$	Hansen (1993)
Production	
Capital share of GDP α	0.310
Annual depreciation of capital stock δ	4.4%
Annual per capita output growth rate g	2.1%
Markov Process for employment transition Π	$\begin{bmatrix} 0.94 & 0.06 \\ 0.94 & 0.06 \end{bmatrix}$
Government	
Unemployment insurance replacement ratio ϕ	25%
Social security replacement ratio θ	41%
Compulsory deposit rate κ	5%

Table 1: Parameter Values

¹⁶However, if we calibrate a model featuring labor-leisure choice, tax rates should be used instead of replacement rates.

¹⁷See Imrohoroglu et al. (1995 and 2003) and Hugget and Ventura(1999).

¹⁸In particular, the lower bound is equal to 0 and the upper bound is equal to 60 times greater than the annual income of an employed agent.

5 Results

Social security reform has long been the subject of an intense debate among academics and policy makers. Many directions towards which social security should be reformed have been proposed over the years. However, the most commonly cited direction of departure from a typical *PAYG* system is the partial or full abolishment of its unfunded component, that is, a move towards a partially or fully-funded social security system.

Although the elimination of a *PAYG* social security system is one policy option (although a sledgehammer-like one), gradually transforming the system into a partially or fully-funded one could very well be alternative policies worth investigating. The types of *PSA* and *PSAA* policies we analyze in this paper are similar to the ones analyzed Storesletten *et al.* (1999) and Fuster *et al.* (2005) and those proposed in the reform recommendations made by the 1997 Advisory Council on Social Security.¹⁹

The novelty of this paper consists in the fact that it revisits these reform proposals, along with two additional policies, through the lens of self-control preferences.²⁰ The large and growing literature on time inconsistency and self-control issues suggests that preference specifications capturing agents' self-control problems might provide richer insights to the observed behavior of agents [for example, see Frederick *et al.* (2002)]. Needless to say, both time inconsistent preferences à la Phelps & Pollak (1968) and self-control preferences à la Gul & Pesendorfer (2004) have been extensively used in an attempt to shed light to various macroeconomic problems, with issues pertaining to social security being among the most prominent ones.

More specifically, Imrohoroglu *et al.* (2003) analyze the welfare implications of the elimination of a *PAYG*-type social security system in an economy populated by agents with time inconsistent preferences while Kumru & Thanopoulos (2008) analyze the same policy proposal in an economy populated by agents with self control preferences. The latter study concludes that the welfare implications of the elimination of the *PAYG* system may vary drastically even if agents' self control problems differ only to a small extent.

Our purpose here is to investigate whether self control preferences have a commensurable impact on social security arrangements that have a partial or fully-funded character.

In summary, we subsequently proceed to look thoroughly at the implications of the following five reform proposals:

- The first reform proposal (*PSA*) postulates the substitution of the current social security system by a two-tier scheme: a universal *PAYG*-financed basic pension combined with a Personal Security Account that does not require annuitization of benefits at retirement.
- The second reform proposal (*PSAA*) is similar to the first one except that it prescribes a mandatory annuitization of the funds accumulated in *PSA* accounts.

¹⁹Please consult Fuster *et al.* (2005) for a detailed exposition of the reform proposals with regard to the US social security system.

²⁰These extra policies emerge as straightforward transformations of the ones proposed in Storesletten *et al.* (1999) and Fuster *et al.* (2005) and hence they are comparable.

- The third reform proposal (*PSAwoFT*) postulates the removal of the PAYG-financed basic pension plan existing in the first reform proposal. It is therefore a fully-funded system which, nevertheless, does not require annuitization of benefits at retirement. In terms of our model this amounts to zeroing out τ_s in the *PSA* scenario.
- Similarly, the fourth reform proposal (*PSAAwoFT*), suggests the removal of the PAYG-financed basic pension plan existing in the second reform proposal. It is therefore again a fully-funded system which, in contrast to *PSAwoFT*, prescribes mandatory annuitization of benefits at retirement. In terms of our model this amounts to setting $\tau_s = 0$ in the *PSAA* scenario.
- Finally the fifth proposal (*elimination*) suggests the complete removal of the social security system; in terms of our model, this amounts to postulating that the social security replacement ratio is equal to zero.

The results of our calibrations are presented in two parts: in the first part, we perform our calibrations under the assumption that agents have CRRA preferences while in the second part we examine the quantitative and qualitative implications that self-control preferences bear on the relative appeal of the these reform proposals.

5.1 CRRA Preferences

In this section we first calibrate our model economy to the US data under the assumption that agents have CRRA preferences and that a *PAYG* system similar to that of the US is in use. We choose the social security replacement rate as 41% since it corresponds to the current average social security replacement rate in the US. Our aim is to gradually converge to the long term average of the US capital-output ratio of 2.5.

The effects that the five competing scenarios have on economic aggregates, as well as their welfare implications are given in Table 2, for the case where agents have CRRA preferences. The welfare implications of a given policy are measured in terms of the average expected utility (*EU*) and it is shown in the last column of Table 2. Both our first reform proposal (featuring as "*PSA*" in Table 2) and our second one (featuring as "*PSAA*" in Table 2) prescribe a specific (given) rate of mandatory savings. We assume that the mandatory savings rate, denoted by κ , is equal to 5% of the gross individual labor income. As a consequence, agents' payments to the social security system across *PAYG*, *PSA*, and *PSAA* policies are essentially equivalent. It is a well established result in the literature that fully, or partially funded social security systems induce an increase in capital accumulation as well as in other aggregate variables such as consumption and output [e.g. Storesletten *et al.* (1999)]. However, the exact magnitude of increase in those aggregate variables is sensitively dependent to the features of the model. Fuster *et al.* (2005) demonstrate that the increases in the absolute levels of aggregate variables are more moderate in an economy populated by altruistic agents compared to an economy without altruistic agents. Previous studies [Imrohoroglu *et al.* (1995), Imrohoroglu *et al.*

(2003), and Hugget & Ventura (1999)] also demonstrated that decreasing the social security replacement rate improves the social welfare whenever agents have CRRA preferences. Their key finding was that the complete elimination of a *PAYG* system would deliver the highest social welfare.

In all tables, the values of the levels of economic aggregates as well as the average expected utility are normalized to 100 under a *PAYG* system. The values of the various reform proposals are calculated accordingly. In Table 2, we set $\beta = 0.9865$.

	$\tau_s(\%)$	$\kappa(\%)$	K	Y	C	K/Y	EU
PAYG	9.37	0	100	100	100	2.5	100
PSA	4.2	5	115.712	104.629	101.633	2.8	102.790
PSAA	4.2	5	117.448	105.111	101.767	2.8	103.550
PSAwoFT	0	5	124.732	107.086	102.305	2.9	104.490
Elimination	0	0	118.657	105.462	101.850	2.8	104.591
PSAAwoFT	0	5	125.340	107.250	102.357	2.9	104.890

Table 2: CRRA Preferences

Our results in Table 2 are consistent with those of previous studies mentioned above. Since both *PSA* and *PSAA* reform proposals entail less distortion on savings than *PAYG*, something that comes as a direct consequence of the lower payroll tax associated with those scenarios, the level of capital stock in both cases is higher than that of a *PAYG* system. Not surprisingly, the complete *elimination* of a *PAYG* system which, by definition, is associated with a payroll tax equal to zero, also induces an even higher capital stock compared not only to that of *PAYG* but also with respect to the capital stock levels in *PSA* and *PSAA* reforms. Moreover, contrary to results obtained in the dynastic framework of Fuster *et al.* (2005), all scenarios that involve a payroll tax equal to zero (*elimination*, *PSAwoFT*, *PSAAwoFT*) generate a higher capital stock than *PSA* and *PSAA*, a quite intuitive result. Note that the aggregate capital stocks in economies with *PSAA* and *PSAAwoFT* are larger than the respective capital stocks in *PSA* and *PSAwoFT*, i.e., the annuitization of funds in *PSA* accounts generates a higher capital stock. The reason is simple: annuitized funds decumulate slower than non-annuitized funds.

From a welfare standpoint, our *PSAAwoFT* scenario [not examined in Fuster *et al.* (2005)] yields the highest welfare improvement, closely followed by *PSAwoFT* [not analyzed in Fuster *et al.* (2005) either] and the complete *elimination* of social security. This happens because in a CRRA environment *PSAAwoFT*, *PSAwoFT* and *elimination* allow agents to engage in consumption smoothing more efficiently than the other proposed reforms, since they prescribe a zero payroll tax.

In summary, our two additional experiments *PSAAwoFT* and *PSAwoFT* allowed us to see more crisply the reasons for the preponderance of fully-funded systems over partially funded ones (such as *PSA*, *PSAA*) in a CRRA setting, and (naturally) *a fortiori* over *PAYG*. However, the additional insight we get here compared to Fuster *et al.* (2005) is that the appeal of *elimination* seems to have much more to do with the zero payroll tax rather than the unnecessary

of social insurance for CRRA agents as it has been argued: our results manifest that CRRA agents *do* value some form of social insurance.

5.2 Self-Control Preferences

In this section we present our results for an economy in which agents have self-control preferences and we compare the effects of the aforementioned five reform proposals on both economic aggregates and social welfare. Before presenting our results for the benchmark case, we first explain the behavioral implications of the existence of temptation and then quantify the effects of temptation on economic aggregates. We then proceed by quantifying the steady-state levels of capital accumulation and consumption under the assumption that agents have self-control preferences.

By keeping the annual discount factor at its CRRA level, we first fix ρ at 2 and vary λ then we fix λ at 0.00009 and vary ρ . Tables 3 and 4 display our results for both cases. Table 3 demonstrates that an increase in the intensity of temptation distorts capital accumulation severely and causes a reduction in steady-state consumption.

λ	K	Y	C	K/Y	r
<i>CRRA</i>	100	100	100	2.8	0.066
$\lambda = 0.0004$	75.507	91.647	96.682	2.3	0.090
$\lambda = 0.001$	62.020	86.221	93.759	2.0	0.109

Table 3: Changes in the Strength of λ

Similarly, Table 4 shows the effects of an increase in an individual's willingness to substitute current temptation consumption with future temptation consumption. Higher values of ρ mean that agents prefer more current temptation consumption. Not surprisingly, higher values of ρ result in a reduction in the steady-state level of capital, which in turn causes a reduction in the steady-state level of consumption.

ρ	K	Y	C	K/Y	r
<i>CRRA</i>	100	100	100	2.8	0.066
$\rho = 2$	91.627	97.314	99.097	2.6	0.073
$\rho = 3$	61.993	86.213	93.749	2.0	0.109

Table 4: Changes in the Strength of γ

Our model provides the opportunity to compare the effects of two opposite factors on savings (capital accumulation). While the existence/availability of PSAs causes an increase in savings, agents with self-control preferences save less in order to escape from the huge self-control cost associated with resisting temptation once the accumulated assets become available. We present our results in Table 5. We set $\rho = 2$, $\lambda = 0.000375$, and $\beta = 1.00092$. The effects of the five reform proposals on economic aggregates and social welfare are significantly different from those

we documented in Table 2 for an economy populated by agents featuring CRRA preferences. In particular, the highest levels average expected utility are reached under the *PSAA* reform scenario. However, the highest levels of capital stock are achieved under *PSAAwoFT* a reform scenario that also ranks in the second position when it comes to average expected utility.

One immediate observation could be that the annuitization feature present on both of these scenarios is valued considerably by self-control agents.

	$\tau_s(\%)$	$\kappa(\%)$	K	Y	C	K/Y	EU
PAYG	9.37	0	100	100	100	2.5	100
Elimination	0	0	113.621	104.025	101.406	2.7	99.556
PSAwoFT	0	5	125.516	107.282	102.367	2.9	102.265
PSA	4.2	5	119.022	105.527	101.923	2.8	102.778
PSAAwoFT	0	5	129.145	108.229	102.646	3.0	103.669
PSAA	4.2	5	123.270	106.686	102.212	2.9	104.175

Table 5: Self-Control Preferences

For the sake of a more concise comparison, we created Table 6; this table presents the levels of capital stock and average expected utility under the five alternative reform proposals for both CRRA and self-control cases. Table 6 reveals that while the *elimination* reform scenario yields the second highest welfare in the *CRRA* case (numerically very close to the highest ranking scenario), *PSAA* is the reform that yields the highest welfare in the self-control case while most notably, *elimination* becomes the least desirable reform scenario for self control agents. The intuition is the following: working-age agents with self-control preferences are tempted to consume their entire wealth each period. Payroll taxes help those agents to reduce their cost of exerting self-control in order to resist temptation. This additional benefit provided by a *PAYG* system, or by a two-tier system featuring a *PAYG* component, gives rise to welfare improvement.

Hence, the *PSA* reforms by construction provide the same additional benefit to working-age agents as the *PAYG* system. Although under CRRA preferences the *elimination* scenario results in the second highest welfare gain, the welfare benefits under almost all competing scenarios are higher under self-control preferences. The reason why this obtains is simple: reforms featuring a personal security account (*PSAA*, *PSAAwoFT*, *PSA*, and *PSAwoFT*) not only provide the additional benefit of a *PAYG* system but also come with higher retirement provisions. In addition, while CRRA agents prefer *PSAwoFT* and *PSAAwoFT* schemes to *PSA* and *PSAA* schemes respectively, self-control agents prefer *PSA* and *PSAA* schemes to *PSAwoFT* schemes without first tiers. This is interesting in that it shows that self-control agents exhibit a strong demand for a *PAYG* financed pension program in order to eliminate their costs from exposure to temptation. Although, the current *PAYG* program decreases agents' self-control cost, this benefit is not large enough to offset social security's negative impact on aggregate savings. However, when a *PSA* is in use, a *PAYG* financed universal pension program provides sufficient relief without inflicting a significant distortion on aggregate savings, and

consequently, we see that agents in economies with PSA and PSAA eventually enjoy higher expected utilities.

	CRRA		Self-Control	
	K	EU	K	EU
PAYG	100	100	100	100
PSA	115.712	102.790	119.022	102.778
PSAA	117.448	103.550	123.270	104.175
PSAwoFT	124.732	104.490	125.516	102.265
PSAAwoFT	125.340	104.890	129.145	103.669
Elimination	118.657	104.591	113.621	99.556

Table 6: Comparison

Finally we check the case where agents face an extremely severe self-control problem. For this purpose we set the temptation function parameters ρ and λ equal to 2 and 0.000750 respectively. We choose $\beta = 1.026$ in order to converge to the long-term capital-output ratio of the US economy when a *PAYG* system is in use. Table 7 below presents the results.

	$\tau_s(\%)$	$\kappa(\%)$	K	Y	C	K/Y	EU
PAYG	9.37	0	100	100	100	2.5	100
Elimination	0	0	110.442	103.123	101.107	2.7	94.647
PSAwoFT	0	5	125.963	107.416	102.410	2.9	99.294
PSA	4.2	5	120.893	106.083	102.089	2.8	101.903
PSAAwoFT	0	5	129.982	108.487	102.741	3.0	102.336
PSAA	4.2	5	125.592	107.326	102.513	2.9	104.745

Table 7: Severe Temptation

As it can be seen in Table 7, the current *PAYG* system dominates the *elimination* reform by generating higher welfare. Since *PSA* and *PSAA* provide the same additional benefit as *PAYG*, it comes as no surprise that in the case of severe temptation they end-up performing better than the *elimination* scenario.

Because of higher retirement benefits, in this environment both *PSA* and *PSAA* outperform the *PAYG* scenario with regards to welfare. A higher value of the time preference parameter, β , might contribute in delivering the above results. Nevertheless, these results are important in that they blatantly manifest how sensitive are the welfare consequences of various reform proposals to little deviations from the CRRA case.

In summary, we show that if an economy is populated by agents with self-control problems, the gain from the two reform proposals is larger than what we observed in the CRRA case. More interestingly the *elimination* reform proposal even decreases welfare in comparison to the *PAYG* system when agents have severe temptation problem.

6 Conclusions

Population aging due to low birth and morbidity rates and the resulting expansion of social security benefits have prompted lively debates around the long-term viability of unfunded social security.²¹ Several reform proposals are being discussed for the US Economy and other industrialized countries, all of which converge to a common resultant: social security must be reformed in the direction of a funded rather than an unfunded system.

In this paper we examine departures from a Pay-As-You-Go social security system towards hybrid systems consisting of two parts: A "defined benefits" component and a "defined contributions" one. This is implemented by means of annexing a(n) (individually managed) Personal Security Account to a universal (PAYG-based) pension system. In parallel, we also consider and evaluate two fully-funded reform scenarios that are constructed merely by shutting off the pay-as-you-go tier in each of our two-tier scenarios.

We quantitatively assess the attractiveness (i.e. the welfare enhancing potential) of such partially and fully-funded schemes in an economy populated by agents that face self control issues. To this purpose, we use two different benchmarks: a economy featuring *PAYG* social security populated by self control agents (Kumru & Thanopoulos (2008)) and an economy featuring funded (as in this paper) social security but populated by CRRA agents. Furthermore, we refine our analysis by investigating the relative appeal of two distinct partially-funded systems, namely, PSAs without annuitization and PSAs with mandatory annuitization. Finally, we assess the relative attractiveness of two fully-funded reform scenarios.

Our analysis suggests that the availability of PSAs increases savings. This is principally true for CRRA agents. In addition, self-control agents seem to have their welfare maximized under a hybrid model featuring a pay-as-you-go tier and a PSA with mandatory annuitization (i.e. *PSAA*). However, it still remains ambiguous as to whether self-control agents are better off with a partially funded system of the analyzed hybrid structure that prescribes mandatory annuitization, or with a fully-funded system. It eventually depends on the intensity of the self-control problem.

Our results in this paper highlight the important role that self control preferences play, especially with regards to the kind of reform that could generate the highest welfare. When the analysis is restricted to CRRA preferences our findings initially are congruent with those obtained in other studies [e.g., Fuster *et al.* (2005)]: we also find that the complete *elimination* of any social security ranks highly with regard to welfare maximization, although it turns out that one of our fully funded scenarios [not analyzed in Fuster *et al.* (2005)], namely *PSAAwoFT* is the reform scenario that generates the highest welfare. When self-control preferences are introduced instead, we come across a drastic alteration of these results: the *elimination* of social security becomes the least desirable policy reform from a welfare maximization standpoint, i.e. *PSAA* and *PSAAwoFT* reforms give rise to larger welfare improvements under self-control preferences.

²¹See US Social Security Administration (2008)

Moreover, our analysis of the two fully-funded settings in addition to the partially funded reform scenarios reveal a very interesting aspect. Contrary to what has been documented in the literature so far, the relative appeal to CRRA agents of the *elimination* scenario, seems to be driven mainly by the zero payroll tax rather than the unnecessary of social insurance for CRRA agents: our results manifest that CRRA agents *do* value some form of social insurance.

Overall, as we move from an economy populated by CRRA agents to an economy with self-control agents, we observe a complete reversal of the importance of *PSAA* relative to *elimination*. This observation combined with the documented appeal of a fully-funded scenario with annuitized benefits to both CRRA and self-control agents hints to the increasing importance of the annuitization of benefits regardless of the assumptions on preferences.

In conclusion, our research indicates that the incontestable advantage of the *elimination* scenario under CRRA preferences rapidly vanishes as self control is introduced and becomes progressively more severe. All of our experiments confirm this finding: in the case of relatively severe temptation the *elimination* of social security becomes the least desirable policy.

References

- Angeletos, G-M., Laibson, D., Repetto, A., Tobacman, J., & Weinberg, S. 2001. The hyperbolic consumption model: Calibration, simulation, and empirical evaluation. *Journal of Economic Perspectives*, **15**, 47–68.
- Auerbach, A. J., & Kotlikoff, L. J. 1987. *Dynamic Fiscal Policy*. New York, NY, USA: Cambridge University Press.
- DeJong, D. N., & Ripoll, M. 2007. Do self-control preferences help explain the puzzling behavior of asset prices? *Journal of Monetary Economics*, **54**, 1035–1050.
- DeNardi, M., Imrohoroglu, S., & Sargent, T. 1999. Projected U.S. demographics and social security. *Review of Economic Dynamics*, **2**, 575–615.
- Diamond, P. A. 1965. National debt in a neoclassical growth model. *American Economic Review*, **55**, 1126–1150.
- Diamond, P. A., & Orszag, P. R. 2005. Saving social security. *Journal of Economic Perspectives*, **19**, 11–32.
- Diamond, P. A., Brown, J., & Thomas, D. 2005. Annuities and individual welfare. *American Economic Review*, **95**, 1573–1590.
- Fehr, H., & Kindermann, F. 2009. Pension Funding and Individual Accounts in Economies with Life-cyclers and Myopes. *Working Paper*.
- Fehr, Hans, Habermann, Christian, & Kindermann, Fabian. 2008. Social Security with Rational and Hyperbolic Consumers. *Review of Economic Dynamics*, **11**(4), 884–903.

- Feldstein, M., & Liebman, J. B. 2002. Social Security. *In: Auerbach, A. J., & Feldstein, M. (eds), Handbook of Public Economics*. New York, NY, USA: Elsevier Science B. V.
- Frederick, S., Loewenstein, G., & O'Donoghue, T. 2002. Time discounting and time preference: A critical review. *Journal of Economic Literature*, **40**, 351–401.
- Fuster, L., Imrohoroglu, A., & Imrohoroglu, S. 2003. A welfare analysis of social security in a dynastic framework. *International Economic Review*, **44**, 1247–1274.
- Fuster, L., Imrohoroglu, A., & Imrohoroglu, S. 2005. Personal security accounts and mandatory annuitization in a dynastic framework. *Working Paper*.
- Gul, F., & Pesendorfer, W. 2004. Self control and theory of consumption. *Econometrica*, **72**, 119–158.
- Hansen, G. 1993. The cyclical and secular behavior of the labor input: Comparing efficiency units and hours worked. *Journal of Applied Econometrics*, **8**, 71–80.
- Huang, Kevin X. D., Liu, Zheng, & Zhu, John Q. 2007. Temptation and self-control: Some evidence and applications. *Working Paper*.
- Hugget, M., & Ventura, G. 1999. On the distributional effects of social security reform. *Review of Economic Dynamics*, **2**, 498–531.
- Imrohoroglu, A., Imrohoroglu, S., & Joines, D. H. 1995. A life cycle analysis of social security. *Economic Theory*, **6**, 83–114.
- Imrohoroglu, A., Imrohoroglu, S., & Joines, D. H. 2003. Time inconsistent preferences and social security. *Quarterly Journal of Economics*, **118**, 745–784.
- Kumru, C. S., & Thanopoulos, A. C. 2008. Social security and self control preferences. *Journal of Economic Dynamics and Control*, **32**, 757–778.
- Laibson, D. 1997. Hyperbolic discounting and golden eggs. *Quarterly Journal of Economics*, **112**, 443–477.
- Phelps, E. S., & Pollak, R. A. 1968. On second-best national savings and game-equilibrium growth. *Review of Economic Studies*, **35**, 185–199.
- Rojas, J. A., & Urrutia, C. 2008. Social security reform with uninsurable income risk and endogenous borrowing constraints. *Review of Economic Dynamics*, **11**, 83–103.
- Storesletten, K., Telmer, C. I., & Yaron, A. 1999. The risk sharing implications of alternative social security arrangements. *Carnegie-Rochester Conference Series on Public Policy*, **50**, 213–259.
- U.S. Census Bureau. 2006. *Mini historical statistics: population*. <<http://www.census.gov>>.

US Department of Labor. 2006. *Labor force statistics from current population survey*.
<<http://www.bls.gov>>.

US Social Security Administration. 2008. *Fast facts and figures about social security*.
<<http://www.ssa.gov>>.