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Social Security, Self-Control Problems and Unknown Preference Parameters

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SOCIAL SECURITY, SELF-CONTROL PROBLEMS AND UNKNOWN PREFERENCE PARAMETERS*

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Abstract

We develop a general equilibrium model with overlapping generations to show that Social Security may increase welfare in dynamically efficient economies where agents are affected by self-control problems à la Gul and Pesendorfer (2001, Econometrica 69, 1403). In calibrating the model to the US economy, we make no assumption on agents' preference parameters and set them to match target levels of capital-output and consumption-output ratios. Our simulations inform that Social Security improves welfare with degrees of temptation not below 11%. We also find support for a program with a tax rate similar to the one in the real US economy.

JEL classification codes: H55; I38; D58.

Keywords: Social Security; temptation disutility model; self-control problems; preference parameters; overlapping-generation models.

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1. INTRODUCTION

Unfunded Social Security is the largest transfer program in most industrialized countries, and has enormous impact on the main economic variables. Although this program serves several purposes (e.g., income redistribution, insurance against longevity risks), it is commonly believed that it exists primarily because some people lack the discipline needed to save for retirement (see for instance Diamond, 1977): they may either save less than needed, or save adequately but at a non-negligible cost. Despite this, a growing literature based on quantitative overlapping-generation models finds no welfare-improving role for Social Security, even after making behavioral assumptions on the agent's preferences (see Imrohoroglu et al., 2003; Kumru and Thanopoulos, 2008; and the literature review in Fehr et al., 2008). The main reasons are that Social Security crowds out private savings (Auerbach and Kotlikoff, 1987), creates tight liquidity constraints to the youngest (Hubbard and Judd, 1987), and offers an implicit interest rate below the one available for private savings (Imrohoroglu et al., 1999).

The aim of this paper is to show that there may be a welfare-improving role for Social Security if the economy is populated by agents affected by temptation à la Gul and Pesendorfer (2001). Temptation is a feature of human behavior consistent with psychological theories (DellaVigna, in press), and observed empirically in different experiments (see Ameriks et al., 2007); recent estimates from household survey data on consumption and wealth holdings also provide support to the Gul and Pesendorfer's (2001) paradigm (Huang et al., 2005; Bucciol, 2008). Agents with temptation problems are rational, forward-looking, and sophisticated, but make choices biased toward alternatives that offer more immediate gratification. Their utility depends on actual consumption on the one hand, and the temptation to consume their entire wealth on the other. Resisting this temptation creates a cost of self-control.

Social Security may be seen as a pre-commitment device since it forces agents to make a mandatory saving, depriving them from the temptation to consume early (Akerlof, 1998). This pre-commitment role of Social Security is valuable for tempted agents as it reduces the cost associated with the exertion of self-control. Despite this, findings in Kumru and Thanopoulos (2008) show that accounting for temptation is not enough to generate welfare improvement with Social Security, unless unrealistically large discount factors above 1 are taken into account. Results in Kumru and Thanopoulos (2008) are drawn from simulations of an overlapping-generation model where the discount factor is set endogenously to match a key feature of the US economy, and the remaining preference parameters are chosen exogenously. In particular, the authors set the coefficient of risk aversion to values that are common in the literature with standard preferences.

The coefficient, however, is likely to change when temptation is taken into account; in our model, it also measures the agent's willingness to substitute current temptation consumption for future one. Empirical exercises in Huang et al. (2005) and Bucciol (2008) estimate a risk aversion in a life-cycle model that is lower when standard preferences are augmented with temptation disutility. Similarly, the estimate of the intertemporal discount factor increases with temptation (Bucciol, 2008). Failing to consider this variation in all the preference parameters generates a behavior that is not consistent with the reality. In Kumru and Thanopoulos (2008), tempted agents hold in aggregate as much wealth as non-tempted ones, but are free to choose how to distribute it over the life-cycle. They rationally concentrate the accumulation of savings in the years near retirement to limit their cost of self-control. Hence the welfare gain due to the pre-commitment role of Social Security is small because tempted agents bear costly self-control only for a few years.

In contrast to the existing literature, in our work we consider the potential interplay among the agents' preference parameters. Rather than making concrete assumptions on unobservable preference parameters, for a range of reasonably small degrees of temptation we calibrate the remaining preference parameters to match aggregate features of the US data. The literature on this field usually calibrates the discount factor keeping fixed the aggregate capital-output ratio (see Imrohoroglu et al., 1995; 2003; Kumru and Thanopoulos, 2008). We instead calibrate the discount factor and the coefficient of risk aversion keeping fixed the aggregate capital-output and consumption-output ratios observed in the real economy. We consider the consumption-output ratio as additional target because it seems the most appropriate for our purpose. Our targets describe the economy's levels of wealth and consumption, the two variables that enter as arguments in the utility function of tempted agents. The calibrations we obtain generate identical predictions, but have different welfare implications. Requiring a given level of consumption as well as a given level of wealth, tempted agents make indeed choices similar to standard agents. In particular, they are forced to make regular savings over the lifetime, thus facing larger self-control costs than in

Kumru and Thanopoulos (2008). As a consequence welfare gains from the pre-commitment implicit in Social Security are larger.

Our underlying model builds on the tradition of analyzing steady-state economies with unfunded Social Security programs. We simulate a quantitative general equilibrium model with overlapping generations, and idiosyncratic income and mortality risk similar to those in Imrohoroglu et al. (1995, 2003) and Kumru and Thanopoulos (2008). In our model agents with temptation preferences supply labor inelastically[1] and can trade in a single asset for both life-cycle and precautionary saving motives. Output arises from an aggregate production technology to which agents rent capital and labor. There is a fixed retirement age, after which agents stop working and start to receive a benefit from an unfunded Social Security scheme. The government funds the benefits with a constant tax on labor income.

We calibrate our theoretical model to reproduce key features of the real US economy, simulate and compare steady-states with different Social Security arrangements. Our framework allows us to construct a measure of welfare that incorporates general equilibrium, insurance and distortionary effects of Social Security; these aspects are all relevant for a proper welfare evaluation (Soares, 2005). In contrast to Kumru and Thanopoulos (2008), we find that the interplay among the three preference parameters of the model generates a welfare-improving role for Social Security, under reasonable values of all the coefficients. In our benchmark analysis, a Social Security program with a tax rate of 2.5% (and a replacement rate of around 10%) increases welfare of agents with a degree of temptation equal to 11% or above. The size of the degree is within the range of values estimated in the literature (from 7.3% in DeJong and Ripoll, 2007, to 20.6% in Huang et al., 2005). We also find support for a program with a tax rate of 10%, similar to the one in the real US economy, in agents with degrees of temptation between 14 and 17%. In particular such degrees are in line with the benchmark estimate of 16% found in Bucciol (2008).

The paper is organized as follows. Section 2 describes the overlapping-generation model used in this analysis. The model does not admit a closed-form solution, and Section 3 presents the calibration of the exogenous parameters based on the US economy. In Section 4 we discuss our main findings under the benchmark economy, and run a sensitivity analysis

[1] As in Kumru and Thanopoulos (2008). Imrohoroglu et al. (1995, 2003) consider labor supply decisions, but find no significant change in work effort with alternative programs.

around critical exogenous parameters. Section 5 concludes, and Appendix A provides mathematical and computational details.

2. THE MODEL

The economy is populated by overlapping generations of individuals with identical preferences. The population grows steadily at a constant rate n; time t is discrete and the period is assumed to be one year. The index j represents individual age; the combination of the two indexes (j,t) identifies unambiguously the cohort of individuals born in year $t-j+1$.

Agents in the economy are observed over their adult age, and are assumed to retire at an exogenous age R. They face long but random lives that last at most D years. Lifespan uncertainty is described by the (time-invariant) survival probability π_{j+1} that a person is alive at age $j+1$ conditional on being alive at age j; $\pi_{D+1}=0$ indicates certain death after age D. Under the stationary population assumption, the cohort shares in each year are stable over time and given by the relations

$$\mu_j = \mu_{j-1}\frac{\pi_j}{1+n}, \qquad j=1,\dots,D \tag{1}$$

2.1. Preferences

Preferences of an agent of age j in year t are defined over sequences of lifetime consumption of non-durable goods $c_{j,t}$. We consider Gul and Pesendorfer's (2001) temptation preferences and represent the period utility function as follows:

$$U\left(c_{j,t},x_{j,t}\right)=u\left(c_{j,t}\right)-\left(v\left(x_{j,t}\right)-v\left(c_{j,t}\right)\right) \tag{2}$$

where $u(\cdot)$ and $v(\cdot)$ are two von Neumann-Morgenstern utility functions and $x_{j,t}=\arg\max_{c_{j,t}}\left\{v\left(c_{j,t}\right)\right\}$ represents the "most tempting" alternative from the set of possible consumption choices. We assume as in Gul and Pesendorfer (2004) that agents are tempted by the opportunity to consume immediately all their available resources, i.e., cash-on-hand (Deaton, 1991). If the agent cannot die with debt, uncertainty on death age binds consumption at any time to be no larger than the most tempting alternative, $c_{j,t} \le x_{j,t}$ [2]. The difference $v(x_{j,t}) - v(c_{j,t})$ can thus be interpreted as the psychological cost of self-control that the agent faces when choosing $c_{j,t}$ rather than its most tempting alternative $x_{j,t}$.

In particular we characterize $u(\cdot)$ with a Constant Relative Risk Aversion (CRRA) utility function,

$$u(c) = \frac{(c)^{1-\gamma} - 1}{1-\gamma} \tag{3}$$

where $\gamma > 0$ is the coefficient of relative risk aversion, and $v(\cdot)$ with a rescaled CRRA utility function,

$$v(c) = \lambda u(c) \tag{4}$$

This representation of the period utility function is consistent with balanced growth (DeJong and Ripoll, 2007) and makes households risk averse in consumption but risk loving in cash-on-hand. An implication is that variations in consumption make the household worse-off, whereas variations in cash-on-hand make the household better-off as they reduce the utility cost of resisting temptation. Tempted agents then rationally choose to postpone the accumulation of wealth as much as possible. The parameter $\lambda \ge 0$, that we call degree of absolute temptation, measures the agent's sensitivity to the tempting alternative. An agent with $\lambda = 0$ is the forward-looking decision-maker in standard life-cycle models. The larger λ is, the more temptation to consume takes control of the individual's behavior. The extreme case of $\lambda \to \infty$ describes completely myopic agents who consume in every period all their income.

2.2. Agents

The timing of the model is the following. An agent enters any age j at time t with a given amount of assets $a_{j,t}$. She then receives a lump-sum government transfer z_t and an income $w_{j,t}$. Income prior to the mandatory retirement age R derives from the inelastical

[2] We make this assumption for sake of simplicity. If we removed it, and allowed agents to borrow against future income up to a certain amount, the most tempting alternative would be larger. This would raise the demand of pre-commitment devices. Hence we would observe a larger support for Social Security in our economy of tempted agents.

supply of an exogenous quantity of labor, and is described by a combination of deterministic and idiosyncratic, agent-specific random components; income after retirement stems from a certain Social Security benefit b_t:

$$w_{j,t} = \begin{cases} (1-\theta) w_t \varepsilon_j \eta_{j,t} & j \le R \\ b_t & j > R \end{cases} \tag{5}$$

where θ is the contribution to Social Security, $(1-\theta) w_t$ is the after-tax wage rate, ε_j is an efficiency index in age j, and $\ln \eta_{j,t} \sim N\left(-\sigma^2/2, \sigma^2\right)$. Cash-on-hand $x_{j,t}$ is the sum of personal wealth, government transfers and income: $x_{j,t} = a_{j,t} + z_t + w_{j,t}$. Given her cash-on-hand $x_{j,t} \ge 0$ the agent determines the optimal level of consumption $c_{j,t} \le x_{j,t}$, and invests the remaining savings ($x_{j,t} - c_{j,t}$) in a market portfolio yielding the risk free real return r_t. The maximization problem is

$$V_{j,t}\left(x_{j,t};\theta\right) = \max_{\left\{c_{j+l,t+l}\right\}_{l=0}^{D-j}} E_t\left[\sum_{l=0}^{D-j} \frac{\beta^l}{\pi_j}\left(\prod_{k=0}^{l} \pi_{j+k}\right) U\left(c_{j+l,t+l}, x_{j+l,t+l}\right)\right] \tag{6}$$

with β discount factor, subject to constraints (2)-(4) and the intertemporal budget constraint

$$x_{j+l+1,t+l+1} \le \left(1+r_{t+l}\right)\left(x_{j+l,t+l} - c_{j+l,t+l}\right) + z_{t+l+1} + w_{j+l+1,t+l+1}, \qquad x_{j+l+1,t+l+1} \ge 0 \tag{7}$$

with $x_{0,t-j+1} = 0$ (no assets at birth). The maximization problem can be defined recursively as

$$V_{j,t}\left(x_{j,t}\right) = \max_{c_{j,t}} \left\{U\left(c_{j,t}, x_{j,t}\right) + \beta \pi_{j+1} E_t\left[V_{j+1,t+1}\left(x_{j+1,t+1}\right)\right]\right\} \tag{8}$$

subject to constraints (2)-(5), and (7).

Since we assume no bequest motives, the optimal choice function $c_{j,t} = c_{j,t}\left(x_{j,t}\right)$ is trivially equal to $x_{j,t}$ at $j = D$ or when $\lambda \to \infty$. In any other case, it is implicit in the Euler equation (see Section A.1)

$$\left(c_{j,t}\right)^{-\gamma} = \left(1+r_t\right) \beta \pi_{j+1} E_t\left[\left(c_{j+1,t+1}\right)^{-\gamma} - \tau\left(x_{j+1,t+1}\right)^{-\gamma}\right] \tag{9}$$

where $\tau = \lambda/(1+\lambda) \in [0,1)$, the *degree of relative temptation*, measures the importance of temptation relative to consumption. Equation (9) differs from the standard case of non-tempted agents (obtained when $\tau = 0$) for the presence of the marginal disutility of next-period tempting alternative, $-\tau\left(x_{i,j+1}\right)^{-\gamma}$. More precisely, the equation informs that the marginal cost of giving up one unit of current consumption must be equal to the marginal benefit of consuming the proceeds of the extra saving in the next period, net of the marginal cost of resisting the additional temptation in the next period. Hence the cost of saving is higher for tempted individuals than for non-tempted ones.

2.3. Aggregate technology

The time-invariant production technology of the economy is given by a constant returns to scale Cobb-Douglas function that uses at time t capital K_t and labor L_t to produce the single good in the model:

$$Y_t = f\left(K_t, L_t\right) = BK_t^{1-\alpha} L_t^{\alpha} \tag{10}$$

where Y_t is aggregate output and $\alpha \in \left(0,1\right)$ is labor's share of output. B_t is a technological parameter growing at a deterministic, exogenously given rate ρ. The firm solves the maximization problem

$$\max_{K,L}\left\{Y_t - r_t^s K_t - w_t L_t\right\} \tag{11}$$

subject to constraint (10). The first order conditions require that

$$\begin{cases} r_t^s = \left(1-\alpha\right) Y_t / K_t \\ w_t = \alpha Y_t / L_t \end{cases} \tag{12}$$

2.4. Government

The government has a twofold role in this economy. It distributes lump-sum transfers equally among the members of all generations. These transfers are financed by the accidental bequests generated with uncertain death ages:

$$\sum_{j=1}^{D} \mu_j z_t = \sum_{j=2}^{D} \mu_{j-1}\left(1-\pi_j\right) a_{j,t} \tag{13}$$

The government also maintains an unfunded Social Security program that is financed by a payroll tax θ from labor income and provides benefits b_t after retirement age. Benefits are computed in such a way to keep the Social Security account in balance on a period-by-period basis, i.e., the sum of all the benefits is financed with the sum of all the contributions:

$$\sum_{j=R+1}^{D} \mu_j b_t = \theta \sum_{j=1}^{R} \mu_j w_t \varepsilon_j \eta_{j,t} \tag{14}$$

Because the annuity b_t is unrelated to an individual's contribution history, Social Security entails some pooling of income risk.

2.5. Market equilibrium

Since individual and aggregate behavior must be consistent in equilibrium, labor supply equals the total number of workers,

$$L_t = \sum_{j=1}^{R} \mu_j \tag{15}$$

aggregate consumption is the sum of individual consumption choices,

$$C_t = \sum_{j=1}^{D} \mu_j c_{j,t} \tag{16}$$

and capital stock K_t is the sum of previous-year individual asset holdings,

$$K_t = \sum_{j=1}^{D} \mu_j a_{j,t-1} \tag{17}$$

We also impose the no arbitrage condition for market returns,

$$r_t^s = r_t + d \tag{18}$$

where d is the capital depreciation rate. Finally the capital market clears:

$$Y_t = C_t + K_{t+1} - (1-d) K_t \tag{19}$$

In equilibrium at time t, the *allocation* $\{c_{j,t}, K_t\}_j$, the *price system* $\{r_t, w_t\}$, and the *government policy* θ are such that *i)* agents choose their consumption profile from (9), given the price system and the government policy; *ii)* the firm maximizes its profits using (11), given the price system and the government policy; *iii)* the government computes the equilibrium lump-sum transfers from (13) and Social Security benefits from (14); *iv)* prices are competitive. In equilibrium aggregate labor income, capital and output grow over time at the constant rate $g = (1+n)(1+\rho)^{1/\alpha} - 1$. Section A.2 sketches the numerical method we adopt to find the solution.

2.6. Welfare evaluation

We define the certain equivalent consumption $CEC_{1,t}$ as the constant consumption flow over the life-cycle under perfect commitment technology that makes a newborn agent as well-off as with the intertemporal utility $V_{1,t}$:

$$CEC_{1,t} = \left(\frac{(1-\gamma)V_{1,t}}{\sum_{l=0}^{D-1} \beta^l \prod_{k=0}^{l} \left(\frac{\pi_{1+k}}{\pi_1} \right)} \right)^{\frac{1}{1-\gamma}} \tag{20}$$

We follow the literature (see Imrohoroglu et al., 2003; Kumru and Thanopoulos, 2008) and quantify welfare gains and losses by computing compensating variations. These are defined as the percentage variation in $CEC_{1,t}$ between two scenarios A and B, differing in the Social Security tax rate (θ_A and θ_B respectively):

$$CV_{1,t}(\theta_A, \theta_B) = \frac{CEC_{1,t}(\theta_A) - CEC_{1,t}(\theta_B)}{CEC_{1,t}(\theta_B)} \tag{21}$$

In our analysis the scenario A refers to a laissez-faire economy with no Social Security, $\theta_A = 0$. A positive $CV_{1,t}(0, \theta_B)$ means that agents are worse-off with Social Security, and $CV_{1,t}(0, \theta_B)$ denotes the fraction by which consumption must be increased in B to compensate for the decrease in welfare generated by the presence of Social Security.

3. CALIBRATION

The exogenous parameters of the model are reported in Table 1. We set them in such a way to capture the main economic, demographic and political aspects of the US economy. We assume that the economically active life of a household starts at age 25. Individuals work for $R = 40$ years until they reach age 65 (the normal retirement age in the US), and live at most for $D = 75$ years, until age 100. We set the sequence of conditional survival probabilities $\{\pi_j, j = 1, \ldots, D\}$ equal to the 1960 cohort life tables for men computed by the Social Security Administration; our results, however, do not change if we consider alternative cohorts. The population growth rate is taken to be $n = 1.19$ percent per year as in Imrohoroglu et al. (2003). Survival probabilities and population growth, under the assumptions of the model, determine the size of each cohort, which we normalize to sum one

($\sum_{j=1}^{D}\mu_j = 1$). The resulting ratio of retirees to active population (the old-age dependency ratio) is $\sum_{j=R+1}^{D}\mu_j \Big/ \sum_{j=1}^{R}\mu_j = 25.34$ percent, that is, in this economy there are four workers paying contributions to finance the benefits of one retiree.

To set the efficiency index we take the average of Hansen's (1993) estimation of median wage rates for males and females; we then interpolate the data using the spline method and normalize the interpolated data to average unity. We set the log-income standard deviation to 0.40 in line with empirical findings (see Carroll and Samwick, 1997; Krueger and Perri, 2006).

We calibrate the parameters describing the supply side of the economy following Imrohoroglu et al. (2003) and Kumru and Thanopoulos (2008), and set the labor's share of output α to 0.69 and the capital depreciation rate to $d = 0.044$ per year. Following the same source, we assume a per capita output growth rate of 2.1 percent; this induces a parameter of technological progress $\rho = (1.021)^{\alpha} - 1 = 1.0144$ percent. Finally, the parameter B_t in the production function is not crucial, and we set it so that output Y_t is normalized to 1 when the payroll tax rate is $\theta = 10$ percent.[3]

To simulate the model we also need to set the agent's preference parameters. In this framework there are three such parameters: the discount factor β, the RRA coefficient γ, and the degree of relative temptation τ. The literature offers a variety of empirical estimates for the discount factor and the relative risk aversion; the coefficients may however vary once they interact with the degree of temptation. The few works attempting to estimate from real data this parameter in economies à la Gul and Pesendorfer generally find it to be significant, but show a broad range of possible values. DeJong and Ripoll (2007) argue that a degree of relative temptation of 0.073[4] is necessary to reconcile the theory with data on stock price volatility, risk-free rates and equity premiums. Huang et al. (2005) obtain a GMM es-

[3] The full Old-Age and Survivors Insurance (OASI) tax rate in the US is 10.6 percent of wage income.
[4] The authors estimate the measure we call degree of absolute temptation, obtaining a value of 0.0787. The degree of relative temptation is then $\left(0.0787/(1+0.0787)\right) = 0.073$.

timate of 0.2058[5] from a log-linearized Euler equation and consumption data of US households. Bucciol (2008) finds a degree of relative temptation of 0.1596 using a MSM approach and data on liquid and quasi-liquid wealth holdings of US households. In our analysis we take an agnostic perspective and avoid concrete assumptions on these parameters. Rather, we consider a range of plausible values for τ, from $\tau = 0$ (no temptation) to $\tau = 0.20$ (moderate temptation). We then set the discount factor and the RRA coefficient to match two target macroeconomic values: the capital-output and consumption-output ratios when the payroll tax is $\theta = 10$ percent. We follow the literature in the field and set the capital-output ratio to 2.50 (see Imrohoroglu et al., 2003; Kumru and Thanopoulos, 2008). We also set the consumption-output ratio to 0.75 following Rios-Rull (1996). This target value is meant to describe an economy without government expenditures. With these two target values we estimate a discount factor $\beta = 0.9744$ and a coefficient of relative risk aversion $\gamma = 2.1653$ in an economy populated by standard, non-tempted agents. The two estimates are in line with common values used in macroeconomic models with standard preferences.

4. SIMULATION RESULTS

In this section we report the main results from 1,000 simulations of steady-state economies around the random variables of the model; refer to Section A.2 for computational details.

4.1. Benchmark case

Table 2 reports the main variables in steady-state economies populated by standard non-tempted agents and under alternative Social security arrangements. We see that Social Security impacts the factor prices: with a larger payroll tax, the interest rate increases and the aggregate labor income decreases. The output, capital stock, and consumption are congruent with those found in previous studies, and all decline as the Social Security tax rate increases. In fact, the assumption on the capital-output ratio gives rise to a dynamically efficient economy, in which the rate of return implicit in Social Security contributions is lower than the rate of return available for private savings. This makes Social Security a poorly

[5] The degree of relative temptation in this case is a non-linear function of the parameter in the log-linearized Euler equation, 0.048, the coefficient of risk aversion, 0.6734, and the wealth-consumption ratio, 9.31. The formula is $\left(9.31^{0.6734} / \left(1 + 1/0.048\right)\right) = 0.2058$.

yielding asset that reduces the present value of lifetime earnings. We find the known result that Social Security reduces welfare in dynamically efficient economies populated by standard agents. Indeed, the last column depicts the percentage compensating variation, that is always positive and increasing with the tax rate θ. For instance, consumption when $\theta = 10\%$ must be increased by 10.26% to make agents as well-off as with a laissez-faire economy with no Social Security.

We then introduce temptation in the model. We consider a range of reasonably low degrees of temptation τ, and every time set the other preference parameters to match some target values in an economy with $\theta = 10\%$. We first hold risk aversion constant, and adjust only the discount factor β to match a capital-output ratio of 2.50, as is done in previous works (see Imrohoroglu et al., 2003; Kumru and Thanopoulos, 2008). The left panel of Table 3 reports the preference parameters, as well as the compensating variation between a laissez-faire economy with $\theta = 0$ and economies with $\theta = 2.5\%$ and 10%. The two tax rates give rise to replacement rates of around 10 and 40 percent respectively. As the degree of temptation increases, the agent is inclined to consume more, and the discount factor has to be higher to induce larger precautionary savings and therefore reproduce the target capital-output ratio.

The two columns reporting the compensating variation inform that when $\tau = 0$ standard, non-tempted agents should increase their consumption by 1.93% to be indifferent between an economy with a tax $\theta = 2.5\%$ and one with $\theta = 0$; this number is comparable with previous estimates assuming non-standard preferences under similar calibrations. When we introduce temptation preferences, the compensating variation is still positive in most cases, but its size is smaller. This finding parallels results in Imrohoroglu et al. (2003) and Kumru and Thanopoulos (2008) in that Social Security entails welfare losses under both standard and non-standard preferences, but it is less severe under the latter. Our extended search over a large grid of temptation values shows that only if $\tau \geq 0.18$ the compensating variation is negative when $\theta = 2.5\%$, meaning that a small level of Social Security protection is beneficial for such households. The gain with Social Security is however small, and equal to 0.02% of consumption if $\tau = 0.18$. Social Security programs with larger tax rates than 2.5% are instead found never optimal.

When we allow both the discount factor β and the risk aversion γ to vary, and match a capital-output ratio of 2.50 and a consumption-output ratio of 0.75, a higher degree of temptation is offset by a larger discount factor and a lower RRA (right panel of Table 3). Intuitively, a larger discount factor creates an additional precautionary saving motive that offsets the stronger desire to consume immediately. Since holding wealth is costly (it creates temptation), savings tend to be concentrated only in few years before retirement. This entails a marked drop in consumption just before retirement. A reduction in the RRA coefficient, however, induces a tempted agent to better smooth consumption and temptation over the years. This combination of preferences generates the same levels of aggregate consumption and wealth as in economies populated by agents without self-control problems. This behavior is however costlier for tempted agents, as they save regularly and every year face costly self-control. As a result, they give more value to the pre-commitment implicit in Social Security. We indeed see from the last two columns of Table 3 that the compensating variation for a given degree of temptation τ is typically lower than in the case where γ is fixed. Figure 1 shows this graphically. We already found that, when only β is free to vary and match the target capital-output ratio, only a Social Security program with a small contribution rate $\theta = 2.5\%$ is welfare-improving for $\tau \geq 0.18$. In contrast, when both β and γ adjust to match the target variables, a program with $\theta = 2.5\%$ is welfare-improving for $\tau \geq 0.11$, its gain is around 1-2% of lifetime consumption, and there are cases $\left(\tau \in (0.14, 0.17)\right)$ in which a tax rate $\theta = 10\%$, similar to the one observed in the US, is also welfare-improving. This welfare-improving role of Social Security is obtained under reasonable values of the discount factor and the RRA coefficient. Agents with larger degrees of temptation find instead a Social Security program with $\theta = 10\%$ detrimental for welfare, as it prevents immediate gratification and defers a large amount of consumption to later ages.

Table 4 is the counterpart to Table 2 in an economy populated by tempted agents with $\tau = 0.16$, and where (β, γ) are set to match the two target variables. We focus on this case as it is, among those in which welfare increases when $\theta = 10\%$, the one providing the largest welfare improvement. A degree of temptation equal to 0.16 is also the benchmark estimate in Bucciol (2008). When $\theta = 10\%$ the consumption-output and capital-output ratios are equal to 0.75 and 2.50 by construction[6], and all the aggregate variables coincide with those of non-tempted agents with $\tau = 0$. While the steady state values of the macroeconomic variables do not seem to change markedly from those in Table 2, the welfare effect of including temptation is large. Indeed, tempted agents prefer economies with any tax rate θ below 12.5% to a laissez-faire economy with $\theta = 0$ (the compensating variation measure in the last column of Table 4 is indeed negative if $\theta < 12.5\%$). It is worth pointing out that agents in this economy are better-off with some Social Security protection, even if aggregate consumption reduces. Welfare gains arise because tempted agents face a large cost of self-control to make the same consumption-saving choice as non-tempted agents, and receive large welfare gains from the pre-commitment implicit in Social Security.

Figure 2 shows the compensating variation by tax rate in economies populated by agents with different preference parameters. In the standard case with no temptation, the compensating variation increases monotonically with the payroll tax rate. Social Security programs with larger contribution rates indeed reduce welfare if the economy is dynamically efficient. When a source of temptation is introduced, the detrimental effect of Social Security is less severe, and the compensating variation is usually lower. When the discount factor and the RRA coefficient are unchanged, but agents exhibit a degree of temptation $\tau = 0.16$, the pre-commitment to save implicit in Social Security limits costly self-control. Figure 2 however informs that this welfare advantage is not high enough to make an economy with Social Security more favorable than a laissez-faire economy with $\theta = 0$. Similarly, Social Security is never optimal when agents are tempted ($\tau = 0.16$), the RRA coefficient γ is fixed, and the discount factor β varies to match the target capital-output ratio. In contrast, Figure 2 shows that, when $\tau = 0.16$ and both β and γ vary, a Social Security program with any payroll tax below $\theta = 12\%$ is welfare-improving with respect to a laissez-faire economy with $\theta = 0$.

4.2. Sensitivity analysis

This section summarizes the findings of a sensitivity analysis over the income standard deviation σ and the retirement age R. In each exercise we keep the preference parameters

[6] Aggregate consumption is instead equal to 0.7481 under the same degree of temptation but when risk aversion is fixed to the level of non-tempted agents. Such a small difference in aggregate consumption may generate large welfare variations.

fixed to the values estimated in the benchmark analysis of Section 4.1. This allows us understand in a clearer way the effect of exogenous parameters on Social Security. The different calibration in the exogenous parameters originates different aggregate consumption-output and capital-output ratios from those in the benchmark case.

One of the main advantages of Social Security is the protection against idiosyncratic income risk. Increasing income uncertainty emphasizes this property of Social Security. Table 5 shows the compensating variation resulting from the simulation of the model when the parameter σ varies. In the analysis we consider the two cases $\sigma = 0.30$ and $\sigma = 0.50$, instead of the benchmark calibration $\sigma = 0.40$. The table informs that the model is not very sensitive to the choice of σ. The compensating variation between the two scenarios with $\theta = 0$ and 2.5% in an economy populated by non-tempted agents is worth 1.99% if $\sigma = 0.30$, and 1.87% if $\sigma = 0.50$ (rather than 1.93% in the benchmark case). Social Security is more attractive in economies populated by tempted agents, and thus the compensating variation reduces. However, when the RRA coefficient is fixed, a Social Security program with a small tax rate $\theta = 2.5\%$ is welfare improving only if $\tau \geq 0.18$, and only if $\sigma = 0.50$. In contrast, the same program is welfare improving for $\tau \geq 0.12$ with both choices of σ, when both the discount factor β and the RRA coefficient γ vary. In this case, a Social Security program with $\theta = 10\%$ is also welfare improving for degrees of temptation between 0.14 and 0.16 ($\sigma = 0.30$) and between 0.16 and 0.18 ($\sigma = 0.50$). All these findings are consistent with those obtained in the benchmark analysis of Section 4.1.

A change in the retirement age R is also likely to influence welfare in economies with Social Security. When R is higher, agents are exposed for a smaller number of years to the longevity risk of outliving their resources. Hence, Social Security should be less attractive. Table 6 shows the compensating variation when $R = 38$ (effective age 62) and 43 (effective age 67). These two choices correspond to the minimum and maximum retirement age in the US. As expected, we find a generalized support for Social Security when R is low: agents in the economy are better-off with a tax rate $\theta = 2.5\%$ if $\tau \geq 0.08$ when both β and γ vary, but also if $\tau \geq 0.10$ when γ is fixed. Support for a larger tax rate as $\theta = 10\%$ is however found only if $\tau \geq 0.14$ when both β and γ vary. In the less favourable case of a higher retirement age R, Social Security is never optimal if we keep the RRA coefficient

γ fixed, but a program with a tax rate $\theta = 2.5\%$ still makes better-off agents with $\tau \geq 0.12$. No support is found, however, for a Social Security program with a tax rate similar to the one active in the US.

5. CONCLUDING REMARKS

In this paper we have shown that Social Security may improve welfare in dynamically efficient economies where agents are affected by self-control problems à la Gul and Pesendorfer (2001), and exhibit reasonable discount factors and RRA coefficients. In our exercise we take an agnostic perspective and avoid making concrete assumptions on the agents' preference parameters. We consider a range of possible values for the degree of temptation, and set the remaining preference parameters of the model (the discount factor and the risk aversion coefficient) to match target levels of consumption and capital. Previous works on self-control preferences (Kumru and Thanopoulos, 2008) found no support for Social Security when keeping aggregate capital fixed. In our view, the reason is that the coefficient of risk aversion is set exogenously to values considered plausible for agents without self-control problems. Tempted agents with this risk aversion face small self-control costs as they rationally concentrate savings near retirement. Since they have fewer occasions to benefit from market returns, their lifetime consumption is lower than the one of non-tempted agents.

Our simulations, calibrated to the US economy and based on a general equilibrium model with overlapping generations, inform that the interplay among the preference parameters determines a welfare-improving role for Social Security for degrees of temptation equal to 11% or higher. Given our methodology, economies with tempted and non-tempted agents are undistinguishable in terms of aggregate consumption-saving behavior. We also find support for a program with a tax rate 10%, similar to the one in the real US economy, in agents with degrees of temptation between 14 and 17%. Our findings are robust to different choices of the exogenous parameters.

The framework we consider is rather simple. In our model we do not allow for various sources of uncertainty not insured by the existing contingent claim markets. In particular, we abstract from the risk of financial loss due to health shocks and low market returns. Including these features in the model, however, would not alter our main conclusions. Social Security would still raise the welfare of tempted agents; the insurance role of this program would just generate a larger welfare improvement. More substantively, we do not consider endogenous labor supply, retirement decisions and alternative pre-commitment devices. Future research should take into account these elements. In particular, holdings of real assets such as home equity are widespread in real data, and may act as a substitute for Social Security in providing a source of wealth that cannot be immediately used for consumption and hence does not create costly self-control.

A. APPENDIX

A.1. Solution to the agents' life-cycle problem

The agents' problem is solved recursively using backward induction. Absent bequest motives, an agent consumes in year t at age $j = D$ all the available resources, $c_{D,t} = x_{D,t}$. The solution $c_{j,t-(D-j)}$ at any age $j < D$ is implicit in the Euler equation (9). To derive it, we first compute the first order condition of the value function (8) with respect to $c_{j,t-(D-j)}$,

$$\begin{aligned}&\frac{\partial V_{j,t-(D-j)}\left(x_{j,t-(D-j)}\right)}{\partial c_{j,t-(D-j)}} = 0 \Rightarrow \\ &\frac{\partial U\left(c_{j,t-(D-j)}, x_{j,t-(D-j)}\right)}{\partial c_{j,t-(D-j)}} = \left(1 + r_{t-(D-j)}\right)\beta\pi_{j+1}E_{t-(D-j)}\left[\frac{\partial V_{j+1,t-(D-j)+1}\left(x_{j+1,t-(D-j)+1}\right)}{\partial x_{j+1,t-(D-j)+1}}\right]\end{aligned} \tag{22}$$

Using the envelope theorem, we derive $V_{j,t-(D-j)}\left(x_{j,t-(D-j)}\right)$ relative to $x_{j,t-(D-j)}$, and obtain that

$$\begin{aligned}&\frac{\partial V_{j,t-(D-j)}\left(x_{j,t-(D-j)}\right)}{\partial x_{j,t-(D-j)}} - \frac{\partial U\left(c_{j,t-(D-j)}, x_{j,t-(D-j)}\right)}{\partial x_{j,t-(D-j)}} \\ &= \left(1 + r_{t-(D-j)}\right)\beta\pi_{j+1}E_{t-(D-j)}\left[\frac{\partial V_{j+1,t-(D-j)+1}\left(x_{j+1,t-(D-j)+1}\right)}{\partial x_{j+1,t-(D-j)+1}}\right]\end{aligned} \tag{23}$$

Substituting (23) into (22) it turns out that

$$\frac{\partial V_{j,t-(D-j)}\left(x_{j,t-(D-j)}\right)}{\partial x_{j,t-(D-j)}} = \left(\frac{\partial U\left(c_{j,t-(D-j)}, x_{j,t-(D-j)}\right)}{\partial c_{j,t-(D-j)}} + \frac{\partial U\left(c_{j,t-(D-j)}, x_{j,t-(D-j)}\right)}{\partial x_{j,t-(D-j)}}\right) \tag{24}$$

From the combination of (22) and (24), and using the definition of $U\left(c_{j,t-(D-j)}, x_{j,t-(D-j)}\right)$ given in equations (2)-(4), it is then possible to rewrite equation (22) as

$$\left(c_{j,t-(D-j)}\right)^{-\gamma} = \left(1+r_{t-(D-j)}\right)\beta\pi_{j+1}E_{t-(D-j)}\left[\left(c_{j+1,t-(D-j)+1}\right)^{-\gamma} - \tau\left(x_{j+1,t-(D-j)+1}\right)^{-\gamma}\right] \qquad (25)$$

A.2. Computational details

Equilibrium is obtained using a computational method conditional on the calibration of the exogenous parameters and the Social Security tax rate θ. The algorithm consists of the following steps:

1. When $\theta = 10\%$:

- **1.1.** We set the aggregate consumption-output and capital-output ratios to the target levels C_t^0/Y_t^0 and K_t^0/Y_t^0; we also normalize output to $Y_t^0 = 1$;
- **1.2.** We use these values to compute the factor prices $\{r_t, w_t\}$ from the first order conditions (12) of the firm's profit maximization problem;
- **1.3.** We choose an arbitrary discount factor β^0 and an arbitrary risk aversion coefficient γ^0 for a given degree of temptation τ;
- **1.4.** Given factor prices, Social Security contributions and preference parameters, we use the Euler equation (9) of the agent's decision problem to compute the optimal consumption and saving of agents belonging to each cohort;
- **1.5.** We use agent's consumption and savings to compute aggregate consumption-output (C_t^*/Y_t^*) and capital-output (K_t^*/Y_t^*) ratios from agent's consumption and asset values, using equation (16) and (17);
- **1.6.** We update our guess of the discount factor and the risk aversion coefficient, and reiterate steps 1.4. and 1.5. until the distance between C_t^0/Y_t^0 and C_t^*/Y_t^* on the one hand, and K_t^0/Y_t^0 and K_t^*/Y_t^* on the other, is below 0.001.
- **1.7.** The resulting discount factor β^* and risk aversion coefficient γ^* are consistent with the target consumption-output and capital-output ratios.

2. For any other $\theta \neq 10\%$:

2.1. We use the discount factor β^* and risk aversion coefficient γ^* obtained in step 1.7. for a given degree of temptation τ;

2.2. We guess a value for the aggregate capital stock K_t^0;

2.3. We compute the factor prices $\{r_t, w_t\}$ from the first order conditions (12) of the firm's profit maximization problem;

2.4. Given factor prices, Social Security contributions and preference parameters, we use the Euler equation (9) of the agent's decision problem to compute the optimal consumption and savings of agents belonging to each cohort;

2.5. We use agent's optimal savings to compute the aggregate capital stock (K_t^*), using equation (17);

2.6. We update the guess and repeat steps 2.3. – 2.5. until the distance between K_t^0 and K_t^* is below 0.001.

2.7. The equilibrium capital stock is K_t^θ.

To obtain the optimal consumption rules in steps 1.4. and 2.4.we solve the agent's decision problem recursively by backward induction using value function iteration. We approximate the random variable distributions by means of a Gauss-Legendre quadrature method (see Tauchen and Hussey, 1991), and discretize the state space along savings, defined as the difference between cash-on-hand and consumption, using a grid with triple exponential growth. We follow Carroll's (2006) "method of endogenous gridpoints" and get for any saving gridpoint s_h, $h = 1, \ldots, S$ the optimal solution $\hat{c}_{h,j} = c_{h,j}\left(s_h, j\right)$ from the Euler equation (9) for any j from terminal age D backward to starting age 1. For points that do not lie on the state space grid, we evaluate the policy function using a linear interpolation. Cash-on-hand is then endogenously derived as $\hat{x}_{h,j} = s_h + \hat{c}_{h,j}$. Substituting the decision rules in the recursive value function we obtain $V_{h,j}\left(\hat{x}_{h,j}, j\right)$. We use these numerical solutions to generate 1,000 simulations of the optimal behavior over random realizations of labor income and death age. Our results are not sensitive to increasing the number of simulations.

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Table 1. Calibration of the exogenous parameters in the benchmark scenario

Parameter	Definition	Value	Source
R	Retirement age	40 (effective age 65)	assumption
D	Maximum lifespan	75 (effective age 100)	assumption
$\{\pi_t, t=1,\ldots,D\}$	Conditional survival probabilities	1960 cohort life tables	Social Security Administration
n	Population growth rate	0.0119	Imrohoroglu et al. (2003)
$\{\varepsilon_j, j=1,\ldots,R\}$	Labor efficiency index	interpolation	Hansen (1993)
σ	Log-income shock standard deviation	0.40	Carroll and Samwick (1997)
α	Labor share of output	0.69	Imrohoroglu et al. (2003)
d	Capital depreciation rate	0.044	Imrohoroglu et al. (2003)
ρ	Technological progress	0.0144	Imrohoroglu et al. (2003)
K/Y	Capital-output ratio	2.50	Imrohoroglu et al. (2003)
C/Y	Consumption-output ratio	0.75	Rios-Rull (1996)

Table 2. Equilibrium aggregate values, non-tempted agents ($\tau = 0$)

Tax rate θ (%)	Repl. rate (%)	r_t (%)	w_t	Y_t	K_t	C_t	K_t/Y_t	C_t/Y_t	CV (%)
0.00	0	5.1665	0.9717	1.1236	3.6411	0.7734	3.2405	0.6883	-
2.50	10.12	6.0657	0.9333	1.0792	3.1966	0.7705	2.9621	0.7140	1.9258
5.00	20.77	6.8036	0.9052	1.0466	2.8960	0.7646	2.7670	0.7307	4.3888
7.50	32.00	7.4349	0.8831	1.0212	2.6748	0.7577	2.6194	0.7420	7.1889
10.00	43.85	8.0000	0.8648	1.0000	2.5000	0.7500	2.5000	0.7500	10.2562
12.50	56.38	8.5191	0.8490	0.9817	2.3557	0.7419	2.3995	0.7557	13.5701
15.00	69.65	9.0044	0.8351	0.9656	2.2331	0.7336	2.3127	0.7597	17.1295
17.50	83.72	9.4639	0.8225	0.9511	2.1267	0.7252	2.2360	0.7624	20.9420
20.00	98.67	9.9030	0.8111	0.9379	2.0327	0.7166	2.1674	0.7641	25.0218

Table 3. Preference parameters and compensating variation

	β free, γ fixed				(β,γ) free			
	Preferences		CV (%)		Preferences		CV (%)	
τ	β	γ	Vs. $\theta = 2.5\%$	Vs. $\theta = 10\%$	β	γ	Vs. $\theta = 2.5\%$	Vs. $\theta = 10\%$
0	0.9744	2.1653	1.9267	10.2579	0.9744	2.1653	1.9267	10.2579
0.02	0.9757	2.1653	1.7169	9.6221	0.9749	2.1147	1.6692	9.3762
0.04	0.9770	2.1653	1.4952	8.9427	0.9756	2.0584	1.3746	8.3605
0.06	0.9783	2.1653	1.2666	8.2296	0.9763	1.9949	1.0417	7.1806
0.08	0.9797	2.1653	1.0380	7.4848	0.9772	1.9218	0.6517	5.7968
0.10	0.9810	2.1653	0.8047	6.7304	0.9783	1.8361	0.1813	4.1478
0.12	0.9824	2.1653	0.5748	5.9766	0.9797	1.7324	-0.4126	2.1444
0.14	0.9838	2.1653	0.3542	5.2329	0.9817	1.6140	-1.1793	-0.2046
0.16	0.9852	2.1653	0.1656	4.5911	0.9845	1.4846	-1.9575	-1.9785
0.18	0.9867	2.1653	-0.0231	3.9446	0.9878	1.4110	-2.3669	0.2584
0.20	0.9880	2.1653	-0.1629	3.4768	0.9903	1.4079	-2.3607	8.4243

Table 4. Equilibrium aggregate values, tempted agents ($\tau = 0.16$), (β,γ) free

Tax rate θ (%)	Repl. rate (%)	r_t (%)	w_t	Y_t	K_t	C_t	K_t/Y_t	C_t/Y_t	CV (%)
0.00	0	5.4400	0.9595	1.1095	3.4953	0.7706	3.1504	0.6946	-
2.50	10.12	6.2576	0.9257	1.0704	3.1135	0.7680	2.9087	0.7175	-1.9575
5.00	20.77	6.9018	0.9016	1.0425	2.8596	0.7630	2.7429	0.7319	-2.7425
7.50	32.00	7.4666	0.8821	1.0199	2.6645	0.7569	2.6124	0.7421	-2.8680
10.00	43.85	8.0000	0.8648	1.0000	2.5000	0.7500	2.5000	0.7500	-1.9785
12.50	56.38	8.5166	0.8491	0.9818	2.3564	0.7421	2.4000	0.7558	0.7381
15.00	69.65	8.9921	0.8354	0.9660	2.2361	0.7338	2.3148	0.7596	5.8282
17.50	83.72	9.2999	0.8269	0.9562	2.1637	0.7268	2.2628	0.7601	12.9469
20.00	98.67	9.0743	0.8331	0.9634	2.2164	0.7259	2.3007	0.7535	19.7359

Table 5. Robustness: income uncertainty, CV (%)

τ	$\sigma=0.30$				$\sigma=0.50$			
	β free, γ fixed		(β,γ) free		β free, γ fixed		(β,γ) free	
	Vs. $\theta=2.5\%$	Vs. $\theta=10\%$	Vs. $\theta=2.5\%$	Vs. $\theta=10\%$	Vs. $\theta=2.5\%$	Vs. $\theta=10\%$	Vs. $\theta=2.5\%$	Vs. $\theta=10\%$
0	1.9868	10.2398	1.9868	10.2398	1.8723	10.3525	1.8723	10.3525
0.02	1.7817	9.5666	1.7309	9.3223	1.6597	9.7403	1.6149	9.4900
0.04	1.5610	8.8547	1.4331	8.2729	1.4361	9.0820	1.3258	8.4947
0.06	1.3312	8.1140	1.0794	7.0484	1.2074	8.3935	0.9974	7.3499
0.08	1.0857	7.3248	0.6485	5.5665	0.9698	7.6734	0.6122	6.0099
0.10	0.8357	6.5013	0.1602	3.8012	0.7280	6.9399	0.1507	4.4190
0.12	0.6002	5.6747	-0.4007	1.8475	0.4867	6.2033	-0.4245	2.4778
0.14	0.4023	4.9113	-1.0647	-0.1544	0.2462	5.4673	-1.1133	0.2867
0.16	0.2532	4.3191	-1.8075	-1.2125	0.0346	4.8068	-1.9590	-1.6807
0.18	0.1316	3.8360	-2.3347	2.6741	-0.1767	4.1566	-2.4826	-0.6655
0.20	0.0767	3.5769	-2.2972	15.9727	-0.3405	3.6449	-2.4950	5.2107

Table 6. Robustness: retirement age, CV (%)

τ	$R=38$ (effective age 62)				$R=43$ (effective age 67)			
	β free, γ fixed		(β,γ) free		β free, γ fixed		(β,γ) free	
	Vs. $\theta=2.5\%$	Vs. $\theta=10\%$	Vs. $\theta=2.5\%$	Vs. $\theta=10\%$	Vs. $\theta=2.5\%$	Vs. $\theta=10\%$	Vs. $\theta=2.5\%$	Vs. $\theta=10\%$
0	1.0927	8.2122	1.0927	8.2122	2.3109	11.1932	2.3109	11.1932
0.02	0.8632	7.5264	0.8541	7.3602	2.1151	10.5951	2.0511	10.3190
0.04	0.6272	6.8127	0.5875	6.3969	1.9060	9.9477	1.7515	9.3031
0.06	0.3936	6.0865	0.2868	5.2913	1.6886	9.2610	1.4110	8.1157
0.08	0.1594	5.3448	-0.0543	4.0153	1.4645	8.5327	1.0064	6.7079
0.10	-0.0587	4.6225	-0.4562	2.5218	1.2322	7.7829	0.5138	5.0231
0.12	-0.2655	3.9288	-0.9761	0.7013	0.9956	7.0199	-0.0887	3.0273
0.14	-0.4458	3.2864	-1.6289	-1.5410	0.7610	6.2596	-0.8548	0.9271
0.16	-0.5892	2.7578	-2.3009	-3.6336	0.5590	5.5806	-1.6251	0.4523
0.18	-0.7092	2.2812	-2.6632	-4.0209	0.3473	4.9432	-1.9317	8.5733
0.20	-0.7629	1.9673	-2.6466	-2.2970	0.1725	4.4871	-1.7711	44.4762

Figure 1. CV by degree of temptation (%)

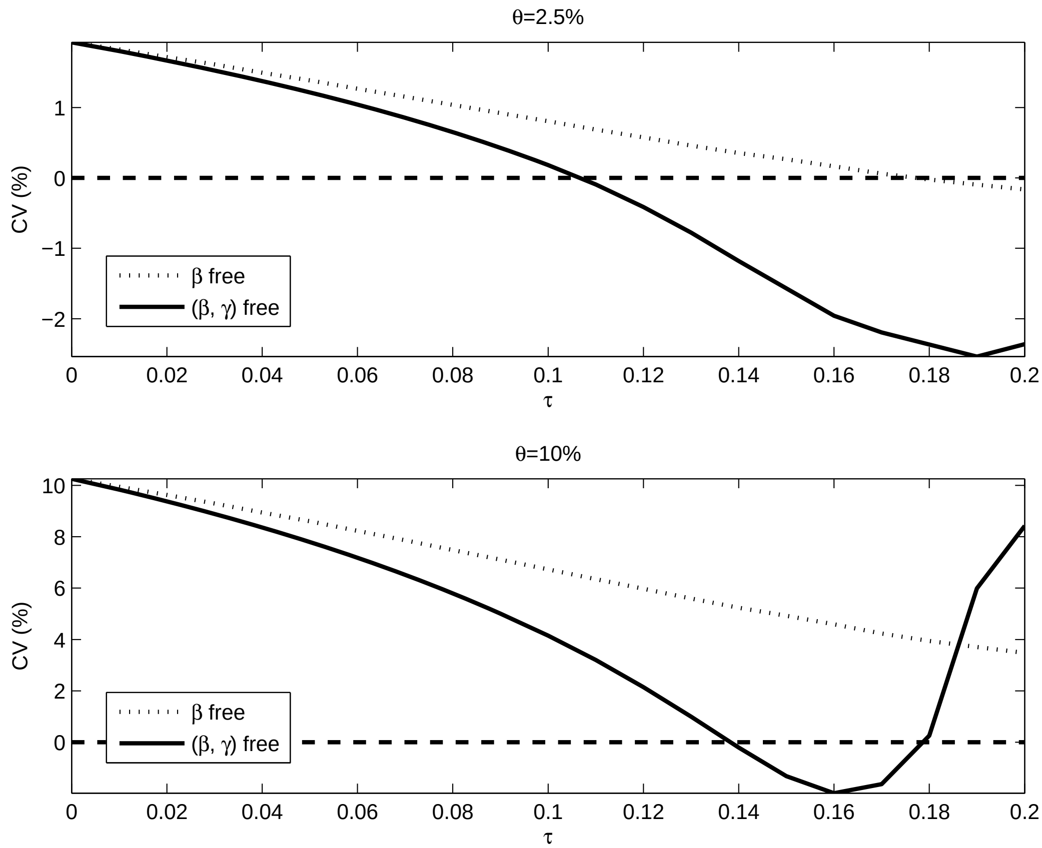

Figure 2. CV by Tax Rate (%)