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Self-control Preferences and Taxation: A Quantitative Analysis in a Life-cycle Model[1]

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Abstract

This paper examines the impact of various fiscal policies, namely, taxes on consumption, labor and capital when agents have self-control preferences. Agents trade in a stochastic overlapping generations economy while facing borrowing constraints. We quantitatively show that modelling choices, such as, liquidity constraints, life-cycle structure and idiosyncratic earnings risks, that were previously considered to be critical in delivering a positive capital income tax, need not be binding in this regard. We argue and quantitatively show that for a sufficiently large measure of individuals having self-control preferences instead of CRRA preferences, or alternatively, for a sufficiently high cost of exercising self control when all individuals are self-control types, the optimal capital income tax is zero. Given there is strong empirical and experimental evidence regarding the existence of self-control problems, our model provides quite an interesting insight: as agents' self-control costs rise, the optimal capital income tax rate will converge to Chamley and Judd value.

    JEL Classification: E21, E62, H55

1   Introduction

Is it true, under fairly general modelling choices, that the government should impose a positive tax on capital income in the long run? The original answer to this question is negative and is due to the seminal papers by Chamley (1986) and Judd (1985) who argued that the optimal tax plan in an infinite horizon, representative agent general equilibrium model calls for zero taxation of capital income. Since then, several modelling choices that could cast doubt on the validity of this result were identified in the literature: Imrohoroglu (1998), inter alia, emphasized that in an overlapping generations setting where individuals face idiosyncratic earnings risk, borrowing constraints and life-span uncertainty, the optimal tax system will in general include a positive capital income tax. More recently, in a life cycle model in which households face borrowing constraints and idiosyncratic income risk Conesa *et al.* (2009) identified an optimal capital income tax rate as significantly positive (at 36%), and concluded that this high rate is mainly driven by the life-cycle structure of the model.

In this paper, we quantitatively show that the aforementioned modelling choices, namely, liquidity constraints, life-cycle structure and idiosyncratic earnings risks, that were previously considered to be critical in delivering a positive capital income tax, need not be binding in this regard. We argue and quantitatively show that for a sufficiently large measure of individuals having self-control preferences instead of CRRA preferences, or alternatively, for a sufficiently high cost of exercising self control when all individuals are self-control types, the optimal capital income tax eventually converges to the Chamley / Judd result, that is, zero.

Along with the fiscal policy literature, there is a growing literature corroborating evidence coming from both introspection and experiments, that agents exhibit preference reversals as time passes. Different strands in the literature have suggested that these preference reversals could be induced by either time-inconsistent preferences, (see Laibson (1997)) or self-control preferences (Gul & Pesendorfer (2004)).[1] Time inconsistent preferences typically assume that agents have sequences of different "selves," each valuing consumption streams in a unique way. On the other hand, the preference structure pioneered by Strotz (1956) and Phelps & Pollak (1968) and further elaborated by Gul & Pesendorfer (2004) to model self-control issues provides a time-*consistent* model suitable for addressing the preference reversals that does not necessitate splitting up the consumer in multiple selves. Instead, preferences are defined over consumption sets rather than over consumption sequences. 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, 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

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[1]The experimental economics literature documents that subjects who face intertemporal choice problems often show preference reversals. The first formal analysis of preference reversals was conducted by Strotz (1956). Ameriks *et al.* (2007) among others find more recent evidence.

and, contrary to time-inconsistent preferences, allow agents in our model to commit.[2]

All the above imply that agents that have nonstandard preferences trading in stochastic environments face a trade-off between commitment and flexibility, as suggested by Amador *et al.* (2006). An environment with a government having a choice out of an array of different tax instruments can considerably alter these trade-offs. Naturally, by now there is a growing number of studies that explore the effect of self-control preferences on agents' decisions and at the same time examine the impact of different fiscal policies on agents' welfare. Within the optimal income tax context, Gruber & Koszegi (2001), Gruber & Koszegi (2004), O'Donoghue & Rabin (2003), O'Donoghue & Rabin (2006), and Aronsson & Sjorgen (2009), study the impact of taxes when agents have Laibson (1997) preferences. The main finding here is that consumers optimally choose to consume more now and less in the future. Agents over-consume in the sense that consumer welfare increases with a tax that reduces consumption to a level which consumers would choose if they could pre-commit to consume less in the future. Thus the optimal tax rates are generally greater than tax rates observed in the data. When dynamically *consistent* preferences *à la* Gul & Pesendorfer (2004) are considered, Krusell *et al.* (2009) characterize an optimal tax rate.[3] The authors show that when period utility is logarithmic the optimal savings subsidies increase over time for any finite horizon. Moreover, as the horizon grows large, the optimal policy prescribes a constant subsidy, in contrast to the well-known zero capital tax rate result of Chamley (1986) and Judd (1985).

The aforementioned studies, (in particular Krusell *et al.* (2009)) that deal with fiscal policies under different specifications of self-control preferences, have not really addressed life-cycle issues, thus ignoring the potentially beneficial function of a certain class of taxes, as a mechanism that restrains young agents' choices and thereby mitigating their self-control problems. The lack of an integrated approach in the public finance literature when it comes

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[2]It is nevertheless critical to address a question that lies at the very core of our line of research, namely, why fiscal policy models with time inconsistent or "temptation" preferences are relevant in the first place. Several factors weigh-in in favor of the relevance of these models. A first one relates to theoretical completeness: a change in the preference structure enhances our understanding of the mechanics of similar models in the literature by providing an additional channel through which capital accumulation is distorted. An additional factor is the need for comprehensive policy evaluation: an augmented preference structure is essential for providing a comprehensive comparison framework for policy makers in their evaluation of various proposals. Thirdly, empirical relevance: there is sound empirical and experimental evidence that agents suffer from self-control problems. Frederick *et al.* (2002) provide an overview of experimental studies documenting that agents indeed exhibit bias toward immediate gratification. Huang *et al.* (2007) and Bucciol (forthcoming) study the empirical relevance of self-control preferences using household-level data from the Consumer Expenditure Survey. Their estimates support the presence of temptation. Ameriks *et al.* (2007) develop a survey instrument to measure self-control problems and apply it to a sample of highly educated adults. They find that self-control problems are smaller in scale for older than for younger individuals. Moreover, in a recent paper Fang & Silverman (2009) empirically identify the existence of time-inconsistency that stems from self-control problems, through the estimation of the structural parameters of a dynamic labor supply model. Similarly, Gruber & Koszegi (2001) recognize that there is strong evidence that preferences related to smoking are time-inconsistent, while Angeletos *et al.* (2001) show that models featuring time-inconsistent preferences perform better in matching the available consumption and asset allocation data drawn from the Panel Study of Income Dynamics and the Survey of Consumer Finances. Finally, the literature documents that the existence of self-control problems affects fundamentally the economic decisions of agents.

[3]Gul & Pesendorfer (2004) explain the self-control phenomenon by constructing self-control preferences that depend not only on an agent's actual consumption but also on the agent's hypothetical temptation consumption.

to the study of the impact of taxes on agent behavior under self-control preferences may cast shadows of doubt on the unbiasedness of some conclusions pertaining to the scope of tax policy under a non-standard preference regime. This is the case because the distortions of different fiscal policies (social security and other taxes) might reinforce one another and change fundamentally the trade-off between commitment and flexibility that agents face. It is therefore essential to approach this issue in a more integrated manner. Kumru & Thanopoulos (2008) and Bucciol (2008) analyze the welfare consequences of unfunded social security when agents have self-control preferences. Both papers show that the a system of unfunded social security helps agents to mitigate their self-control costs by functioning as a forced savings mechanism that effectively contracts young agents' choice sets. Hence, social security turns out not to be as detrimental to welfare as shown by the earlier studies, while in some cases it may even be welfare enhancing. In a similar spirit, a certain combination of capital income, labor income, and consumption taxes might relatively work better in economies with self-control agents in terms of providing a superior protection against self-control problems.

In view of the above, this paper examines the impact of different fiscal policies, namely, taxes on consumption, labor income and capital income as well as social security taxes, when agents have self-control preferences. Agents trade in a stochastic overlapping generations economy while facing borrowing constraints.[4] In such an environment, different cohorts face different trade-offs between commitment and flexibility. We consider Gul-Pesendorfer preferences because: (i) they are time consistent, and (ii) they nest standard utility. This is the case as Gul-Pesendorfer preferences can be thought as a perturbed case of the standard ones (in other words, standard preferences can be derived as a limiting case of the self-control specification). These properties allow us to solve the problem recursively. Moreover, by maintaining the same class of models we retain comparability, and hence we can assess the robustness of previous results in the literature that used standard preferences. Finally, a self-control preference specification allows us to have an environment with agent heterogeneity. Thus, we can examine the impact of fiscal policies when a measure of the agents in the population has standard preferences while its complement exhibits self-control preferences, which is consistent with recent empirical evidence.

To explore the quantitative implications of the model we consider an incomplete markets general equilibrium model that is populated by overlapping generations of agents who can live up to 65-periods. During the course of life, agents face idiosyncratic income risk, a liquidity constraint, and uncertain life-time. Before retirement, agents face a stochastic employment opportunity and hence, they can be unemployed in a given period and receive unemployment benefits. Employed agents supply labor inelastically. While all agents pay consumption and capital taxes, only employed agents pay labor income and payroll taxes. After retirement agents receive an earnings-dependent pension benefits.

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[4]The borrowing constraint, for example, has conflicting impacts. Relaxing (or tightening) borrowing constraint extends (or restraints) the choice set, which in turn has two opposing effects: first, it allows individuals to have more (or less) flexibility to cope with income uncertainty; second, it increases (decreases) the severity of self-control problem, which is welfare improving.

Our results here document that if we take into account agents' self-control problems, then the highest welfare will be generated by significantly lower capital income tax rates than those recently documented in the literature. Given the strong empirical and experimental evidence with regard to the existence of self-control problems, our model provides quite an interesting insight: the optimal capital income tax rate will converge to Chamley and Judd's rate as agents' self-control problems become more acute, and as the respective costs for resisting temptation get higher.

This paper is organized as follows. Section 2 presents our large scale model economy. Section 3 describes the values of the model's parameters. In section 4 we present results of our policy experiments. Section 5 concludes.

2   A model of taxation

The framework we consider here builds on the work of Imrohoroglu (1998) and studies the implications of deviating from CRRA preferences by allowing self-control preferences and heterogeneity in the population's preferences (self-control and CRRA ones). This departure lets us determine the robustness of previous results in the literature pertaining to the consequences of the tax related fiscal policies within the life-cycle framework as in Conesa *et al.* (2009), Krusell *et al.* (2009), and Imrohoroglu (1998). This is the case as the class of self-control preferences proposed by Gul & Pesendorfer (2004) nests those of standard and Laibson-type time-inconsistent preferences. We follow Ameriks *et al.* (2007) and conduct experiments by assuming a certain portion of the population has self-control preferences while others have standard CRRA preferences.[5] Incorporating this fact allows us to quantify the consequences of the preference heterogeneity for the aggregate economy under different taxation regimes. In the next subsections we provide more details regarding the economic environment, different agents in the economy, and their optimal decisions.

2.1   The environment

The economy is populated with overlapping generations of a large number of agents. Time is discrete and at each period a new generation is born. At each point in time, the economy has a time-invariant measure, X, of new born agents that have self-control preferences, while the remaining new born agents, $1 - X$, do not; i.e., these agents have standard CRRA preferences. We define $z \in \{0, 1\}$ to denote the type of preferences agents have. In particular, when $z = 0$ ($z = 1$) agents have self-control (standard CRRA) preferences. Finally, the population grows at a constant rate n.

Agents value consumption and live for a maximum of J periods while facing individual income risk, borrowing constraints, and life-span uncertainty. More precisely, agents face a

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[5]Ameriks *et al.* (2007) finds that over 10% of agents in the survey have self-control problems as measured by the revealed preferences gap. In contrast, over 30% agents have self-control problems according to the gap between expected and ideal consumption.

probability of surviving from age $j - 1$ to j conditional on having survived up to $j - 1$, which we denote by s_j. Since we focus on stationary economies, age j agents constitute a fraction μ_j of the population at any given date. The corresponding cohort shares, $\{\mu_j(z)\}_{j=1}^J$, are given by

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

where $\mu_1(0) = X$, $\mu_1(1) = 1 - X$. Note that the sum of these cohort shares are normalized to 1.

2.2 Preferences

Following Gul & Pesendorfer (2004) and DeJong & Ripoll (2007) we model self-control preferences recursively. Agents with self-control preferences face the temptation to consume their entire wealth at any given point in time. Resisting to this temptation creates a self-control cost which is absent in the models with standard CRRA and Laibson type time-inconsistent preferences.

Let $W(x)$ denote the maximized value of the expected discounted utility associated with state x, which is given by

$$W(x) = \max_c \{u(c) + \mathbf{1}_{\{i \in S_X\}} v(c) + \beta E W(x')\} - \mathbf{1}_{\{i \in S_X\}} \max_{\check{c}} v(\check{c}), \tag{1}$$

where E denotes the expectation operator; $u(.)$ and $v(.)$ are von Neumann-Morgenstern utility functions; S_X denotes the set of agents who have self-control preferences; $\mathbf{1}_{\{S_X\}}$ is the corresponding indicator function; $0 < \beta < 1$ represents the discount factor; c is the commitment consumption; $\check{c}$ represents the temptation consumption; and x' denotes next period state variable. Finally, $u(.)$ represents the momentary utility and $v(.)$ represents temptation utility, respectively. Notice then that $v(c) - \max_{\check{c}} v(\check{c})$ denotes the disutility of choosing commitment consumption, c, instead of temptation consumption, $\check{c}$. The concavity or convexity of $v(.)$ is crucial for our analysis as it determines the overall concavity of the problem.[6]

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

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

and

$$v(c) = \lambda \frac{c^\rho}{\rho}, \tag{3}$$

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 whereas higher values of the risk loving parameter $\rho > 0$ imply that

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[6]Notice that if $v(.)$ is convex, we need to make sure that $v(.) + u(.)$ is stricly concave. In particular, $\gamma > 0$, $\rho > 1$ and $0 < \lambda < \gamma/(c^{\gamma+1} c^{\rho-2})$ guarantee that $u(.)$ is concave, $v(.)$ is convex and $u(.) + v(.)$ is strictly concave. When $v(.)$ is concave, one should show that $W(.)$ is strictly concave.

agents prefer current temptation consumption more than future temptation consumption. The momentary utility function $u(.)$ 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). Notice that this specification nests the standard preferences. In particular, when $\lambda = 0$ we recover the standard preferences used in the literature; i.e., Imrohoroglu (1998) among others. Thus by considering small values of the temptation parameter, $\lambda \approx 0$, we can determine the impact of small deviations from the standard preferences to the behavior of agents as different fiscal policies are considered.

Huang *et al.* (2007) point out that only $v(c) = \lambda u(c)$,(introduced by Krusell & Smith (2003)), is compatible with a balanced growth path. For the sake of completeness we duly produce results when the temptation function takes either form.

2.3 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.[7] 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 $\Pi(e', e) = [\pi_{i'i}]$ where $i', i = 0, 1$ and $\pi_{i'i} = \Pr\{e' = i' | e = i\}$.

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.

When agents retire at age j^*, they receive a lump-sum social security benefit which we denote by b. This benefit is defined as a fraction θ of an average life time employed income, which is independent of an agent's employment history and is given by:

$$b = \begin{cases} 0 & \text{for } j = 1, 2, ..., j^* - 1; \\ \theta \frac{\sum_{j=1}^{j^*-1} w\epsilon_j}{j^*-1} & \text{for } j = j^*, j^* + 1, ..., J. \end{cases}$$

An agent at age j has net-of-tax earnings inclusive of social security benefits, q_j, given by:

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

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[7] 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.

where τ_n, τ_s, and τ_u represent the labor income tax rate, the social security tax rate, and the unemployment insurance tax rate respectively.

As in the previous literature, our economic environment does not consider private insurance markets that can reduce employment risk nor private annuities market that provide insurance for uncertain life span.[8] Thus the only private device to smooth consumption across one's lifetime is the accumulation of assets in terms of physical capital (savings). This financial market has some imperfections as agents cannot hold negative assets at any period. In other words, an agent faces a borrowing (or liquidity) constraint.[9] As a result, social security partially fulfils the role of the missing annuities market. In other words, it can be considered as mandatory annuitization.

Since death is certain at J and there is no bequest motive, the borrowing constraint can be stated as:[10]

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

where a_j denotes the end-of-period asset holdings. Note that if agents in this economy die before age J, their remaining assets will be distributed to all of the survivors in a lump-sum fashion. Let η_1 denote the equal amount of accidental bequests distributed to all remaining members of the society:

$$\eta_1 = \sum_z \sum_j \sum_a \sum_e \mu_j(z) \Lambda_j(z, a, e)(1 - s_{j+1}) a_j(z, a, e), \tag{4}$$

where $\Lambda(z, a, e)$ denotes the measure of agents with the state (z, a, e).

Given the our economic environment, the corresponding commitment consumption and temptation consumption budget constraints of an agent are then given by:

$$a_j + (1 + \tau_c)c_j = [1 + (1 - \tau_k)r]a_{j-1} + q_j + \eta_1 + \eta_2; \tag{5a}$$

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[8]Although the annuities market exist in U.S., it is very thin (Imrohoroglu, 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.

[9]Given the size of private credit markets, this assumption may seem not so innocuous. There are two main reasons behind this assumption: First, we would like to make careful comparison of our results with those of the existing social security literature and this assumption is the "industry standard." Second, when agents are not allowed to borrow against their future-income, this induces an additional boost in (private) savings for precautionary purposes, since agents may be/remain 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 collinear, hence the effect of social security on savings due to self-control is non-identifiable. In a recent paper, Rojas and Urrita (2004) show that adding endogenous borrowing constraint reduces the welfare cost of having a social security.

[10]Allowing bequest motive also changes welfare implications of 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.

and

$$a_j + (1 + \tau_c)\check{c}_j = [1 + (1 - \tau_k)r]a_{j-1} + q_j + \eta_1 + \eta_{2,} \tag{6}$$

where τ_c is the consumption tax rate; τ_k denotes the capital income tax rate; r represents the rate of return from the asset holdings; and η_2 denotes lump-sum government transfers.

2.4 Production function

Firms have access to a constant returns-to-scale Cobb-Douglas technology that produces output, Y, by using aggregate labor, L, and capital, K, inputs, which is given by:

$$Y = F(K, L) = AK^\alpha L^{(1-\alpha)}, \tag{7}$$

where A denotes total factor productivity, aggregate labor L is defined as $0.94h \sum_z \sum_{j=1}^{j^*-1} \mu_j(z)\epsilon_j$, with h denoting hours of work, and $\alpha \in (0, 1)$ representing the capital's share of output. Defining the capital-labor ratio as $k = \frac{K}{L}$, we can write the production function in the intensive form as follows:

$$y = f(k) = Ak^\alpha.$$

Total factor productivity, A, grows at a constant rate g and capital depreciates at a constant rate δ. Competitive firms in this economy maximize their profits taking prices as given. Production factors are paid their marginal products. Thus, the real rate of return from asset holdings, r, and the real wage rate, w, are determined by the following equations:

$$r = A\alpha k^{\alpha-1} - \delta \tag{8}$$

and

$$w = A(1 - \alpha)k^\alpha. \tag{9}$$

2.5 Government

The government in this economy need to finance a stream of government expenditures, G, while providing two social insurance programs. The first one is an unemployment insurance program that provides partial insurance against the idiosyncratic earnings risk. The second one is a social security program that provides partial insurance against mortality risk. Each program is assumed to be self-financing. Thus the government budget constraints can be written as follows:

$$\tau_s \sum_z \sum_{j=1}^{j^*-1} \sum_a \mu_j(z)\Lambda_j(z, a, e = 1)w\epsilon_j = \sum_{j=j^*}^{J} \sum_a \mu_j(z)\Lambda_j(z, a, e)b, \tag{10}$$

$$\tau_u \sum_z \sum_{j=1}^{j^*-1} \sum_a \mu_j(z)\Lambda_j(z, a, e = 1)w\epsilon_j = \sum_z \sum_{j=1}^{j^*-1} \sum_a \mu_j(z)\Lambda_j(z, a, e = 0)\phi w\epsilon_j, \tag{11}$$

8

and

$$G + \eta_2 = \tau_k r K + \tau_n w L + \tau_c C, \tag{12}$$

where C denotes aggregate consumption. Note self-financing is guaranteed if the government chooses the payroll tax rates τ_s and τ_u endogenously given the social security and unemployment insurance replacement rates θ and ϕ respectively.

2.6 An agent's dynamic program

Since temptation utility $v(.)$ is strictly increasing, an agent who has self-control preferences is tempted to consume his entire wealth in each period. This implies that the agent maximizes the second component of equation (1) with no savings, i.e. setting $a_j = 0$ in equation (6). Thus, we can write the agent's dynamic program for any arbitrary two period as follows:

$$W(x) = \max_c \{u(c) + \mathbf{1}_{\{i \in S_X\}} v(c) + \beta E_{s'} W(x')\} - \mathbf{1}_{\{i \in S_X\}} v(((1 + (1 - \tau_k)r)a_{j-1} + q_j + \eta_1 + \eta_2)/(1 + \tau_c))$$
$$\tag{13}$$

subject to

$$a' + (1 + \tau_c)c = [1 + (1 - \tau_k)r]a + q + \eta_1 + \eta_2, \ a' \geq 0, \ a_0 \text{ is given}, \tag{14}$$

where $x = (z, a, e)$ is the agent's state vector $E_{s'}$ denotes the expectation over survival probabilities and the initial asset holdings a_0 are given.

If an agent succumbs to temptation and consumes his entire wealth, then

$$\mathbf{1}_{\{i \in S_X\}} v(c) = \mathbf{1}_{\{i \in S_X\}} v(((1 + (1 - \tau_k)r)a_{j-1} + q_j + \eta_1 + \eta_2)/(1 + \tau_c))$$

When an agent resists to temptation and consumes less than his wealth, he faces a self-control cost equal to

$$v(c) - v(((1 + (1 - \tau_k)r)a_{j-1} + q_j + \eta_1 + \eta_2)/(1 + \tau_c)).$$

Thus, an agent with self-control problems tries to balance his urge for current consumption $v(c)$ and long-term commitment utility $u(c) + \beta E_{s'} W(x')$.

2.7 Steady state equilibrium

In our characterization of the steady state equilibrium, we follow Imrohoroglu $et\ al.$ (2003) and Hugget & Ventura (1999). Note that an agent's state vector $x = (z, a, e)$.

Given a set of government policy $\{G, \theta, \phi, \tau_c, \tau_k, \tau_n, \tau_s, \tau_u\}$, a steady state recursive competitive equilibrium is a set of value functions $\{W_j(x)\}_{j=1}^J$, agents' 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_1 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 (8) and (9).

- Given government policy set $\{G, \theta, \phi, \tau_c, \tau_k, \tau_n, \tau_s, \tau_u\}$, factor prices (w, r), and lump-sum transfer of accidental bequests η_1, an agent's policy rule $\{a_j(x)\}_{j=1}^J$ solves the agent's maximization problem (13) subject to the budget constraint (14).

- Aggregation holds:

$$K = \sum_z \sum_j \sum_a \sum_e \mu_j(z) \Lambda_j(x) a_{j-1}(x). \tag{15}$$

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

$$\Lambda_j(z, a', e') = \sum_e \sum_{a:a'=a_j(x)} \prod(e', e) \Lambda_{j-1}(z, a, e), \tag{16}$$

where Λ_1 is given.

- The lump-sum distribution of accidental bequests η_1 satisfies the equation (4).

- Both the social security system and the unemployment insurance benefit program are self-financing (the equations (10) and (11) are satisfied).

- Government's budget constraint satisfies the equation (12).

- Aggregate feasibility holds so that:

$$\sum_z \sum_j \sum_a \sum_e \mu_j(z) \Lambda_j(x)[a_j(x) + c_j(x)] + G \tag{17}$$
$$= Y + (1-\delta) \sum_z \sum_j \sum_a \sum_e \mu_j \Lambda_j(x) a_{j-1}(x).$$

3   Calibration

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

3.1   Demographic and labor market parameters

Agents are born with a real life age of 21, which corresponds to a model age of 1, and they can live up to a maximum real life age of 85 years, which corresponds to a model age of 65. The population growth rate, n, is equal to the average U.S. population growth rate between 1931-2003 which corresponds, on average, to 1.19% per year.[11]. The mandatory retirement age is set to age 65 (model age 45).

The sequence of conditional survival probabilities is taken from the Social Security Administration's sequence of survival probabilities for men in the year 2001. In order to determine the

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[11]The population data are obtained from the U. S. Census Bureau (the US Census Bureau (2006)) .

efficiency index, we choose the average of Hansen (1993)'s estimation of median wage rates for males and females for each age group. We then 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.[12] The implied employment transition matrix assumes the following form:

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

3.2 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, which is reported as 3.2 in Imrohoroglu (1998).

Following Imrohoroglu (1998), we let the risk aversion parameter, γ, be equal to 1.8. When agents have standard CRRA preferences we choose the value of the 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 featuring a temptation function in the form of $v(c) = \lambda \frac{c^\rho}{\rho}$, 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.[13] 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 60% and the unemployment replacement ratio is 25% during our search.[14]

We also conduct our analysis by employing a temptation function in the form of $v(c) = \lambda u(c)$. In this case we choose the values of λ as 0.0786 and 0.1572 which are in the range of estimates made by DeJong & Ripoll (2007) and Huang *et al.* (2007). Note that we adjust β by keeping γ and λ constant this time.

3.3 Production parameters

The parameters describing the production side of the economy are chosen to match the long-run features of the US economy. Following Imrohoroglu *et al.* (1998), we set the capital share of

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

[13]Note 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.

[14]Please note that we could adjust the depreciation rate to match the K/Y ratio while keeping β below one. The reasons why we proceed with adjusting β instead are the following: First, our models are meant to differ only in terms of preference specifications. If we adjusted the depreciation rate on top of it, models would differ along two dimensions instead: preferences and capital depreciation rate. Second, we (safely) adjust β in the range of empirical estimates (for example see Imrohoroglu *et al.* (1995) regarding studies that estimate β larger than 1). Third, capital depreciation rate estimates for the US are more accurate and reliable than the estimates of β. As a result, we opt for adjusting β instead of the depreciation rate.

output α equal to 0.40 and the annual depreciation rate of physical capital equal to 6%. 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)). In cases where aggregate technology is considered constant, $g = 0$. The technology parameter A, can be chosen freely. In our calibration exercises, it is set equal to 1.2. All per capita quantities are assumed to grow at a constant rate g.

3.4   Government

We set the unemployment insurance replacement ratio (ϕ) equal to 30% of the employed wage and set the social security replacement ratio (θ) equal to 60%, 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 of labor.[15] Government expenditures (G) are assumed as 20% of the GDP.

In the benchmark case, we follow Imrohoroglu (1998) and set the values of the capital income tax rate (τ_k), the labor income tax rate (τ_n), and the consumption tax rate (τ_c) as 40%, 20%, and 5.5% respectively. Lump-sum transfers (η_2) are determined endogenously to make sure that the government runs a balanced budget. See table 1 for the exact numerical values of all parameters in the model.

3.5   Solution method

Given a particular parametrization, we use discrete-time, discrete-state optimization techniques to find a steady-state equilibrium of our hypothetical economy. Our solution method designedly resembles those of previous studies.[16]

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.[17] While the state space for working age agents comprises 4097×2 points, the state space for retired agents consists of only 4097×1 points. This is the case as there is no state transition after j^*. The discrete set of the control variable (consumption) contains 4097×1 points.

In order to compute the resulting equilibrium in the economy, 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

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

[16] See Imrohoroglu *et al.* (1995), Imrohoroglu (1998), and Hugget & Ventura (1999).

[17] In 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.

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 a fixed point for the accidental bequests and the capital stock.

Demographics	
Maximum possible life span J	65
Obligatory retirement age j^*	45
Growth rate of population n	1.19%
Conditional survival probabilities $\{s_j\}_{j=1}^J$	U.S. 2001
Labor efficiency profile $\{\epsilon_j\}_{j=1}^{j^*-1}$	Hansen (1993)
Production	
Capital share of GDP α	0.40
Annual depreciation of capital stock δ	6%
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	30%
Social security replacement ratio θ	60%
Capital income tax rate τ_k	40%
Labor income tax rate τ_n	20%
Consumption tax rate τ_c	5.5%

Table 1: Parameter Values

4   Results

In this section we consider two policy regimes. First, we consider eliminating taxes on capital income. Second, we analyze a situation where higher consumption taxes partially replace capital and labor income taxes.

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 various taxation schemes.

We follow the common practice in the public finance literature in our welfare and steady-state comparisons. More specifically, we calibrate our benchmark (status quo) economy to the US data: capital income, labor income, and consumption taxes are 40%, 20%, and 5.5% respectively. We aim at generating a long-run average of the capital-output ratio in the US in each case.

In the first policy regime, keeping government expenditures, transfer payments, and the consumption tax rate constant, we gradually reduce the capital income tax rate in steps of 5% each time and re-calibrate the model economy to the data. The corresponding labor income tax rates are determined endogenously.

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In the second policy regime, we first examine the effect of the elimination of the tax on capital income while maintaining the tax on labor income at its status-quo level. Then, we go ahead and eliminate taxes on both capital and labor income. In both cases the corresponding consumption taxes are determined endogenously.

The effects of a given policy change are reflected in the changes in the economic aggregates and the expected utility of a new-born agent.

In order to compare welfare across different tax policies, following Conesa *et al.* (2009), we compute the corresponding to each case consumption equivalent variation (CEV) which is simply the uniform percentage decrease in consumption required to make an agent indifferent between being born under the scenario of a reformed tax system (comparison case) relative to being born under the status-quo system (benchmark case). For instance, a positive CEV reflects a welfare increase due to a given reformed system compared to the benchmark case.[18]

4.1 CRRA preferences

Labor and capital income taxation

In this section we first calibrate our model economy to the US data under the assumption that agents have CRRA preferences while keeping the capital income, labor income, and consumption taxes at 40%, 20%, and 5.5% respectively. In all tables, the values of the economic aggregates are normalized to 100 under the status quo economy. The values of the various tax schemes in terms of welfare are calculated accordingly. In Table 2, we set $\beta = 0.991$. The capital-output ratio and the interest rate in the status-quo economy is 3.1 and 6.7% respectively. These values are close enough to the values reported by Kydland & Prescott (1996) for the US economy.The effects that the resulting nine competing scenarios have on economic aggregates, as well as their welfare implications are reported in Table 2.

$\tau_k(\%)$	$\tau_n(\%)$	K	C	Y	$r(\%)$	$CEV(\%)$
40	20	100	100	100	6.70	0
35	21.610	104.103	101.028	101.553	6.41	0.0593
30	23.030	108.079	101.972	103.049	6.14	0.1206
25	24.460	111.422	102.764	104.327	5.92	0.0073
20	25.850	114.655	103.489	105.549	5.72	−0.1716
15	27.220	117.619	104.129	106.685	5.53	−0.4376
10	28.540	120.959	104.753	107.812	5.35	−0.7267
5	29.870	123.941	105.258	108.778	5.20	−1.1327
0	31.250	125.619	105.629	109.498	5.09	−1.7458

Table 2: CRRA-no growth

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[18]In other words, we calculate welfare by using the value function in equation 13 and transform into consumption units. When agents have CRRA and Krusell-Smith type of self-control preferences, the welfare consequences of switching from a steady-state allocation x_0 to x_* is given by $CEV = [\frac{W(x_*)}{W(x_0)}]^{1/(1-\gamma)} - 1$. When agents have temptation utility in the form of $v(c) = \lambda\frac{c^\rho}{\rho}$, we use $CEV = [\frac{W(x_*)}{W(x_0)}]^{1/(1-\gamma-\rho)} - 1$ to make welfare comparisons.

Our results in Table 2 show that if we were to completely eliminate the capital income tax while at the same time keeping the transfer payments and the government expenditures at their benchmark levels, the capital stock would naturally increase by 25.6%. Note that this increase in the capital stock comes at the expense of an increase in the labor income tax from 20% to 31.3%. The level of aggregate consumption increases by just 5.6% hinting to a small capital stock effect. Our economy is dynamically efficient at all levels of the capital income tax rate and hence, reducing or even eliminating the capital income tax rate makes our economy closer to its golden-rule steady state level. From Table 2 we see that highest steady-state welfare is generated when the capital income tax rate is 30%. This significantly high positive tax rate is in line with the findings of Conesa *et al.* (2009) who show that a capital income tax rate of a 36% magnitude is optimal.

In line with Imrohoroglu (1998), we observe that eliminating the capital income tax creates a trade-off between the positive capital stock effect on the one hand, and the negative consumption profile effect on the other. In other words, on the one hand, aggregate consumption and welfare increase as a result of an increase in the capital stock. On the other hand, the tax burden shifts from agents with low saving propensities to agents with high saving propensities. The lost revenue for the government from eliminating the capital tax rate is made up by an increase in the labor income tax rate. This shift in the tax burden reduces welfare as a result of its negative effects on agents' ability to smooth out consumption and to insure against risks pertaining to future income fluctuations and longevity. Thus, the presence of a budget constraint and the timing of the tax burden over the life-cycle might give rise in a welfare maximizing capital income tax rate that is positive. Our results indicate that the timing of tax burden is important and the consumption profile effect dominates the capital stock effect at a capital income tax rate of 30%.

Note that in this environment agents supply labor inelastically. When on the other hand we allow for an endogenous labor-leisure choice the above result would be further amplified: higher labor income tax rates will have more severe allocative consequences. This, in turn, will push the optimal capital tax rate further up. Conesa *et al.* (2009) show that the optimal capital income tax rate is significantly higher when the model incorporates labor-leisure choice.

Consumption taxation

In this section we compare the two alternatives of the status quo economy. We present the results of the three alternative tax schemes in Table 3.

$\tau_k(\%)$	$\tau_n(\%)$	τ_c	K	C	Y	$r(\%)$	$CEV(\%)$
40	20	5.500	100	100	100	6.840	0
0	20	10.410	138.989	107.959	114.066	4.540	8.028
0	0	18.050	162.169	110.720	121.333	3.610	24.595

Table 3: Alternative tax bases - CRRA no-growth

When the capital income tax is replaced with a higher consumption tax, the capital stock increases by 38.9%. Going one step further, when we replace both labor and capital income taxes with an even higher consumption tax, the capital stock increases by 62.2%. In both cases there is substantial utility gain as reflected in the higher CEV values reported. Our results are in line with those of the previous studies, in particular those of Imrohoroglu (1998) and the intuition is clear: the capital stock effect is larger and the consumption profile effect is smaller since the consumption tax removes the distortion on private saving and smooths out the tax burden over the life-cycle.

4.2 Self-control preferences

4.2.1 Two dimensional temptation function ($v(c) = \lambda \frac{c^\rho}{\rho}$)

In this section we present our results for an economy in which agents have self-control preferences and compare the effects of the various tax schemes on both economic aggregates and social welfare with the results obtained in the respective cases involving CRRA preferences analyzed in the previous section.

We assume that temptation utility takes the form $v(c) = \lambda \frac{c^\rho}{\rho}$. Note that in this case, in order to have balanced growth we need to assume that aggregate technology remains constant i.e. there is no growth.

Before presenting our results, 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. In doing this, we first keep ρ fixed at 2 and vary λ, then we keep λ constant at 0.00009 and vary ρ while keeping the annual discount factor at its no-growth CRRA level throughout the exercise. Tables 4 and 5 display our results for both cases.

λ	K	e_K	Y	e_Y
0.00025	100		100	
0.00050	91.063	0.089	96.326	0.037
0.00075	84.402	0.146	93.464	0.059
0.001	72.298	0.181	91.134	0.074

Table 4: Changes in the strength of λ

Table 4 demonstrates that an increase in the intensity of temptation distorts capital accumulation and output severely. In order to perform meaningful comparisons we calculate elasticities associated with each aggregate variable. An initial 1% increase in the values of λ, gives rise to a 0.09% decrease in the aggregate capital stock. Subsequent equal step increases in the numerical value of λ create increasingly higher distortions on the aggregate capital stock. Similarly, while an initial 1% increase in λ causes a 0.037% decrease in aggregate output, further equal step increases in λ create higher distortions in aggregate output.

ρ	K	e_K	Y	e_Y
2	100		100	
3	75.182	0.496	89.220	0.216
4	49.115	1.040	75.266	0.469
5	35.882	1.077	66.368	0.473

Table 5: Changes in the strength of ρ

Table 5 shows the effects of an increase in an agent'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 and output. An initial 1% increase in ρ creates a 0.49% decrease in K and a 0.22% decrease in Y while further increases give rise to higher distortions on K and Y.

Labor and capital income taxation

Now, our model differs from Imrohoroglu (1998) and Conesa *et al.* (2009) in terms of preference specification.

In Table 6 we present our results when agents suffer from moderate self-control problems. This table is generated by assuming $\lambda = 0.005$ and $\beta = 1.045$. As in the benchmark case, the model is able to generate a capital-output ratio and an interest rate close enough to their empirical estimates.

$\tau_k(\%)$	$\tau_n(\%)$	K	C	Y	$r(\%)$	$CEV(\%)$
40	20	100	100	100	6.550	0
35	21.640	102.013	100.520	100.799	6.400	0.041
30	23.230	104.185	101.056	101.625	6.250	0.083
25	24.780	106.480	101.609	102.508	6.090	0.121
20	26.340	108.328	102.045	103.221	5.960	0.128
15	27.880	110.190	102.464	103.926	5.840	0.125
10	29.390	111.929	102.866	104.592	5.730	0.112
5	30.870	113.824	103.252	105.287	5.610	0.095
0	32.350	115.622	103.587	105.907	5.510	0.062

Table 6: Self-control preferences I

Our results in Table 6 show that, the complete elimination of the capital income tax rate increases the capital stock by 15.6%. This rate is comparatively lower than that of the previous section. The intuition here lies behind the fact that agents with self-control preferences inherently save less than agents with standard preferences. As a result, eliminating the capital income tax is not as effective as in the previous section in terms of increasing the capital stock. Not surprisingly, the level of aggregate consumption increases comparatively less as well. As

it was the case in the previous section, the economy is dynamically efficient and therefore, any reduction in the capital income tax rate would raise steady-state welfare as the steady-state capital stock would rise toward the golden-rule level. In this economy welfare is maximized at a 20% capital tax rate which is lower than the corresponding rate obtained in the previous section.

Higher taxes on labor income mitigate workers' self-control cost. Self-control cost tends to be particularly high in the mid-to-old-age years when agents earn higher wage income and have higher accumulated assets. In these age brackets, imposing a tax on labor income can be an effective tool to mitigate self-control cost. Accordingly, a tax on capital income can play a similar to the above role in mitigating self-control costs. However, a capital income tax reaches its maximum potential as a self-control cost reducing device during the early retirement ages in which agents' asset holdings reach their maximum (and wage income is zero).

In the previous section dealing with CRRA agents we identified the main trade-off between decreasing capital income tax rate and increasing labor income tax rate as a positive capital stock effect versus a negative consumption profile effect. Yet, when agents have self-control preferences, higher taxes on labor income come with a benefit: reducing self-control costs. This in turn mitigates the negative consumption profile effect of higher labor income taxes.

$\tau_k(\%)$	$\tau_n(\%)$	K	C	Y	$r(\%)$	$CEV(\%)$
40	20	100	100	100	6.560	0
35	21.670	101.925	100.504	100.753	6.450	0.099
30	23.270	103.971	101.007	101.544	6.310	0.193
25	24.870	105.917	101.494	102.307	6.170	0.277
20	26.460	107.625	101.897	102.947	6.060	0.339
15	28.020	109.336	102.300	103.615	5.940	0.397
10	29.580	110.935	102.653	104.209	5.840	0.442
5	31.080	112.717	103.039	104.868	5.730	0.488
0	32.590	114.212	103.375	105.442	5.630	0.518

Table 7: Self-control preferences II

In Table 7 we present our results when agents suffer from severe temptation. This table is generated by assuming $\lambda = 0.0075$ and $\beta = 1.070$. The benchmark model is able to generate a capital-output ratio and an interest rate close enough to their empirical estimates.

It is noteworthy that a complete elimination of the capital tax rate in this case generates a capital stock increase only equal to 14.2%. This reflects nothing but the increasingly dominant role of the self control problem in agents' saving decisions. The level of aggregate consumption is increased by 3.38%. The interesting result here is the following: When agents have severe self-control problems, a 0% capital income tax is the rate that gives rise to the highest welfare. In other words, in this environment, the self-control cost reducing potential of a labor income tax rate is overriding in terms of effectiveness any other fiscal instrument.

Recent studies using life-cycle frameworks in incomplete market settings showed that the

well-known Chamley (1986) and Judd (1985) zero capital tax rate result does not hold in general, and that the capital income tax rate should be significantly higher (see Imrohoroglu (1998) and Conesa *et al.* (2009)) in these environments. However, our results here document that if we factor in agents' self-control problems, then the highest welfare will be generated by significantly lower capital tax rates. Given the strong empirical and experimental evidence with regard to the existence of self-control problem driven preference reversals, our model provides quite an interesting insight: the optimal capital income tax rate will converge to the Chamley and Judd rate as agents' self-control problems become more acute, and as the respective costs for resisting temptation get higher.

$\tau_K(\%)$	Model 1		Model 2		Model 3	
	K	$CEV(\%)$	K	$CEV(\%)$	K	$CEV(\%)$
40	100		100		100	
35	103.776	0.117	103.036	0.001	102.484	0.052
30	107.706	0.222	106.463	0.039	105.017	0.089
25	110.723	0.045	109.601	−0.019	107.548	0.113
20	113.904	−0.094	112.255	−0.134	109.762	0.100
15	117.006	−0.316	114.933	−0.287	111.944	0.079
10	119.994	−0.583	117.747	−0.426	114.066	0.043
5	122.310	−1.002	119.826	−0.626	116.257	−0.016
0	124.826	−1.430	123.320	−0.816	117.979	−0.083

Table 8: Preference Heterogeneity

Now we focus our attention to economies in which a certain proportion is populated by self-control agents while the remaining population has standard preferences. We compare three model economies that differ in terms of population composition:

- in Model I, 90% of agents have standard preferences while the remaining 10% of agents have self-control preferences;

- in Model II, 50% of agents have standard preferences while the remaining 50% of agents have self-control preferences;

- in Model III, 10% of agents have standard preferences while the remaining 90% have self-control preferences.

In all models agents' self-control preference parameter values and CRRA preference parameter values are the same, i.e., $\lambda = 0.0075$; $\rho = 2$; $\gamma = 1.8$. The time-discount factor β, however, is adjusted in each case in order to ensure that the capital-output ratios and interest rates generated are sufficiently close to their empirical estimates in the benchmark cases. Following this guideline, we set β to 0.994, 1.003, and 1.030 in models I, II, and III respectively. Results are documented in Table 8.

In Model I, eliminating the capital income tax rate increases the capital stock by 24.8%. In this economy, a 30% capital income tax rate maximizes welfare. In Model II, eliminating the

capital income tax rate increases the capital stock by 23.2%. In this economy, a 30% capital income tax rate maximizes welfare as well. In Model III, eliminating the capital income tax rate increases the capital stock by 17.9% while a 25% capital income tax rate maximizes welfare.

Thus, our analysis provides a first indication in support of the fact that as the share of agents with self-control preferences in the population increases, the capital income tax rate that generates the highest welfare decreases.

In interpreting the above result we will first invoke, *inter alia*, some recent related studies that analyze the effects of various social security arrangements when agents face self-control problems which are modeled by either time-inconsistent or self-control (Gul & Pesendorfer) preferences. Kumru & Thanopoulos (2008), Kumru & Thanopoulos (2011), and Bucciol (2008) document that a higher payroll tax rate associated with a higher social security replacement rate might improve welfare to a considerable degree. The channel through which this result obtains, is the restrainment of agents' choice sets and the consequent mitigation of agents' self-control problems.

In our environment, higher labor income taxes play a similar role as that of higher payroll taxes and help agents to partly overcome their self-control problems to the extent of the deprivation of any extra consumption possibilities. This, in turn, implies that the welfare reducing negative consumption profile effect of higher labor income taxes is mitigated. Therefore, the usefulness of labor income taxes critically hinges on which out of these two competing effects eventually prevails:

Now, although the negative consumption profile effect seems to dominate the additional benefit stemming from the restriction of self control agents' choice sets, relatively higher labor income taxes needed to make up for the lower capital income taxes (in order to balance the budget) can be overall welfare improving when agents have moderate self-control problems. Interestingly, for severe self-control problems, the additional benefit stemming from the restriction of self control agents' choice sets completely dominates the negative consumption profile effect and then, the highest possible labor income tax (implying a zero capital income tax rate) can be sustained as the welfare maximizing option.

In conclusion, our results are in line with those of previous studies in the social security literature in terms of emphasizing the welfare improving potential of taxes imposed on labor income.

However, what is missing from all previous studies (in both social security and capital taxation literature) is an integrated assessment of the combined effects of the relevant trade-offs, both along the dimension of differences in preferences (in particular characterized by self-control problems) and along the dimension of the scope of capital income taxation versus labor income taxation. What is therefore identified and quantitatively assessed for the first time in the fiscal policy literature, is yet another dimension of a trade-off which is due to the agents' enhanced preference specification, and the effect of its interplay with the formerly identified trade-offs pertaining to capital income taxation versus labor income taxation. It turns out that this latter effect may reverse a well known result that was previously mistakenly attributed to

borrowing constraints and the life-cycle structure of the model.

Notice that a capital income tax provides a similar self-control cost reducing benefit as a labor income tax since both fiscal instruments, either immediately or with a time lag, restrain agents' choice sets. Yet, a high labor income tax provides a relatively larger additional benefit that is applicable to agents' resources during a longer period of time. This is because agents' wage income is higher than their income from asset holdings most of the life-span. The latter remark applies a fortiori for self control agents whose asset holdings at retirement are expected to be even lower compared to those of their CRRA counterparts, and hence an increased capital income tax rate will bite even less in their case.

Consumption taxation

In this section we consider replacing partly or in whole the capital income tax (and the labor income tax) with a consumption tax.

As we can see from Table 9 the capital stock increases by 22.1% and CEV is 1.303% when the capital income tax is replaced with a higher consumption tax. When we replace both labor and capital income taxes with a higher consumption tax the capital stock increases by 25.9% and CEV is 3%.

$\tau_k(\%)$	$\tau_n(\%)$	τ_c	K	C	Y	$r(\%)$	$CEV(\%)$
40	20	5.500	100	100	100	6.840	
0	20	12.060	122.059	102.843	108.308	5.390	1.303
0	0	20.870	125.945	103.132	109.681	5.180	2.994

Table 9: Alternative tax bases - Self-control preferences I

Table 10 presents our results when agents have severe temptation: although replacing the capital income and labor income taxes with a consumption tax is still the best option from a welfare standpoint, this substitution does not generate any astonishing increases in capital stock and welfare.

$\tau_k(\%)$	$\tau_n(\%)$	τ_c	K	C	Y	$r(\%)$	$CEV(\%)$
40	20	5.500	100	100	100	6.770	0
0	20	12.180	119.661	102.551	107.450	5.460	1.089
0	0	21.080	121.211	102.685	107.944	5.370	2.098

Table 10: Alternative tax bases - Self-control preferences II

In addition to that, a quick comparison of the results in this section with the results of the CRRA case reveals that self-control agents do not benefit much from the substitution of capital and labor income taxes by a higher consumption tax. When agents have standard preferences, a substitution of the capital income tax by a consumption tax gives rise to a huge welfare gain (8.03% increase in CEV) in contrast to moderate gains in economies with self-control

agents (1.30% and 1.01% respectively). In the CRRA case, the abolishment of both capital and labor income taxes creates an astonishing welfare improvement (24.59% increase in CEV), but the exact same scenario creates substantially lower welfare improvement when agents have self-control problems (2.99% and 2.09% increases respectively).

This result clearly demonstrates that from the perspective of self-control agents, higher labor income taxes and higher capital income taxes are much less detrimental to welfare. This is the case because self-control agents value the relief (in terms of the cost of exerting self-control) provided by higher capital and labor income tax rates.

To summarize, agents with a two-dimensional self-control problem prefer a significantly different tax rate mix compared to their counterparts that have standard preferences.

4.2.2 One-dimensional temptation function ($v(c) = \lambda u(c)$)

Labor and capital income taxation

In this section, agents' temptation is one-dimensional and is captured by the temptation strength parameter λ only. For the moderate temptation case we set $\lambda = 0.0786$ and $\beta = 1.02$ while for the severe temptation case we set $\lambda = 0.1572$ and $\beta = 1.025$. In the benchmark economies we were able to generate the capital-output ratios and interest rates that are close enough to their estimates. Note that this temptation function is consistent with a balanced growth path and therefore we can assume that there is positive economic growth here. In order to make meaningful comparison with standard preferences case, we re-calibrated CRRA economies under the assumption of positive economic growth. See Table 11.

CRRA (growth)				Self-control pref. III			Self-control pref. IV		
$\tau_k(\%)$	$\tau_n(\%)$	K	CEV	$\tau_n(\%)$	K	$CEV(\%)$	$\tau_n(\%)$	K	$CEV(\%)$
40	20	100	0	20	100	0	20	100	0
35	21.510	103.093	0.222	21.470	103.983	0.333	21.400	105.057	0.619
30	23.030	107.185	0.231	22.900	107.747	0.579	22.820	109.099	0.974
25	24.500	110.672	0.236	24.360	110.912	0.608	24.220	113.108	1.211
20	25.970	113.633	0.071	25.740	114.602	0.666	25.610	116.685	1.305
15	27.420	116.518	-0.151	27.140	117.423	0.527	26.950	120.217	1.355
10	28.830	119.237	-0.429	28.500	120.294	0.367	28.300	123.262	1.270
5	30.250	121.679	-0.828	29.830	122.975	0.138	29.600	126.502	1.151
0	31.620	124.286	-1.214	31.180	125.449	-0.196	30.930	129.924	0.880

Table 11: Labor and capital income taxation

Note that when agents' temptation is captured by a function in the form of $v(c) = \lambda u(c)$, the self-control problem is not as acute compared to the case captured by a function in the form of $v(c) = \lambda \frac{c^\rho}{\rho}$. This happens because in the latter form, temptation comes from two sources: temptation towards current consumption and preference of current temptation consumption to future temptation consumption. In the former form, however, temptation comes only from one source, that is, temptation towards current consumption. As a result, although the values

of temptation strength parameters are relatively higher in the former form, the levels of self-control cost are lower for a given set of choices the agent faces. This is best reflected in the changes in the capital stock levels. When agents have an one-dimensional temptation function, eliminating the capital income tax rate increases the capital stock more. While 25% capital income tax rate maximizes welfare in the CRRA case, 20% and 15% capital income tax rates maximize the welfare in the cases of moderate and severe temptation respectively (i.e. self-control preferences III and self-control preferences IV). This shows that the existence of a labor income tax provides self-control relief when agents have one dimensional temptation function as well.

Consumption taxation

Following our earlier practice, in this section we compare three alternative tax schemes: (i) the status-quo ($\tau_k = 40\%$, $\tau_n = 20\%$, $\tau_c = 5\%$), (ii) abolishing the capital income tax while adjusting the consumption tax ($\tau_k = 0\%$, $\tau_n = 20\%$), and (iii) abolishing both capital income and labor income tax rates while adjusting the consumption tax ($\tau_k = 0\%$ and $\tau_n = 0\%$) accordingly. Since the one-dimensional temptation function is consistent with balanced growth, we re-calibrate the CRRA economy by assuming a positive economic growth in order to make a meaningful comparison with moderate and severe self-control economies (self-control preferences III and self-control preferences IV). Results are provided in Table 12.

CRRA - growth			Self-control pref. III			Self-control pref. IV		
$\tau_c(\%)$	K	$CEV(\%)$	$\tau_c(\%)$	K	$CEV(\%)$	$\tau_c(\%)$	K	$CEV(\%)$
5.500	100	0	5.500	100	0	5.500	100	0
11.190	137.163	7.398	11.020	138.036	7.599	10.920	140.847	8.288
19.610	160.007	21.673	19.580	161.035	20.879	19.510	164.134	20.949

Table 12: Alternative tax bases

Our results here demonstrate that when agents face one-dimensional temptation, substituting capital and labor income taxes with higher consumption taxes increase the capital stock and improve the welfare at the similar rates as in the CRRA economy. This is not a surprising result, since one-dimensional temptation function is by construction a smooth and continuous departure from standard preferences.

5   Conclusion

There is a growing number of studies that explore the effect of self-control preferences on agents' decisions. At the same time, there is an increasing number of recent studies using life-cycle frameworks in incomplete market settings showing that the well-known Chamley (1986) and Judd (1985) zero capital tax rate result does not hold in general, and that the capital income tax rate should be significantly higher in these environments.

This paper combines the aforementioned literature strands with a view to revisit the question of whether eliminating capital income taxation can be optimal under non-standard preference specifications. To explore the quantitative implications of the model we consider an incomplete market general equilibrium model that is populated by overlapping generations of agents who can live up to 65-periods. During the course of life, agents face idiosyncratic income risk, a liquidity constraint, and uncertain life-time.

More specifically, we use this setting to examine the impact of different fiscal policies, namely, taxes on consumption, labor and capital as well as social security taxes, when agents have "Gul & Pesendorfer" self-control preferences. Furthermore, we examine the impact of the fiscal policies as described above when a measure of the agents in the population has standard preferences and its complement exhibits self-control preferences, something that is consistent with recent empirical evidence.

Our results are in line with those of previous studies in the social security literature with agents featuring self-control preferences, in terms of emphasizing the welfare improving potential of taxes imposed on labor income.

However, an integrated assessment of the combined effects of the relevant trade-offs, both along the dimension of differences in preferences and along the dimension of the scope of capital income taxation versus labor income taxation is missing from all previous studies (in both social security and capital taxation literature) and this paper aims to fill-in this gap and contribute in this aspect.

We therefore identified and quantitatively assessed for the first time in the fiscal policy literature, yet another dimension of a trade-off which is due to the agents' enhanced preference specification, and the effect of its interplay with the formerly identified trade-offs pertaining to capital income taxation versus labor income and consumption taxation. It turns out that this latter effect may reverse a well known result that was previously mistakenly attributed to borrowing constraints, the life-cycle structure, or the stochastic nature of models.

Our results here document that if we take into account agents' self-control problems, then the highest welfare will be generated by significantly lower capital tax rates than those recently documented in the literature. Given the strong empirical and experimental evidence with regard to the existence of self-control problems, our model provides quite an interesting insight: the optimal capital income tax rate will converge to Chamley and Judd's rate as agents' self-control problems become more acute, and as the respective costs for resisting temptation get higher.

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