



Temptation and Taxation with Elastic Labor

Chung Tran
Research School of Economics
Australian National University

ANU Working Papers in Economics and Econometrics
617

June, 2014

JEL: D01, D91, H31

ISBN: 0 86831 617 2

Temptation and Taxation with Elastic Labor*

Chung Tran[†]

Australian National University

29th May 2014

Abstract

In this paper we study the corrective role of income taxation in a model with the Gul and Pesendorfer type of temptation and self-control preferences embedded with labor/leisure choice. “Excessive” impatience created by the presence of temptation in preferences causes a bias in favour of present consumption and a two-dimensional problem: under-saving and over-supply-of-labor. In such an environment, the two-dimensional problem requires two-dimensional tax policy tools rather than one-dimensional ones. In particular, we first show that subsidizing savings alone improves welfare because it mitigates the under-saving problem i.e. inter-temporal allocation distortion; however, the optimal subsidy rate is not as high as in Krusell, Kuruscu and Smith (2010) because the savings subsidy amplifies the over-supply-of-labor problem, i.e. intra-temporal allocation distortion. Next, we find that labor income tax policy alone improves welfare because it mitigates the intra-temporal allocation distortion; however, its welfare gains are constrained by its adverse effects on savings. Finally, we demonstrate that a combination of capital and labor income taxation appears to be a more effective policy.

JEL Classification: D01, D91, H31

Keywords: Temptation, Self-Control, Consumption Bias, Under-Saving, Over-Supply-of-Labor, Capital Taxation, and Labor Taxation, Welfare, Dynamic General Equilibrium.

*We appreciate comments from Gerhard Glomm and Juergen Jung, Timothy Kam, and the participants of Australasian Economic Theory Workshop and WEAI's Annual Conference.

[†]Research School of Economics, The Australian National University, ACT 0200, Australia. *Telephone:* 61 6125 5638, *E-mail:* chung.tran@anu.edu.au.

1 Introduction

It has been documented in the literature that some individuals suffer from self-control problems regularly.¹ Gul and Pesendorfer (2001), Gul and Pesendorfer (2004*b*) and Gul and Pesendorfer (2005) provide a theoretical foundation to formalize the ideas of self-control problems. In their environment, the presence of temptation in preferences creates an urge for potentially tempting alternative which is costly to control. Individuals with temptation and self-control preferences have lower utility in an ex ante sense if tempting allocations are available in their choice set. Yet, different from a standard preference case, the size and shape of the choice set matter for individuals' well-being. Individuals with Gul and Persendorfer type of preferences would be better off if choosing from a smaller set.²

In the absence of mechanisms for commitment, the urge of temptation and cost of self-control give rise for government intervention. Most notably, Krusell, Kuruscu and Smith (2010) embed the Gul and Pesendorfer type of preferences into a standard macroeconomic setting and show that the optimal policy is to subsidize savings when consumers are tempted by “excessive” impatience. In the Krusell-Kuruscu-Smith framework, “excessive” impatience caused by the presence of temptation in preferences distorts individuals' inter-temporal allocation in favour of present consumption and undermines incentives to save for future consumption (inter-temporal channel). In the Krusell-Kuruscu-Smith model, the optimal tax policy prescribes as savings/investment subsidies to make savings more attractive. The Krusell-Kuruscu-Smith result provides a simple, potentially verifiable condition: negative capital taxation is socially desirable if individuals display temptation and self-control problems.

It has been documented in the macro/public finance literature that a key variable in the design and assessment of government policies is labor supply. However, Krusell et. al. (2010) assume inelastic labor supply and focus only on the temptation distortion operating through inter-temporal trade-off channel. Arguably, relaxing the inelastic labor assumption introduces intra-temporal trade-off between consumption and leisure, which induces a potentially important mechanism through which temptation influences allocation and welfare. In particular, the urge of temptation can influences an individual's consumption-leisure choice and the size and

¹Ameriks, Caplin, Leahy and Tyler (2007) develop a survey instrument to measure self-control problems and find that self-control problems are smaller in scale for older than for younger individuals. Frederick, Loewenstein and O'Donoghue (2002) provide an overview of experimental studies documenting that individuals indeed exhibit bias toward immediate gratification. Fang and Silverman (2009) estimate the structural parameters of a dynamic labor supply model and empirically identify the existence of time-inconsistency that stems from self-control problems. Bucciol (2012) tests the empirical relevance of self-control preferences using household-level data from the Consumer Expenditure Survey; and his estimates support the presence of temptation in preferences.

²The theoretical analysis of preferences reversal is dated back to Strotz (1956). Later, Phelps and Pollak (1968) to analyze inter-generational altruism to model preference reversals. Laibson (1997) adopts that structure and incorporates an additional discounting factor that captures the present-bias. The new discounting factor distorts the time-consistent feature of the standard exponential model. Laibson's preference structure is often called as time-inconsistent preferences. Gul and Pesendorfer (2004*a*) attempt to explain the same phenomenon by creating self-control preferences that depend not only on an agent's actual consumption but also on the agent's hypothetical temptation consumption. Krusell, Kuruscu and Smith (2010) show that the Phelps–Pollak–Laibson multiple-selves model is nested in the Gul-Pesendorfer self-control model as a special case.

shape of choice sets, which matters for welfare. Inclusion of elastic labor is essential to fully characterize the potential distortions caused by temptation so that a government can design an effective intervention policy that helps individuals to overcome the cost of self-control problems.³

To that end, we embed labor/leisure choice into the class of preferences developed by Gul and Pesendorfer. More specifically, we formulate a standard two-period overlapping generations model populated with individuals who supply labor elastically while facing temptation and self-control problems. Our model captures essential features of dynamic interactions between temptation and individuals' intra- and inter-temporal allocation, while it is simple enough to obtain an analytical insight. We first characterize the corrective role of capital and labor income taxation. Next, we conduct a quantitative analysis and analyze the importance of general equilibrium channels. Our key results are summarized as follows:

First, we find that inclusion of elastic labor, qualitatively and quantitatively, matters for allocation and welfare. More specifically, inclusion of elastic labor introduces in a new channel of effects operating through consumption-leisure trade-off (intra-temporal channel). The presence of temptation in preferences triggers "excessive" impatience and results in a bias in favour of present consumption. The urge of temptation induces individuals to work longer when inter-temporal elasticity of substitution is relatively small i.e. less than 1. This further amplifies the bias toward present consumption, but partially mitigating the adverse effect on savings. Intuitively, the temptation distortions working through the inter- and intra-temporal channels create a two-dimensional problem: under-saving and over-supply-of-labor, which lowers welfare. In our simple setting, we are able to isolate analytically three channels behind welfare losses: inter-temporal channel, intra-temporal channel and self-control cost channel. Our quantitative results indicates that intra-temporal and self-control cost channels are the main driving forces at work.

In absence of any mechanism for commitment, the intra- and inter-temporal allocation distortions caused by the presence of temptation in preferences call for government intervention. In the second part, we examine whether a government can eliminate such distortions. We first analyze the corrective role of capital income taxation and find that subsidizing savings/investments is socially desired because it makes succumbing to temptation less attractive. However, the optimal subsidy rate is not as high as in Krusell et al (2010). The intuition is that the distortions created by a savings subsidy program introduce two opposing effects: one mitigating the under-saving problem and one worsening the over-supply-of-labor problem. The latter counteracts the former. The welfare gains resulting from eliminating the adverse effects on savings are constrained by the welfare losses resulting from inducing individuals to work longer. Therefore, the optimal subsidy rate is lower when the intra-temporal channel is present.

Next, we demonstrate a new role of labor income taxation. Yet, the labor income tax

³Diamond and Koszegi (2003) add endogenous retirement to Laibson (1996)'s consumption-savings model with time-inconsistent preferences and find that inclusion of retirement choice changes consumption pattern and policy implications.

policy improves welfare in the Gul-Pesendorfer self-control model embedded with labor/leisure choice. The underlying reason is that taxing labor income provides a mechanism to eliminate the temptation distortion to the intra-temporal trade-off i.e. the over-supply-of-labor problem. Notably, the labor income tax policy amplifies the temptation distortion to the inter-temporal trade-off i.e. the under-saving problem. This adverse saving effect subsequently limits the welfare benefit from inducing individuals to work less. Finally, we study a mix of capital and labor income taxation and find that a combination of these two tax instruments appears to be a more effective policy. Indeed, the two-dimensional problem created by “excessive” impatience requires a two-dimensional tax policy. More importantly, we find that general equilibrium channels amplify the distortions caused by temptation and induce strong demand for income taxation as a corrective device.

Our study is related to several branches of the taxation literature. First, our paper is connected to the theory of optimal capital taxation. Since the well-known zero capital income taxation (e.g. see Atkinson and Stiglitz (1976), Judd (1985) and Chamley (1986)), the optimal taxation literature have shown that the optimal capital income tax can be non-zero. Aiyagari (1995) and Chamley (2001) show that the optimal capital income tax is positive because it is a mechanism to redistribute from those with no credit constraints to those with credit constraints. Conesa, Kitao and Krueger (2009) find that the optimal capital income tax is rather high at 36% in an overlapping generations model with earning risks and imperfect capital markets. In such a framework filled with rational agents having standard preferences, the optimal capital tax rate is positive because it is a way to redistribute wealth across agents. Differently, there is an alternative approach that views capital income taxation as a corrective tool to help individuals to overcome their behavioral issues. Notably, Laibson (1996) studies capital income taxation in an environment in which individuals suffer from self-control problem due to time-inconsistent preferences and find that optimal capital income tax rate is negative. Krusell, Kuruscu and Smith (2010) incorporate Gul-Pesendorfer type of self-control preferences into a standard macroeconomic setting and prove that the optimal capital tax rate is also negative. Tran (2012) conducts a welfare decomposition exercise and isolates the mechanics behind negative capital income taxation in a simplified version of the Krusell-Kuruscu-Smith model. In this paper, we extend the Krusell-Kuruscu-Smith model to incorporate labor/leisure choice. We show that the negative capital tax rate result is carried on to our new setting. However, the optimal subsidy rate is relatively smaller because of the extra distortion operating through the intra-temporal channel when labor/leisure choice is in play.

Our paper contributes to the optimal labor income tax literature. That literature studies design of income taxation and transfer systems to distribute fairly and efficiently the tax burden across individuals with different earnings. Social welfare is larger when resources are more equally distributed, but redistributive tax and transfers negatively affect incentives to work. The optimal labor income taxation as a redistributive device is socially desired because welfare gains from redistributing resources dominate welfare losses from distorting incentives to work.

That literature shows that the optimal labor income tax rate can be measured in terms of elasticities (Shenshiski (1972), Diamond (1980), and Saez (2001)). Similarly, we find that the optimal labor income tax rate depends on inter-temporal elasticity of substitution. However, the underlying mechanism is different. The labor income tax policy in our setting prescribes as a corrective device that helps to eliminate the distortions to the consumption-leisure wedge rather than a redistributive device. Indeed, the optimal tax rate is driven by severity of temptation and self-control problems in our environment.

There is a parallel literature on optimal commodity taxation when self-control issues are present (e.g. see Gruber and Koszegi (2001), Gruber and Koszegi (2004), O’Donoghue and Rabin (2003) and O’Donoghue and Rabin (2006)). That literature includes “sin good” as goods for which preferences are time-inconsistent. Individuals optimally choose to consume more now and less in the future. However, next period they also optimally choose to consume more now and less in the future in a model with “sin goods”. Yet, individuals are rational, but over-consume due to lack of self-control. These behavioral issues give rise for government intervention to help individuals to overcome consumption bias. In particular, imposing a commodity tax on “sin goods” reduces consumption to a level which households would choose if they could pre-commit to consume less in the future. O’Donoghue and Rabin (2006) show that the optimal tax rates on “sin goods” i.e. unhealthy foods rather high, up to 72 percent. In a similar fashion, the present consumption bias appears in a consumption-savings model when individuals succumb to temptation. We show that capital and labor income taxation can provide a similar mechanism to correct the present consumption-bias in a consumption-saving model. Intuitively, subsidizing savings or taxing labor income is an implicit way to tax present consumption in our analysis. We also conduct a quantitative analysis and find that the optimal rates are relatively high in a general equilibrium model.

The paper is organized as follows. Section 2 presents a two-period partial equilibrium model with elastic labor and analytical results. In section 3 we incorporate government to study the role of income taxation. In section 4 we examine the role of general equilibrium price adjustments. Section 5 concludes. Appendix presents the detailed solution method.

2 Temptation, allocation and welfare

2.1 Basic model

We consider a partial equilibrium overlapping generations model.

Endowment, markets and constraints. The economy is populated with overlapping individuals who live for two periods: young and old. In each period, individuals are endowed with 1 unit of time. Individuals supply elastically n_1 unit of labor time in the first period, and retire in the second period. There are competitive labor and financial markets with prevailing wage rate w and real interest rate r . There is a no-borrowing constraint, so individuals can save (s), but are not allowed to borrow in period 1, where s is savings with $s \geq 0$.

A typical individual values consumption in period 1 (c_1) and consumption in period 2 (c_2), and leisure time ($1 - n_1$). The individual's budget constraints are given by

$$c_1 + s = wn_1 \text{ and } c_2 = (1 + r) s,$$

and the time constraint is given by $0 \leq n_1 \leq 1$.

Temptation and self-control preferences. In our setting, individuals value consumption and leisure while facing temptation and self-control problems. We assume that individuals are tempted toward consumption as described in Gul and Persendorfer (2001 and 2004).⁴

The period utility function with temptation and self-control problem is specified as $U(c, n, \tilde{c}, \tilde{n}) = u(c, n) - [v(\tilde{c}, \tilde{n}) - v(c, n)]$, where \tilde{c} is temptation consumption, $u(\cdot)$ represents the momentary utility deriving from consumption and leisure, and $v(\cdot)$ represents the temptation utility. We consider a typical utility function that is homothetic and separable in consumption and labor

$$u(c, n) = \frac{c^{1-\sigma}}{1-\sigma} + \gamma \frac{(1-n)^{1-\varphi}}{1-\varphi},$$

where the curvature parameters σ and $\varphi > 0$.⁵ The parameter γ denotes the utility weight on leisure. We restrict $\gamma > 0$; otherwise, there is no labor-leisure choice if $\gamma = 0$.

We assume that the function $v(c, n)$ is equal to $u(c, n)$ re-scaled by factor $\lambda \geq 0$, so that $v(c, n) = \lambda u(c, n)$. The parameter λ measures the agent's sensitivity to the tempting alternative. The agent with $\lambda = 0$ is a forward-looking decision-maker in standard models with no temptation. The larger value λ , the more temptation to consume agents have. The extreme case of $\lambda \rightarrow \infty$ describes completely myopic agents who accumulate no wealth and consume all their income in every period. The difference $v(\tilde{c}, \tilde{n}) - v(c, n)$ represents the dis-utility cost of self-control when choosing (c, n) rather than (\tilde{c}, \tilde{n}) .

Optimization problems. A typical individual makes a decision on consumption, leisure and savings to maximize his lifetime utility while facing a temptation and self-control problem, and hence, resisting to temptation results in a self-control-related cost. In the first period, the

⁴Basically, Gul and Pesendorfer define preferences over consumption sets rather than over consumption sequences and propose an axiomatic approach to modeling preference reversals as follows. For a set of consumption B in a two-period setting and under a specific assumption on choice sets (set betweenness) combined with other standard axioms a typical individual with temptation and lack of self-control has the utility function as $U(B) = \max_{c \in B} \{u(c) + v(c)\} - \max_{\tilde{c} \in B} \{v(\tilde{c})\}$, where $U(B)$ is the utility that the individual associates with set B . In this representation, there are two utility components: commitment utility and temptation utility. The function $u(\cdot)$ represents the individual's ranking over alternatives when he is committed to a single choice; while when he is not committed to a single choice, his welfare is affected by the temptation utility represented by $v(\cdot)$. Note that when B is a singleton, the terms involving $v(\cdot)$ will vanish leaving only the $u(\cdot)$ terms to represent preferences. However, if it is e.g. $B = \{c, \tilde{c}\}$ with $u(\tilde{c}) > u(c)$ the individual will succumb to the temptation only if the latter provides a sufficiently high temptation utility $v(\cdot)$ and offsets the fact that $u(\tilde{c}) > u(c)$, i.e., when $u(c) + v(c) > u(\tilde{c}) + v(\tilde{c})$. In this case the individual wishes he had only c as the available alternative, since under the presence of \tilde{c} , he cannot resist the temptation of choosing the latter. When the above inequality is reversed, however, the individual will pick c , albeit at a cost of $v(c) - v(\tilde{c})$, which is referred as "cost of self-control."

⁵This functional form of preferences is commonly used in macroeconomic models.

utility maximization problem is given by:

$$V_1 = \left\{ \begin{array}{l} \max_{c_1, n_1, s} \{ U(c_1, n_1, \tilde{c}_1, \tilde{n}_1) + \beta V_2(s) \mid c_1 + s = wn_1, 0 \leq n_1 \leq 1, \text{ and } s \geq 0 \} \\ - \max_{\tilde{c}_1, \tilde{n}_1, \tilde{s}} \{ v(\tilde{c}_1, \tilde{n}_1) \mid \tilde{c}_1 + \tilde{s} = w\tilde{n}_1, 0 \leq \tilde{n}_1 \leq 1, \text{ and } \tilde{s} \geq 0 \}, \end{array} \right.$$

where V_1 is the young's value function, \tilde{c}_1 , \tilde{n}_1 and \tilde{s} are the first period's hypothetical temptation consumption, labor supply and savings, respectively, and V_2 is the old's value function. In the second period, the household problem is given by:

$$V_2(s) = \left\{ \begin{array}{l} \max_{c_2, s_2} \{ u(c_2, s_2) + v(c_2, s_2) \mid c_2 + s_2 = Rs \} \\ - \max_{\tilde{c}_2, \tilde{s}_2} \{ v(\tilde{c}_2, \tilde{s}_2) \mid \tilde{c}_2 + \tilde{s}_2 = Rs \}, \end{array} \right.$$

where, Rs is the total wealth available at the beginning of period 2, (c_2, s_2) is the choice of commitment consumption and savings in period 2, $(\tilde{c}_2, \tilde{s}_2)$ is the choice of temptation consumption and savings in period 2, $u(c_2, s_2)$ denotes the momentary utility, and $v(c_2, s_2)$ denotes the temptation utility in the second period.

Optimal allocation. To simplify the solution method for the first sub-max problem, we make two assumptions. First, we follow Gul and Pesendorfer (2004) to assume that individuals are tempted by the opportunity to consume immediately as much as possible. Second, we assume individuals have temptation toward consumption only.

The household's optimization problem is solved by the backward induction. In the second period, the optimal choices are $\tilde{c}_2 = c_2 = Rs$ and $\tilde{s}_2 = s_2 = 0$, and the value function in period 2 is $V_2(s) = \frac{(Rs)^{1-\sigma}}{1-\sigma}$. In the first period, the optimal solution for temptation allocation is trivial and given by $\tilde{n}_1 = 1$, $\tilde{c}_1 = w$ and $\tilde{s} = 0$, and the temptation utility is $v(\tilde{c}_1, \tilde{n}_1) = \lambda \frac{w^{1-\sigma}}{1-\sigma}$.⁶ The optimal solution for commitment allocation is given by solving this optimization problem:

$$L(.) = \max_{c_1, n_1, s, \mu} \left\{ (1 + \lambda) \frac{c_1^{1-\sigma}}{1-\sigma} + \gamma \frac{(1-n_1)^{1-\varphi}}{1-\varphi} + \beta V_2(s) + \mu (wn_1 - c_1 - s) \right\} - \lambda \frac{w^{1-\sigma}}{1-\sigma}$$

with μ is the shadow price.

Assuming an interior solution, we obtain the corresponding F.O.Cs: $\frac{\partial L}{\partial c_1} : (1 + \lambda) c_1^{-\sigma} = \mu$, $\frac{\partial L}{\partial n_1} : \gamma (1 - n_1)^{-\varphi} = \mu w$, $\frac{\partial L}{\partial s} : \beta \frac{\partial V_2(s)}{\partial s} = \mu$ and $\frac{\partial L}{\partial \mu} : wn_1 - c_1 - s = 0$. The optimal labor supply is given by

$$(1 - n_1) = \frac{\gamma^{\frac{1}{\varphi}}}{(w(1 + \lambda))^{\frac{1}{\varphi}}} \left(\frac{w}{1 + \frac{1}{R} \left(\frac{\beta R}{1 + \lambda} \right)^{\frac{1}{\sigma}}} \right)^{\frac{\sigma}{\varphi}} n_1^{\frac{\sigma}{\varphi}},$$

and consumption is subsequently defined by $c_1 = \left(\frac{w}{1 + \frac{1}{R} \left(\frac{\beta R}{1 + \lambda} \right)^{\frac{1}{\sigma}}} \right) n_1$ and $c_2 = \left(\frac{\beta R}{1 + \lambda} \right)^{\frac{1}{\sigma}} c_1$.

⁶If agents are allowed to borrow against future income up to a certain amount, the most tempting alternative would be larger, raising the demand for commitment devices. Also, note that our specific form of preferences $u(c_1, n_1) = \frac{c_1^{1-\sigma}}{1-\sigma} + \gamma \frac{(1-n_1)^{1-\varphi}}{1-\varphi}$ has simplified the solution for the temptation allocation.

2.2 Temptation and allocation

In this section we examine how the presence of temptation affect individuals' incentives to save and to work. To draw an analytical solution we first consider a special case $\varphi = \sigma$. The individual's optimal allocation is given by

$$\begin{aligned} c_1 &= \frac{1}{1 + \theta_1 + \theta_2} w, \\ s &= \frac{\theta_1}{1 + \theta_1 + \theta_2} w, \\ (1 - n_1) &= \frac{\theta_2}{1 + \theta_1 + \theta_2}, \end{aligned}$$

where, $\theta_1 = \frac{1}{R} \left(\frac{\beta R}{(1+\lambda)} \right)^{\frac{1}{\sigma}}$ and $\theta_2 = w \left(\frac{\gamma}{(1+\lambda)w} \right)^{\frac{1}{\sigma}}$. Intuitively, θ_1 and θ_2 measure the weight of savings and leisure relative to present consumption, respectively.

Temptation and consumption smoothing motive. We begin with the Gul and Pesendorfer model in which labor supply is inelastic (i.e. $\gamma = 0$ and $\theta_2 = 0$). In this setting, the individual's optimal inter-temporal allocation is simplified to $c_1 = \frac{1}{1+\theta_1} w$ and $s = \frac{\theta_1}{1+\theta_1} w$.

Note that θ_1 measures how much individuals value future consumption relative to present consumption. When the temptation and self-control problem is assumed away, $\lambda = 0$, the relative weight on savings is simplified further to $\theta_1^{\lambda=0} = \frac{1}{R} (\beta R)^{\frac{1}{\sigma}}$. We interpret $\theta_1^{\lambda=0}$ as an indicator for the strength of consumption smoothing motive. When temptation appears in preferences $\lambda > 0$, the relative weight on savings relative to consumption is modified to

$$\theta_1^{\lambda>0} = \overbrace{\left(\theta_1^{\lambda=0} \right)}^{\text{Cons. smoothing}} \overbrace{\left(\frac{1}{(1+\lambda)^{\frac{1}{\sigma}}} \right)}^{\text{Temptation distortion}}. \quad (1)$$

The weight on savings now has two components: the strength of consumption smoothing motive $\theta_1^{\lambda=0}$ and the temptation distortion against future consumption $\left(\frac{1}{(1+\lambda)^{\frac{1}{\sigma}}} \right)$. Since the first derivative of the savings weight is negative i.e. $\frac{\partial \theta_1}{\partial \lambda} < 0$ the presence of temptation undermines the consumption smoothing motive. The urge of temptation influences individuals' inter-temporal allocation toward more present consumption i.e. a present consumption bias. As a consequence, individuals save less for future consumption. Mathematically, $c_1^{\lambda>0} > c_1^{\lambda=0}$ and $s^{\lambda>0} < s^{\lambda=0}$ as $\frac{\partial s}{\partial \lambda} = -\frac{1}{(1+\theta_1)^2} < 0$.

Thus, individuals with temptation and self-control preferences undersave. This result is dated back to Gul and Pesendorfer (2004).⁷ We call this channel of effects an *inter-temporal channel*.

Temptation and incentives to work. We turn our analysis to the model with elastic labor, i.e. $\gamma > 0$ and $\theta_2 > 0$. Note that θ_2 measures the importance of leisure relative to current

⁷Laibson (1997, 1998) find that sophisticated individuals with a quasi-hyperbolic discount structure undersave. All inter-temporal selves could be made better off if all of them saved a little bit more.

consumption.

In a model with standard preferences i.e. $\lambda = 0$, the relative weight on leisure $\theta_2^{\lambda=0} = w \left(\frac{\gamma}{w}\right)^{\frac{1}{\sigma}}$ is formulated by three factors: the utility weight on leisure γ , opportunity cost of leisure w , and the parameter governing the inter-temporal elasticity of substitution σ . In a model with self-control preferences i.e. $\lambda > 0$, the relative weight on leisure becomes

$$\theta_2^{\lambda>0} = \underbrace{\theta_2^{\lambda=0}}_{\text{Cons. - leisure wedge}} \overbrace{\left(\frac{1}{(1+\lambda)^{\frac{1}{\sigma}}}\right)}^{\text{Temptation distortion}} \quad (2)$$

The weight on leisure consists of two components: the weight on leisure $\theta_2^{\lambda=0}$ and the distortion caused by temptation $\left(\frac{1}{(1+\lambda)^{\frac{1}{\sigma}}}\right)$. The former is a consumption-leisure wedge between marginal rate of substitution of consumption for leisure and marginal product of labor, while the latter reflects the effect of temptation on consumption-leisure choice. It is straightforward to show that the presence of temptation weakens the weight on leisure, i.e. $\frac{\partial \theta_2^{\lambda}}{\partial \lambda} < 0$. This points out that the presence of temptation in preferences distorts the consumption-leisure trade-off toward present consumption i.e. present consumption bias. Basically, individuals with temptation and self-control problems tend to work longer in response to the “excessive” demand for present consumption. This is a new channel that is absent in Krusell, Kuruscu and Smith (2010). We call this new channel of effects an *intra-temporal channel*.

To understand how temptation affects individuals’ incentives to work, we consider the first derivative of the labor supply function with respect to λ

$$\frac{\partial n_1}{\partial \lambda} = \overbrace{\left(\frac{\theta_2}{(1+\theta_1+\theta_2)^2} \frac{\partial \theta_1}{\partial \lambda}\right)}^{\text{inter-temporal channel: } <0} + \overbrace{\left(-\frac{(1+\theta_1)}{(1+\theta_1+\theta_2)^2} \frac{\partial \theta_2}{\partial \lambda}\right)}^{\text{intra-temporal channel: } >0} \stackrel{?}{\leq} 0. \quad (3)$$

As seen in equation 3, the presence of temptation in preferences introduces two opposing effects on labor supply. First, the urge of temptation distorts inter-temporal trade-off between present consumption and future consumption and increases the utility weight on current consumption. This then induces individuals to supply less labor to equalize marginal utility of consumption to marginal utility of leisure (inter-temporal channel). Second, the urge of temptation affects the consumption-leisure wedge and induces individuals to work longer so that they are able to increase their income to meet higher demand for consumption (intra-temporal channel).

In general, the sign of this derivative is undetermined. A typical individual with temptation and self-control preferences might consume less (or more) leisure and supply more (or less) labor, depending on inter-plays between intra- and inter- temporal channels. If we assume that the intra-temporal effect dominates the inter-temporal channel, we can show that individuals supply more labor, $\frac{\partial(1-n_1)}{\partial \lambda} < 0$ and $n_1^{\lambda>0} > n_1^{\lambda=0}$, when they suffer from the cost of temptation and self-control problem.⁸

⁸ Arguably, this result is sensitive to the assumption that individuals are tempted to consumption only. In-

Inclusion of labor-leisure choice introduces another channel through which temptation influences individuals' decisions. This new channel complicates the distortions caused by the presence of temptation in preferences. The final effect of temptation on an individual's labor supply depends on the interplay between inter- and intra- temporal channels. If the effect operating through the intra-temporal channel dominates the effect operating through the inter-temporal channel, the final effect on labor supply is positive. Indeed, the presence of temptation in preferences induces individuals to work longer when the effects operating through the intra-temporal channel dominates the effects operating through the inter-temporal channel.

The consumption bias with elastic labor. We study the effects of temptation on individuals' consumption in period 1 when labor-leisure choice is included. We consider the first derivative of present consumption with respect to the strength of temptation

$$\frac{\partial c_1}{\partial \lambda} = \overbrace{\left(-\frac{w}{(1 + \theta_1 + \theta_2)^2} \frac{\partial \theta_1}{\partial \lambda} \right)}^{\text{inter-temporal channel: } >0} + \overbrace{\left(-\frac{w}{(1 + \theta_1 + \theta_2)^2} \frac{\partial \theta_2}{\partial \lambda} \right)}^{\text{intra-temporal channel: } >0} > 0. \quad (4)$$

As stated in equation 4, there are two channels through which the presence of temptation distortion consumption in period 1 in a setting with elastic labor: First, it distorts inter-temporal trade-off between present and future consumption toward present consumption, $\frac{\partial \theta_1}{\partial \lambda} < 0$; Second, it distorts the consumption-leisure wedge in favor of more consumption in present and less leisure, $\frac{\partial \theta_2}{\partial \lambda} < 0$. These effects operate in the same direction and result in a bias toward present consumption when individuals suffer from temptation and self-control problems. Notice that the second channel exists only when labor is elastic. Yet, the existence of intra- temporal channel amplifies the consumption distortion created by temptation and self-control problem.

Proposition 1 *Inclusion of elastic labor amplifies the present consumption bias caused by the presence of temptation in preferences.*

Temptation and savings with elastic labor. We now examine the savings effects in a setting in which the intra-temporal channel is present. We consider the first derivative of the optimal savings with respect to the strength of temptation

$$\frac{\partial s}{\partial \lambda} = \overbrace{\left(\frac{(1 + \theta_2) w}{(1 + \theta_1 + \theta_2)^2} \frac{\partial \theta_1}{\partial \lambda} \right)}^{\text{inter-temporal channel: } <0} + \overbrace{\left(-\frac{w}{(1 + \theta_1 + \theta_2)^2} \frac{\partial \theta_2}{\partial \lambda} \right)}^{\text{intra-temporal channel: } >0} \geq 0. \quad (5)$$

The presence of temptation influences individuals' savings decisions through inter- and intra-temporal channels. More importantly, these two channels generate two opposing forces. First,

dividuals might exhibit temptation toward both current consumption and leisure. Temptation toward leisure makes it costlier to work, and indulge in leisure at higher rates, compared to nontempted agents. In such environment, the final effect on labor depends on inter-play between these temptation forces. This case, theoretically and empirically, has not been investigated in the previous literature. As a first step to analyze that issue, we limit our analysis an environment in which we only allow the temptation bias toward consumption.

the urge of temptation, operating through the inter-temporal channel, undermines consumption-smoothing motive, so that induces individuals to save less for future consumption. On other hand, the urge of temptation, working through the intra-temporal channel, induces individuals to work longer, so that there is more income available for present consumption. In return, as individuals have more income they also want to save more for consumption smoothing motive. The final effect on savings depends on how these two opposing forces play out.

Proposition 2 *The presence of intra-temporal channel mitigates the under-saving problem caused by temptation (i.e. inter-temporal allocation distortion).*

The under-saving problem due to temptation is documented in a model where the intra-temporal channel is excluded (e.g. see Gul and Pesendorfer (2004) and Krusell et al (2010)). In our setting where the intra-temporal channel is included, the presence of temptation in preferences undermines the under-savings problem. The logic is followed. All else equal (i.e. budget constraint), temptation distorts labor supply upwards and this increases income, hence increasing both period 1 consumption and savings. Hence, inclusion of elastic labor adds a new channel of effects, which then has implications for welfare outcomes.

2.3 Temptation and welfare

Welfare measure. To measure welfare we use a young individual's value function V_1 :

$$V_1 = \left\{ \begin{array}{l} \left[\overbrace{\left(\frac{1}{1+\theta_1+\theta_2} \right)^{1-\sigma} + \beta \left(\frac{\theta_1 R}{1+\theta_1+\theta_2} \right)^{1-\sigma}}^{v^{cs}} + \overbrace{\gamma \left(\frac{\theta_2}{1+\theta_1+\theta_2} \right)^{1-\sigma}}^{v^{cn}} \right] \frac{w^{1-\sigma}}{1-\sigma} \\ - \lambda \left[1 - \left(\frac{1}{1+\theta_1+\theta_2} \right)^{1-\sigma} \right] \frac{w^{1-\sigma}}{1-\sigma}. \end{array} \right.$$

We define three new variables $v^{cs} = \left(\frac{1}{1+\theta_1+\theta_2} \right)^{1-\sigma} + \beta \left(\frac{\theta_1 R}{1+\theta_1+\theta_2} \right)^{1-\sigma}$, $v^{cn} = \gamma \left(\frac{\theta_2}{1+\theta_1+\theta_2} \right)^{1-\sigma}$ and $v^{scc} = \lambda \left(1 - \left(\frac{1}{1+\theta_1+\theta_2} \right)^{1-\sigma} \right)$ that denote three channels of welfare effects. These variables are formulated by a number of structural parameters including the strength of temptation, the utility weight on leisure, the rate of time discount and risk aversion, and the market wage rate and the interest rate. Analytically,

$$V_1 = [v^{cs} + v^{cn} - v^{scc}] \frac{w^{1-\sigma}}{1-\sigma}. \quad (6)$$

Notice that v^{cs} is basically the optimal rule that the agent follows to trade off his present consumption with future consumption (*inter-temporal channel*); v^{cn} is the optimal rule that the agent uses to trade off consumption with leisure in period 1 (*intra-temporal channel*); v^{scc}

is the rule of thumb to measure dis-utility cost of self-control (*self-control cost channel*). In our simple two-period partial equilibrium model, V_1 is the social welfare function.

Welfare decomposition and transmission mechanism. To understand how the presence of temptation influences an individual's inter-temporal allocation and utility, we consider the first derivative of value function V_1 with respect to the temptation parameter λ as

$$\frac{\partial V_1}{\partial \lambda} = \left(\frac{\partial v^{cs}}{\partial \lambda} + \frac{\partial v^{cn}}{\partial \lambda} - \frac{\partial v^{scc}}{\partial \lambda} \right) \frac{w^{1-\sigma}}{1-\sigma}.$$

This derivative indicates three channels through which the presence of temptation in preferences influence welfare outcome. First, the urge of temptation distorts individuals' inter-temporal trade-off between present and future consumption directly since individuals are tempted to consume more in present time, which subsequently lowers welfare - the inter-temporal channel effect. Second, the urge of temptation distorts individuals' intra-temporal trade-off between consumption and leisure, which has implications for welfare outcome - the intra-temporal channel effect. Finally, with the presence of temptation individuals suffer from the cost of self-control, which is costly and also lowers welfare - the self-control cost effect.

We start with the self-control channel effect. We let $SCC = -v^{scc} \frac{w^{1-\sigma}}{1-\sigma}$ be dis-utility cost of self-control. If individuals have standard preferences with no temptation $\lambda = 0$, the self-control cost vanishes, i.e. $SCC = 0$. However, if $\lambda > 0$, $v^{scc} > 0$ and the self-control cost is negative, i.e. $SCC = -v^{scc} \frac{w^{1-\sigma}}{1-\sigma} < 0$. This implies that individuals with temptation and self-control preferences suffer from efforts to balance out the short-term urge for a higher level of current consumption with the long-term commitment for smoothing consumption. In our setting, severity of self-control efforts is governed by the budget size in young age. The more income available the more self-control costs tempted individuals have to pay.

Taking the first derivative yields

$$\frac{\partial v^{scc}}{\partial \lambda} = 1 - \left(\frac{1}{1 + \theta_1 + \theta_2} \right)^{1-\sigma} - \frac{\lambda(1-\sigma)}{(1 + \theta_1 + \theta_2)^\sigma} \left(\frac{\partial \theta_1}{\partial \lambda} + \frac{\partial \theta_2}{\partial \lambda} \right). \quad (7)$$

It appears that the sign of $\frac{\partial v^{scc}}{\partial \lambda}$ depends on inter-temporal elasticity of substitution. With any $\sigma \geq 1$ it is clear that $\frac{\partial v^{scc}}{\partial \lambda} > 0$. This implies that the negative welfare effect operating through self-control cost is further magnified as severity of temptation is increased. Indeed, the size of budget matters for welfare when individuals suffer from the self-control problems.

Next, we examine the inter-temporal channel effect ($\frac{\partial v^{cs}}{\partial \lambda}$) and the intra-temporal channel effect ($\frac{\partial v^{cn}}{\partial \lambda}$). Taking the first derivatives yields

$$\frac{\partial v^{cs}}{\partial \lambda} = \left[\left(\frac{\partial g_{c_1}}{\partial \lambda} \right)^{-\sigma} + \beta R^{1-\sigma} \left(\frac{\partial g_s}{\partial \lambda} \right)^{-\sigma} \right], \quad (8)$$

and

$$\frac{\partial v^{cn}}{\partial \lambda} = \left[(1-\sigma) \gamma (g_l)^{-\sigma} \frac{\partial g_l}{\partial \lambda} \right], \quad (9)$$

where $g_{c_1} = \frac{1}{1+\theta_1+\theta_2}$, $g_s = \frac{\theta_1}{1+\theta_1+\theta_2}$ and $g_l = \frac{\theta_2}{1+\theta_1+\theta_2}$. It is straightforward to show that $\frac{\partial g_{c_1}}{\partial \lambda} > 0$; however, the signs of $\frac{\partial g_s}{\partial \lambda}$ and $\frac{\partial g_l}{\partial \lambda}$ are ambiguous and depend on elasticity of substitution. The sign of $\frac{\partial v^{cs}}{\partial \lambda}$ and $\frac{\partial v^{cn}}{\partial \lambda}$ are not analytically identified unless we make specific assumptions on the values of parameters.

To isolate how each underlying channel contributes to the final welfare outcomes, we conduct a welfare decomposition. We let $V_1^{\lambda=0}$ denote an individual's welfare when temptation is assumed away. In a two period, partial equilibrium overlapping generations model without any distortion to individuals' decision, the optimal allocation taken by individuals with standard preference yields the maximum level of welfare. That is, $V_1^{\lambda=0}$ be the first-best welfare outcome. We also let $V_1^{\lambda>0}$ be an individual's welfare when temptation is present. We let $dV_1 = V_1^{\lambda>0} - V_1^{\lambda=0}$ denote change in utility due temptation. As argued before, the presence of temptation in preferences distorts allocation and potentially lowers welfare. In our simple setting, the welfare losses caused by temptation can be decomposed according to three channels

$$dV_1 = V_1^{\lambda>0} - V_1^{\lambda=0} = \left[\underbrace{\left(v^{cs, \lambda>0} - v^{cs, \lambda=0} \right)}_{\text{inter-temporal channel}} + \underbrace{\left(v^{cn, \lambda>0} - v^{cn, \lambda=0} \right)}_{\text{intra-temporal channel}} + \underbrace{\left(0 - v^{scc, \lambda>0} \right)}_{\text{self-control cost channel}} \right] \frac{w^{1-\sigma}}{1-\sigma}. \quad (10)$$

Equation (10) provides a simple way to isolate the mechanics behind welfare outcomes. First, the urge of temptation distorts intra- and inter-temporal allocations and therefore lowers welfare (intra- and inter-temporal channel effects). Second, the presence of temptation triggers individuals' efforts to control their temptation, which is costly and also lowers welfare (self-control cost effect). This negative welfare outcome caused by temptation is documented in the previous studies based on models with inelastic labor (e.g. see Gul and Pesendorfer (2001, 2004) and Krusell et al (2010)). Inclusion of elastic labor introduces a new transmission mechanism that operates through the intra-temporal channel. Qualitatively, this channel matters for welfare outcome.

So far we have restricted our analysis to a special case with $\varphi = \sigma$, so that we are able draw a closed form and the economic intuitions. It is clear that our qualitative results are limited to our modelling assumptions. In the next section, we relax those assumptions and conduct a quantitative analysis.

2.4 A quantitative analysis

We consider a commonly-used functional form of preferences $u(c, n) = \frac{c^{1-\sigma}}{1-\sigma} + \gamma \frac{(1-n)^{1-\varphi}}{1-\varphi}$ with $\varphi \neq \sigma$. To conduct a quantitative analysis we set φ at the value of 4, which implies the average Frisch elasticity of 0.5 and $\gamma = 3$. We consider three alternative values for risk-aversion parameter $\sigma = [2, 4, 6]$. Regarding to the estimated values of the temptation parameter λ , the literature reports different values. In particular DeJong and Ripoll (2007) estimate that $\lambda = 0.0786$; meanwhile, Huang, Liu and Zhu (2007) report that λ is either equal to 0.2849 or

0.4795 depending on the data set. We consider a reasonable range of the temptation parameter values λ between 0 and 0.125 in our quantitative analysis, $\lambda = [0, 0.05\dots, 0.125]$. Without loss of generality we normalize market wage rate to 1 ($w = 1$) and the interest rate to zero ($r = 0$).

We solve the model numerically and report our quantitative results in Tables 1 and 2.

	λ	<i>(i)</i> Inelastic Labor: $\gamma = 0$				<i>(ii)</i> Elastic Labor: $\gamma = 3$			
		$dc_1(\%)$	$ds(\%)$	$dn_1(\%)$	$dV(\%)$	$dc_1(\%)$	$ds(\%)$	$dn_1(\%)$	$dV(\%)$
$\sigma = 2$	0.000	0.000	0.0000	0.000	0.0000	0.000	0.0000	0.000	0.0000
	0.050	1.219	-1.219	0.000	-1.235	1.796	-0.657	0.569	-0.968
	0.075	1.808	-1.808	0.000	-1.841	2.669	-0.977	0.846	-1.445
	0.100	2.382	-2.382	0.000	-2.440	3.527	-1.290	1.118	-1.915
	0.125	2.944	-2.944	0.000	-3.033	4.369	-1.599	1.385	-2.379
$\sigma = 4$	0.000	0.000	0.0000	0.000	0.0000	0.000	0.0000	0.000	0.0000
	0.050	0.609	-0.609	0.000	-2.165	0.854	-0.368	0.243	-1.447
	0.075	0.904	-0.904	0.000	-3.230	1.267	-0.547	0.360	-2.157
	0.100	1.191	-1.191	0.000	-4.286	1.672	-0.722	0.475	-2.858
	0.125	1.472	-1.472	0.000	-5.331	2.068	-0.893	0.588	-3.550
$\sigma = 6$	0.000	0.000	0.0000	0.000	0.0000	0.000	0.0000	0.000	0.0000
	0.050	0.406	-0.407	0.000	-2.397	0.560	-0.254	0.153	-1.535
	0.075	0.603	-0.603	0.000	-3.576	0.831	-0.377	0.227	-2.287
	0.100	0.794	-0.794	0.000	-4.744	1.096	-0.498	0.299	-3.029
	0.125	0.982	-0.982	0.000	-5.901	1.354	-0.616	0.369	-3.762

Table 1: Temptation, Allocation and Welfare

Temptation and allocation. We first quantify the effects of increasing the strength of temptation on allocation. To isolate the role of inter- and intra-temporal channels we compare two distinct settings: *(i)* inelastic labor ($\gamma = 0$) and *(ii)* elastic labor ($\gamma > 0$). In each setting, we start from the standard preferences case ($\lambda = 0$) and then introduce the temptation and self-control preferences cases ($\lambda > 0$). We gradually increase the value of temptation parameter and compute percentage changes in consumption (dc_1), savings (ds), labor supply (dn_1) and utility (dV). We report the results in Table 1.

We begin with setting *(i)* when labor is inelastic. We focus on the case $\sigma = 2$. As expected, individuals with temptation and self-control preferences save less and consume more in period 1. Particularly, an increase in the value of temptation parameter from 0 to 0.05 results an increase in consumption in period 1.2 percent while savings decreases by an identical amount (row 2). As the strength of temptation increases the bias toward present consumption is larger. When the strength of temptation increases to the value of 0.125, present consumption increases by 3 percent (row 5).

We now turn to setting *(ii)* when labor is elastic. Similarly, we find that individuals with temptation and self-control preferences save less and consume more. However, the magnitudes of the changes in consumption and savings are substantially different when labor is elastic.

Compared between setting (i) and setting (ii), we find that present consumption increases more while savings decreases less when labor is elastic as stated in Proposition 2. Considering the case $\sigma = 2$ and $\lambda = 0.125$, consumption is increased by about 1.4 percent more, while savings is decreased by about 1.4 percent less in setting (ii). The underlying reason is due to the presence of intra-temporal channel. Individuals with temptation and self-control preferences work longer. Particularly, an individual with $\lambda = 0.125$ supplies about 1.4 percent more labor, compared to an individual with $\lambda = 0$. This indicates that the effects operating via the intra-temporal channel dominates the effects operating via the inter-temporal channel, so that the final effect on labor supply is positive (compared to the analytical result stated in Proposition 1). As the strength of temptation increases labor supply increases further.

Hence, the presence of intra-temporal channel magnifies the effects of temptation on present consumption. This quantitative result confirms the analytical results described in Propositions 1 and 2.

Temptation and welfare. We now move to the welfare effects. As expected, our quantitative results confirm that the presence of temptation significantly lowers welfare in both setting (i) and (ii). As seen in setting (i) of Table 1, individuals suffer from the temptation distortions to allocation and the cost of self-control problem, their utility is lower. Comparing two scenarios for the inelastic labor case ($\gamma = 0$): no temptation with $\lambda = 0$ and temptation with $\lambda = 0.125$ we find a significant drop in utility level, around 3 percent. Interestingly, the decreases in the agent's utility is relatively smaller in setting (ii) when labor is elastic. Considering the case with $\gamma = 3$ and $\sigma = 2$, an incremental increase in the value of temptation parameter by .025 decreases utility by at least 0.6 percent. Compared the case with no temptation and self-control problem (first row with $\lambda = 0$) and the case with temptation parameter value around 0.125, welfare is lower by 2.4 percent. This confirms that the presence of temptation distorts allocation and triggers self-control problems, which then lead to welfare losses. The mechanics behind the welfare loss result is described in sub-section 2.2.

The pattern is generally applied for other cases with bigger values for σ . Considering other cases with $\sigma = 4$ or 6, we find a similar pattern that higher temptation parameter values lower welfare. An incremental increase in the value of temptation parameter by 0.025 decreases welfare by almost 1.1 percent with $\sigma = 4$; meanwhile, an incremental increase in the value of temptation parameter by 0.025 decreases welfare by almost 1.2 percent with $\sigma = 6$. The negative welfare effect of temptation appears more severe when inter-temporal elasticity of substitution ($\frac{1}{\sigma}$) is smaller. This implies that the tension between long-term commitment for consumption smoothing and a short-term urge of temptation and dis-utility costs of self-control are severer when individuals are less willing to substitute present consumption for future consumption.

Welfare decomposition. We quantify the welfare effects according to three channels: inter-temporal effect (dV^{cs}), intra-temporal effect (dV^{cn}) and self-control effect (dV^{sc}), respectively. To simplify our comparison, we compute welfare losses or gains in percentage

points, compared to the standard preferences case ($\lambda = 0$). We report the welfare results in Table 2.

We first consider setting (i) when labor is inelastic. As seen in the left panel of Table 2, when labor-leisure choice is excluded welfare losses are driven by two only channels mechanism: distorting inter-temporal allocation and exerting efforts to self-control. Compared to the standard preference case, an increase in the value of temptation parameter from 0 to 0.15 leads to a drop in welfare by 3 percent, of which the inter-temporal effect contribute a small proportion, while the self-control cost effect plays a significant role. As temptation and self-control problems become severer, the welfare loss contributed by the self-control cost (V^{scc}) declines a little bit but it still overwhelmingly dominates the inter-temporal channel effect (V^{sc}). The intra-temporal channel effect (V^{cn}) is excluded in this setting. Hence, the urge of temptation triggers “excessive” impatience, which causes a bias toward present consumption and an *under-saving problem*, and also the cost of self-control. These are main driving forces behind welfare losses.

	λ	(i) Inelastic Labor ($\gamma = 0$)				(ii) Elastic Labor ($\gamma = 3$)			
		$dV(\%)$	dV^{cs}	dV^{cn}	dV^{scc}	$dV(\%)$	dV^{cs}	dV^{cn}	dV^{scc}
$\sigma = 2$	0.000	0.0000	0.0000	0.000	0.0000	0.0000	0.000	0.0000	0.0000
	0.050	-1.235	-0.015	0.000	-1.219	-0.969	0.295	-0.307	-0.957
	0.075	-1.841	-0.033	0.000	-1.808	-1.444	0.432	-0.458	-1.418
	0.100	-2.440	-0.057	0.000	-2.383	-1.915	0.562	-0.607	-1.870
	0.125	-3.033	-0.087	0.000	-2.946	-2.380	0.686	-0.754	-2.312
$\sigma = 4$	0.000	0.0000	0.0000	0.000	0.0000	0.0000	0.000	0.0000	0.0000
	0.050	-2.165	-0.022	0.000	-2.142	-1.446	0.424	-0.442	-1.428
	0.075	-3.230	-0.049	0.000	-3.181	-2.156	0.617	-0.658	-2.115
	0.100	-4.286	-0.085	0.000	-4.201	-2.857	0.801	-0.872	-2.786
	0.125	-5.331	-0.130	0.000	-2.501	-3.551	0.974	-1.083	-3.442
$\sigma = 6$	0.000	0.0000	0.0000	0.000	0.0000	0.0000	0.000	0.0000	0.0000
	0.050	-2.397	-0.025	0.000	-2.372	-1.536	0.459	-0.481	-1.514
	0.075	-3.576	-0.055	0.000	-3.522	-2.288	0.669	-0.716	-2.241
	0.100	-4.744	-0.095	0.000	-4.649	-3.029	0.867	-0.947	-2.949
	0.125	-5.901	-0.145	0.000	-5.756	-3.762	1.053	-1.176	-3.639

Table 2: Welfare Losses and Transmission Channels

We now turn to the elastic labor case. As seen in setting (ii) of Table 2, the mechanics behind welfare losses are quite different. Unlike the inelastic labor case, the welfare effects through the inter-temporal channel are positive. This outcome is due to the presence of the intra-temporal channel and its interactions with the inter-temporal channel. The presence of temptation in preferences induces individuals to work longer, and subsequently allows individuals to increase their consumption in both periods. The welfare gains from the inter-temporal channel come at the cost of leisure. As a direct consequence, the welfare effects operating through the intra-temporal channel are negative. Finally, we find that the utility cost to resist

temptation is still a main contribution to the final welfare loss.

The differences in welfare outcomes between setting (i) and setting (ii) as well as the driving mechanisms are explained by the presence of intra-temporal channel. In setting (i) where labor is inelastic, the size and shape of their budget constraints are predetermined at the beginning of period 1. Conversely, in setting (ii) inclusion of labor-leisure choice allows individuals to change the size and shape of their budget constraints. In reaction to the urge of temptation, individuals optimally adjust their labor decisions and so do the size and shape of their budget constraint, which matters for welfare.

Thus, in setting (ii) where the intra-temporal channel is in play, individuals increase their work hours to respond the “excessive” demand for consumption caused by the urge of temptation. Such additional labor incomes induced by temptation further magnifies the bias in favour of present consumption; meanwhile, mitigating the adverse savings effect of temptation. In general, there is an additional problem attributed to the presence of temptation in preferences in setting (ii) where labor is elastic: *over-supply-of-labor problem*. In absence of mechanism for commitment, the presence of temptation calls for government intervention to eliminate the distortions caused by temptation.

3 Taxation as a corrective device

In this section, we investigate whether fiscal intervention improves welfare. To address this question, we will extend our basic model to include a government and characterize the equilibrium condition. We next analyze whether income taxation can help individuals to overcome their self-control problems.

3.1 Capital income taxation

In this section we study whether an introduction of a savings subsidy program, as described in Krusell et al (2010), can eliminate the allocative distortions and improves welfare.

3.1.1 Environment

Government. We consider a simple setting in which government collects lump-sum tax revenue to subsidize individuals’ savings. The government’s budget constraint is given by $T = \tau^s s$, where τ^s is a subsidy rate to savings and T is lump-sum tax.

Household. The household problem in the model with a savings subsidy program becomes:

$$V_1 = \begin{cases} \max_{c_1, n_1, s} \{U(c_1, n_1, \tilde{c}) + \beta V_2(s) \mid c_1 + (1 - \tau^s)s = wn_1 + T \text{ and } s \geq 0\} \\ - \max_{\tilde{c}_1, \tilde{n}_1, \tilde{s}} \{v(\tilde{c}_1, \tilde{n}_1) \mid \tilde{c}_1 + \tilde{s} = (1 - \tau^w)w\tilde{n}_1 \text{ and } \tilde{s} \geq 0\}, \end{cases} \quad (11)$$

and

$$V_2(s) = \max_{c_2, s_2} \left\{ \frac{c_2^{1-\sigma}}{1-\sigma} \mid c_2 = Rs \right\}.$$

for young and old individuals, respectively.

Equilibrium. For given market factor prices $\{R, w\}$, and savings subsidy rate $\{\tau^s\}$, a competitive equilibrium is an allocation $\{s, c_1, n_1, c_2\}$ that solves the household problem (11), and lump-sum tax $\{T\}$ that clears the government budget.

Assuming that $u(c, n) = \frac{c^{1-\sigma}}{1-\sigma} + \gamma \frac{(1-n)^{1-\sigma}}{1-\sigma}$, $u(c, n) = \lambda v(c, n)$ and $T = \tau^T w$, we are able to draw a closed form solution:

$$\begin{aligned} c_1 &= \frac{1}{1 + (1 - \tau^s)^{(1-\frac{1}{\sigma})} \theta_1 + \theta_2} (1 - \tau^T) w, \\ s &= \frac{(1 - \tau^s)^{-\frac{1}{\sigma}} \theta_1}{1 + (1 - \tau^s)^{(1-\frac{1}{\sigma})} \theta_1 + \theta_2} (1 - \tau^T) w, \\ (1 - n_1) &= \frac{\theta_2}{1 + (1 - \tau^s)^{(1-\frac{1}{\sigma})} \theta_1 + \theta_2} (1 - \tau^T), \\ g(\tau) &= \tau^s s - \tau^T w = 0, \end{aligned}$$

where $\theta_1 = \frac{1}{R} \left(\frac{\beta R}{(1+\lambda)} \right)^{\frac{1}{\sigma}}$ and $\theta_2 = w \left(\frac{\gamma}{(1+\lambda)w} \right)^{\frac{1}{\sigma}}$.

3.1.2 Tax distortion, allocation and welfare

As discussed in the previous section, the presence of temptation distorts inter-temporal allocation in favour of more consumption and less savings. Subsidizing savings provides a mechanism to correct such adverse effect on inter-temporal allocation.

Consumption bias. We start with the central point that is used to justify an introduction of a savings subsidy program. To examine to what extent a savings subsidy program can eliminate the consumption bias caused by temptation we consider the first derivative of consumption with respect to savings subsidy rate

$$\frac{\partial c_1}{\partial \tau^s} = \overbrace{\left(\frac{-\left(1 - \frac{1}{\sigma}\right) (1 - \tau^s)^{-\frac{1}{\sigma}} \theta_1 (1 - \tau^T) w}{\left[1 + (1 - \tau^s)^{(1-\frac{1}{\sigma})} \theta_1 + \theta_2\right]^2} \right)}^{\text{inter-temporal price effect: } <0 \text{ if } \sigma \geq 1} + \overbrace{\left(\frac{-w \frac{\partial \tau^T}{\partial \tau^s}}{\left[1 + (1 - \tau^s)^{(1-\frac{1}{\sigma})} \theta_1 + \theta_2\right]} \right)}^{\text{wealth effect: } <0}. \quad (12)$$

The savings subsidy program influences consumption in period 1 via two channels. First, subsidizing savings affects price of present consumption relative to future consumption. It basically makes future consumption relatively cheaper; and therefore inducing individuals to delay consumption to future time (inter-temporal price effect). Second, lump-sum tax results in negative income effect and reduces consumption (income effect). In general, the sign of the inter-temporal price effect is undetermined, depending on inter-temporal elasticity of substitution. If we assume that inter-temporal elasticity of substitution is less than 1, i.e. $\frac{1}{\sigma} \leq 1$, we can show that the inter-temporal price effect is always negative if inter-temporal elasticity of

substitution is less than 1.⁹ Therefore, subsidizing savings mitigates the present consumption bias created by temptation, as $\frac{\partial c_1}{\partial \tau^s} < 0$ when $\frac{1}{\sigma} \leq 1$.

Proposition 3 *If inter-temporal elasticity of substitution is smaller than unity, i.e. $\frac{1}{\sigma} \leq 1$, subsidies to savings mitigate the present consumption bias caused by temptation.*

Incentives to work. We analyze the effects of the savings subsidy policy on incentives to work. The intra-temporal trade off between consumption and leisure is given by $(1 - n_1) = \frac{\theta_2}{w} c_1$. This implies that there are two underlying forces influencing individuals' incentives to work: the intra-temporal price effect due to subsidies to savings and the wealth effect due to lump-sum tax as a financing instrument. The latter is negative while the former is ambiguous. To isolate the effects of the savings subsidy on the consumption-leisure trade-off, we take the first derivative of labor supply with respect to subsidy rate

$$\frac{\partial n_1}{\partial \tau^s} = - \left(\frac{\gamma}{(1 + \lambda) w} \right)^{\frac{1}{\sigma}} \overbrace{\frac{\partial c_1}{\partial \tau^s}}^{<0 \text{ if } \sigma \geq 1} \quad (13)$$

It is straightforward to show that if inter-temporal elasticity of substitution is relatively small ($\frac{1}{\sigma} \leq 1$), the final effect on labor supply is positive, $\frac{\partial n_1}{\partial \tau^s} > 0$. This implies that subsidizing savings induces individuals to consume less, but work longer.

Incentives to save. It is known that a savings subsidy program is a device to correct the inter-temporal distortion of consumption in a model with inelastic labor, compared to Krusell et al (2010). We now examine the savings effect in a model with elastic labor. We first combine savings and consumption to yield $s = \frac{\theta_1}{(1 - \tau^s)^{\frac{1}{\sigma}}} c_1$. We take the first derivative with respect to subsidy rate to have:

$$\frac{\partial s}{\partial \tau^s} = \overbrace{\frac{1}{\sigma} (1 - \tau^s)^{-(1 + \frac{1}{\sigma})} \theta_1 c_1}^{>0} + \overbrace{(1 - \tau^s)^{-\frac{1}{\sigma}} \theta_1 \frac{\partial c_1}{\partial \tau^s}}^{<0 \text{ if } \sigma \geq 1}. \quad (14)$$

The distortions created by a savings subsidy program results in two effects on savings: positive one due to higher rate of return on savings that tends to induce individuals to delay consumption (inter-temporal price effect), and negative one due to inter-temporal link between the early and late stages of the life cycle (life cycle effect). The final effect on savings depends on inter-play between these two effects. If the inter-temporal price effect dominates the life cycle effects, the introduction of a savings subsidy program induces individuals with temptation and self-control preferences to save more.

It is argued in the previous literature that the distortion created by subsidizing savings induces tempted individuals to save more (e.g. see Krusell et al (2010)). With inelastic labor

⁹A key parameter in the design and assessment of tax policies is the inter-temporal elasticity of substitution. It has been documented in the literature that most macro estimates of this inter-temporal elasticity have it at less than unity and in some cases closer to 0.5. In our analysis, we restrict our analysis to the case with inter-temporal elasticity less than unity.

supply the subsidy is in response to the distortion caused by temptation, i.e. it mitigates an existing distortion due to temptation. However, with elastic labor the subsidy can possibly create a new distortion while mitigating the existing temptation distortion.

Proposition 4 *If inter-temporal elasticity of substitution is relatively small, i.e. $\frac{1}{\sigma} \leq 1$, a savings subsidy program mitigates the under-saving problem. However, it induces tempted individuals to work longer and amplifies the over-supply-of-labor problem.*

Hence, the presence of temptation in preferences causes a bias toward present consumption, which then leads to two underlying problems: under-savings and over-supply-of-labor, in a model with elastic labor. In absence of labor-leisure choice, the latter is assumed away; therefore, a savings subsidy program that targets the former arises as an optimal policy. This is the underlying mechanism behind the finding by Krusell et al (2010). However, in a setting with presence of the over-supply-of-labor problem, a savings subsidy program becomes a sub-optimal policy. The reason is that the adverse effects of a saving subsidy program mitigate the inter-temporal distortions, but further amplify the intra-temporal distortion. That is, in response to savings subsidies individuals with self-control preferences not only save more for future consumption but also work longer. The implication for welfare is ambiguous and depends on trade-off between fostering savings and distorting labor supply.

Welfare. We now evaluate the welfare effects of a savings subsidy program. Let $V_1^{\lambda>0}$ and $\tau>0$ denote the social welfare function when the government is active to help individuals to overcome the temptation and self-control problems

$$V_1^{\lambda>0 \text{ and } \tau>0} = \left(v^{cs, \lambda>0 \text{ and } \tau>0} + v^{cn, \lambda>0 \text{ and } \tau>0} - v^{scc, \lambda>0 \text{ and } \tau>0} \right) \frac{w^{1-\sigma}}{1-\sigma},$$

where $\tau = \{\tau^s, \tau^T\}$ and

$$\begin{aligned} v^{cs, \lambda>0 \text{ and } \tau>0} &= \left\{ \left(\frac{(1-\tau^T)}{1+(1-\tau^s)^{(1-\frac{1}{\sigma})}\theta_1 + \theta_2} \right)^{1-\sigma} + \beta \left(\frac{(1-\tau^s)^{-\frac{1}{\sigma}}\theta_1(1-\tau^T)R}{1+(1-\tau^s)^{(1-\frac{1}{\sigma})}\theta_1 + \theta_2} \right)^{1-\sigma} \right. \\ v^{cn, \lambda>0 \text{ and } \tau>0} &= \gamma \left(\frac{(1-\tau^T)^{(1-\frac{1}{\sigma})} \frac{\theta_2}{w}}{1+(1-\tau^s)^{(1-\frac{1}{\sigma})}\theta_1 + \theta_2} \right)^{1-\sigma}, \text{ and} \\ v^{scc, \lambda>0 \text{ and } \tau>0} &= \lambda \left[(1-\tau^T) - \left(\frac{(1-\tau^T)}{1+(1-\tau^s)^{(1-\frac{1}{\sigma})}\theta_1 + \theta_2} \right)^{1-\sigma} \right]. \end{aligned}$$

Let $V_1^{\lambda>0 \text{ and } \tau=0}$ be the social welfare when there is no fiscal intervention. Let $dV_1 = V_1^{\lambda>0 \text{ and } \tau>0} - V_1^{\lambda>0 \text{ and } \tau=0}$ denote changes in welfare due to fiscal intervention. We can express

changes in welfare in the following form:

$$dV_1 = \left[\begin{array}{c} \overbrace{\left(v^{cs, \lambda > 0 \text{ and } \tau > 0} - v^{cs, \lambda > 0 \text{ and } \tau = 0} \right)}^{\text{inter-temporal channel}} \\ + \overbrace{\left(v^{cn, \lambda > 0 \text{ and } \tau > 0} - v^{cn, \lambda > 0 \text{ and } \tau = 0} \right)}^{\text{intra-temporal channel}} \\ + \overbrace{\left(0 - v^{scc, \lambda > 0 \text{ and } \tau = 0} \right)}^{\text{self-control channel}} \end{array} \right] \frac{w^{1-\sigma}}{1-\sigma}.$$

Basically, changes in welfare are decomposed into three components: $dV_1 = dV^{cs} + dV^{cn} + dV^{scc}$. This points out three channels through which a savings subsidy program affects welfare: one mitigating the distortion to the inter-temporal allocation, one distorting the intra-temporal allocation, one releasing the cost of self-control problems.

We examine these channels to understand the mechanics behind the welfare effects of a savings subsidy program. There are intra- and inter-temporal trade-offs when introducing a savings subsidy program. An introduction of a savings subsidy program creates are two opposing effects on individuals' welfare. First, subsidizing savings mitigates the inter-temporal allocation distortion i.e. under-savings problem, which improves welfare. On other hand, subsidizing savings, however, amplifies the intra-temporal allocation distortion i.e. over-supply-of-labor, which reduces welfare. The final effect depends on how these two opposing effects play out. A savings subsidy program is socially desired if welfare gains resulting from eliminating the inter-temporal allocation distortion as well as releasing self-control costs dominate welfare losses resulting from further distorting the intra-temporal allocation. The welfare criteria for fiscal intervention is given by $dV_1 = V_1^{\lambda > 0 \text{ and } \tau > 0} - V_1^{\lambda > 0 \text{ and } \tau = 0} > 0$. Interactions between intra- and inter-temporal channels determine whether or not a negative capital income taxation results in a positive welfare outcome. The optimal subsidy rates are the one that maximizes welfare gains, $\{dV_1(\tau)\}$, subject to the government budget's constraint $g(\tau) = 0$ and the household's optimal allocation that solves the utility maximization problem (11).

Due to complex interactions we are not able to obtain an analytical solution for the optimal subsidy rate. It is clear that the values of the structural parameters determines the induced preference for a savings subsidy program. In next section, we parameterize the model and quantify the extent to which a capital income tax policy can eliminate the allocation distortions caused by temptation.

3.1.3 A quantitative analysis

We conduct a quantitative analysis based standard parameter values from the previous literature including $\sigma = 2$, $\gamma = 3$, $\varphi = 4$, $\lambda = 0.10$, $\beta = 1$ and $r = 0$.¹⁰ To highlight the role

¹⁰ $\varphi = 4$ implies the Frisch elasticity of 0.5. Notice that, the inter-temporal elasticity of substitution less than unity is crucial to pin down analytically the direction of the effects of fiscal policy.

of intra-temporal channel, we consider two distinct settings: (i) inelastic labor ($\gamma = 0$) and (ii) elastic labor ($\gamma > 0$). We implement a policy experiment in which government collects lump-sum tax T to subsidize savings at rate of τ^s . In particular, we start from a benchmark case in which there is no savings subsidy ($\tau^s = 0$), and introduce a savings subsidy program with various subsidy rates. Our main results are reported in Table 3. Notice that, to ease our analysis, we compute percentage changes in consumption (dc_1), savings (ds), labor supply (dn_1) and utility (dV), compared to the benchmark case when $\tau^s = 0$. The government adjusts lump-sum tax to clear its budget constraint.

We first with setting (i) when labor is inelastic. We find that a savings subsidy program induces individuals with temptation and self-control preferences to consume less and save more. An introduction of a savings subsidy program with $\tau^s = 1$ percent results in a reduction in consumption by 0.5 percent and an increase in savings by 0.52 percent. There is no change in labor supply in this setting. As savings subsidy becomes more progressive consumption drops further while savings increases more. Most importantly, the introduction of a savings subsidy program results in positive welfare outcome. This is driven by two forces: mitigating the allocation distortions caused by temptation and releasing severity of self-control problem. As discussed before, stimulating savings comes with costs. The reason is that more savings intensify tension between the urge for immediate consumption and the commitment for consumption smoothing motive, and therefore magnifies severity of self-control problems. This subsequently reduces the welfare benefits of releasing self-control cost. This explains the hump-shape pattern of welfare effects in Table 3. That is, the level of welfare gains first increases and then decreases as subsidy rate increases. The optimal subsidy rate that maximizes welfare gain in setting (i) is around 11 percent.

τ^s	(i) Inelastic Labor ($\gamma = 0$)				(ii) Elastic Labor ($\gamma = 3$)			
	$dc_1(\%)$	$ds(\%)$	$dn_1(\%)$	$dV(\%)$	$dc_1(\%)$	$ds(\%)$	$dn_1(\%)$	$dV(\%)$
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.005	-0.251	0.263	0.000	0.024	-0.356	0.898	0.256	0.013
0.010	-0.503	0.527	0.000	0.048	-0.717	1.808	0.515	0.019
0.015	-0.756	0.793	0.000	0.071	-1.082	2.729	0.778	0.018
0.020	-1.523	1.059	0.000	0.113	-1.451	3.663	1.045	0.100
0.030	-1.523	1.598	0.000	0.132	-2.203	5.565	1.588	0.029
...
0.100	-5.527	5.527	0.000	0.289	-7.963	20.297	5.831	-1.252
0.105	-5.548	5.819	0.000	0.292	-8.409	21.449	6.164	-1.411
0.110	-5.828	6.112	0.000	0.293	-8.859	22.614	6.503	-1.581
0.115	-6.109	6.407	0.000	0.292	-9.315	23.794	6.845	-1.761
0.125	-6.677	7.002	0.000	0.288	-10.240	26.196	7.544	-2.155
0.150	-8.123	8.519	0.000	0.253	-12.635	32.448	9.369	-3.348

Table 3: Saving subsidy, Allocation and Welfare.

We now turn to setting (ii) when labor is elastic. Compared to setting (i), we find a similar pattern that a savings subsidy program induces individuals with temptation and

self-control preferences to consume less and save more. Noting that these effects are more pronounced. For example, with a subsidy rate at 1 percent savings is increased by 1.8 percent, which is three times as much as that in setting (i). Most importantly, we find that individuals work harder when a savings subsidy program is introduced. With a 1 percent subsidy rate, individuals increase their labor supply by 0.5 percent. This outcome is consistent with our analytical result when inter-temporal elasticity of substitution is smaller than 1 i.e. $\sigma \geq 1$. That subsidizing savings leads to more labor supply explains why individuals can increase their savings more in setting (ii).

The presence of intra-temporal channel has interesting implications for welfare outcome. On one hand, the tax distortion operating through the intra-temporal channel contributes to mitigating the under-saving problem caused by temptation, which potentially improved welfare. On other hand, the introduction of a savings subsidy program clearly worsens the over-supply-of-labor problem, which lowers welfare. This negative effect erodes the welfare gains from correcting the under-savings problem. The final welfare is either positive or negative, depending on how severe a savings subsidy program distorts individuals' labor decisions.

As seen in setting (ii) of Table 4, the welfare effects are positive. This implies that welfare gains from correcting the under-savings problem dominates welfare losses resulting tax distortions. Interestingly, compared between setting (i) and setting (ii), we find the welfare benefits of a savings subsidy program are much smaller when labor is elastic. More specifically, a similar savings subsidy program with $\tau^s = 10$ results in welfare gain by 2.9 percent in setting (i) but welfare loss by 1.2 percent in setting (ii). The optimal subsidy rate reduces from 11 percent in setting (i) to 1 percent in setting (ii). Our quantitative result confirm our qualitative result that inclusion of elastic labor open a new channel through which a savings subsidy program distorts individuals' intra-temporal allocation. Yet, the adverse effect on incentives to work limits welfare gains from correcting the under-saving problem. As seen in column 3 of setting (ii), the welfare gains are smaller; and the negative welfare outcomes are quickly revealed as the government increase subsidy rates.

Thus, subsidizing savings is still a welfare improving policy in a model with elastic labor, as in Krusell et al (2010); however, it is less attractive. The presence of intra-temporal channel limits the extent to which the government can use a savings subsidy program to correct the inter-temporal distortions caused by the presence of temptation in preferences. Arguably, a negative capital income tax policy do not guarantee the first best welfare outcome as in Krusell et al (2010) because this policy only focuses on one side of a two-dimensional problem.

3.2 Labor income taxation

In this section we consider a case that the government targets to the over-supply-of-labor problem.

The government introduces a labor income tax and transfer program. The government budget constraint is given by: $\tau^L wn_1 = T$, where τ^L is labor income tax and T is a lump-sum

transfer. The agent's optimization problem is given by:

$$L(.) = \max_{c_1, n_1, s, \mu} \left\{ (1 + \lambda) \frac{c_1^{1-\sigma}}{1-\sigma} + \gamma \frac{(1-n_1)^{1-\varphi}}{1-\varphi} + \beta V_2(s) \right\} - \lambda \frac{(w)^{1-\sigma}}{1-\sigma} + \mu [(1 - \tau^L) w n_1 + T - c_1 - s]$$

Assuming $\sigma = \varphi$ we obtain a closed form solution for the household problem:

$$\begin{aligned} c_1 &= \frac{1}{1 + \theta_1 + (1 - \tau^L)^{(1-\frac{1}{\sigma})} \theta_2} (w - T), \\ 1 - n_1 &= \frac{(1 - \tau^L)^{-\frac{1}{\sigma}} \theta_2}{1 + \theta_1 + (1 - \tau^L)^{1-\frac{1}{\sigma}} \theta_2} (w - T), \\ s &= \frac{1}{R} \frac{\theta_1 (w - T)}{1 + \theta_1 + (1 - \tau^L)^{1-\frac{1}{\sigma}} \theta_2}. \end{aligned}$$

Tax distortions, labor supply and savings. We analyze the effects of labor income tax on consumption, labor supply and savings. We take the first derivative of consumption with respect to labor tax rate and obtain

$$\frac{\partial c_1}{\partial \tau^L} = \overbrace{\left(-\frac{(1 - \frac{1}{\sigma}) (1 - \tau^L)^{-\frac{1}{\sigma}} \theta_2 (w - T)}{(1 + \theta_1 + (1 - \tau^L)^{(1-\frac{1}{\sigma})} \theta_2)^2} \right)}^{\text{inter-temporal price effect: ? } <0 \text{ if } \sigma \geq 1} + \overbrace{\left(\frac{-w \frac{\partial T}{\partial \tau^L}}{1 + \theta_1 + (1 - \tau^L)^{(1-\frac{1}{\sigma})} \theta_2} \right)}^{\text{wealth effect: } <0}. \quad (15)$$

The effect of labor income tax on consumption is ambiguous. Assuming inter-temporal elasticity of substitution is relatively small, $\sigma \geq 1$, we can show that labor income taxation results in negative effects on consumption, $\frac{\partial c_1}{\partial \tau^L} < 0$. Thus, taxing labor income results a similar outcome as subsidizing savings, i.e. neutralizing the consumption bias caused by temptation. However, it operates through a different channel. To understand the mechanism at work, we take the first derivative of labor supply with respect to tax rate

$$\frac{\partial n_1}{\partial \tau^L} = \frac{1}{\sigma} (1 - \tau^L)^{-\frac{1}{\sigma}-1} \left(\frac{\gamma}{(1 + \lambda) w} \right)^{\frac{1}{\sigma}} \overbrace{\frac{\partial c_1}{\partial \tau^L}}^{<0 \text{ if } \sigma \geq 1} < 0. \quad (16)$$

We can show that if $\sigma \geq 1$, $\frac{\partial c_1}{\partial \tau^L} < 0$ taxing labor income negatively influences individuals' labor supply. In our setting in which individuals over-supply labor, the distortion created by the labor income tax policy mitigates the over-supply-labor problem caused by temptation. This potentially improves welfare. On other hand, taxing labor income however lowers welfare as it amplifies the under-saving problem. Taking this first derivative of the savings function

with respect to the labor tax rate yields negative sign when $\sigma \geq 1$

$$\frac{\partial s}{\partial \tau^L} = \theta_1 \overbrace{\left(\frac{\partial c_1}{\partial \tau^L} \right)}^{<0 \text{ if } \sigma \geq 1} < 0. \quad (17)$$

That is, as individuals work less they earn less and therefore save less.

Proposition 5 *If inter-temporal elasticities of substitution is relatively small, i.e. $\frac{1}{\sigma} \leq 1$, taxing labor income mitigates the over-supply-of-labor problem; however, it amplifies the under-saving problem.*

Labor income taxation can be used to correct the bias in favour of present consumption and the over-supply-of-labor problem. However, this tax policy does not help to overcome the under-saving problem. Qualitatively, the welfare effects are not clearly determined. Next, we conduct a quantitative analysis to explore whether labor income taxes can eliminate the distortions caused by temptation.

Quantitative analysis. We again consider a numerical example with $\sigma = 2$, $\gamma = 3$, $\varphi = 4$, $\lambda = 0.10$, $\beta = 1$ and $r = 0$. In our experiments, we start from a benchmark economy with no government ($\tau^L = 0$). We then introduce labor income tax ($\tau^L > 0$) and lump-sum transfer (T) schemes. We report our experiment results in Table 4. Note that we report percentage changes in consumption (dc_1), savings (ds), labor supply (dn_1) and utility (dV).

τ^L	(ii) Elastic Labor: T adjusts ($\gamma = 3$, $\sigma = 2$, $\lambda = 0.10$)			
	$dc_1(\%)$	$ds(\%)$	$dn_1(\%)$	$dV(\%)$
0.000	0.0000	0.0000	0.0000	0.0000
0.005	-0.1047	-0.1047	-0.1047	0.0018
0.010	-0.2099	-0.2099	-0.2099	0.0032
0.015	-0.3156	-0.3156	-0.3156	0.0043
0.020	-0.4219	-0.4219	-0.4219	0.0051
0.025	-0.5287	-0.5287	-0.5287	0.0055
0.030	-0.6361	-0.6361	-0.6361	0.0053
0.035	-0.7440	-0.7440	-0.7440	0.0051
0.040	-0.8525	-0.8525	-0.8525	0.0044
0.045	-0.9616	-0.9616	-0.9616	0.0032
0.050	-1.0712	-1.0712	-1.0712	0.0017

Table 4: Labor Income Taxation, Allocation and Welfare.

As seen columns 2, 3 and 4 in Table 4, an introduction of a labor income tax and transfer program results in decreases in consumption, savings and labor supply. This quantitative result is consistent with the analytical result stated in Proposition 6. Indeed, the labor income tax policy works against the bias towards current consumption and incentives to work. On other

hand, it undermines individuals' incentives to save and dampens the under-saving problem. Overall, if welfare gains resulting from correcting the over-supply-labor problem dominates welfare losses resulting from distorting incentives to save, the final welfare effects are positive. As seen in column 4 of Table 4, the welfare outcomes are positive. The highest welfare gain is obtained when the labor income tax rate is around 2.5 percent. As the labor tax rate increases further, the positive welfare effect declines. Eventually, the welfare effect turns negative when the distortions to savings incentives become very severe and takes away all the welfare benefits from eliminating the distortions to work incentives.

Hence, taxing labor income improves welfare in a setting with elastic labor because it mitigates the over-supply-of-labor problem. However, the welfare benefits of labor income taxation is limited by its negative effects on savings.

3.3 A mix of capital and labor income taxation

As argued before, neither subsidizing savings or taxing labor income separately can be the best policy to deal with the two-dimensional problem caused by temptation. In this section we investigate whether a combination of capital and labor income taxes is more effective to help individuals overcome their "excessive" impatience.

We consider model with a government that collects labor income taxes to finance a savings subsidy scheme. The government's budget constraint is given by $\tau^L w n_1 = \tau^s s$, where τ^L is labor income tax rate. The optimal allocation is given by

$$\begin{aligned} c_1 &= \frac{(1 - \tau^L) w}{1 + (1 - \tau^s)^{(1-\frac{1}{\sigma})} \theta_1 + (1 - \tau^L)^{(1-\frac{1}{\sigma})} \theta_2}, \\ s &= \frac{(1 - \tau^s)^{-\frac{1}{\sigma}} \theta_1 (1 - \tau^L) w}{1 + (1 - \tau^s)^{(1-\frac{1}{\sigma})} \theta_1 + (1 - \tau^L)^{(1-\frac{1}{\sigma})} \theta_2}, \\ (1 - n_1) &= \frac{(1 - \tau^L)^{(1-\frac{1}{\sigma})} \theta_2}{1 + (1 - \tau^s)^{(1-\frac{1}{\sigma})} \theta_1 + (1 - \tau^w)^{(1-\frac{1}{\sigma})} \theta_2}. \end{aligned}$$

We analyze whether a combination of capital and labor income taxes can resolve the two dimensional problem created by the presence of temptation in preferences.

Consumption smoothing and incentive to save. We begin with the first derivative of

present consumption with respect to subsidy rate

$$\frac{\partial c_1}{\partial \tau^s} = \left\{ \begin{array}{l} \overbrace{\left(\frac{(1 - \frac{1}{\sigma}) \left[(1 - \tau^s)^{(-\frac{1}{\sigma})} \theta_1 + (1 - \tau^L)^{(-\frac{1}{\sigma})} \theta_2 \right] [(1 - \tau^L) w]}{[1 + (1 - \tau^s)^{(1-\frac{1}{\sigma})} \theta_1 + (1 - \tau^L)^{(1-\frac{1}{\sigma})} \theta_2]^2} \right)}^{\text{inter-temporal price effect: } <0 \text{ if } \sigma \geq 1} \\ + \left(\frac{- \left(w \frac{\partial \tau^L}{\partial \tau^s} \right)}{[1 + (1 - \tau^s)^{(1-\frac{1}{\sigma})} \theta_1 + (1 - \tau^L)^{(1-\frac{1}{\sigma})} \theta_2]} \right) \end{array} \right. \quad (18)$$

As seen in equation 18, subsidizing savings results in two effects on the present consumption. If inter-temporal elasticity of substitution is less than 1, i.e. $\sigma \geq 1$, it is straightforward to show that the final effect on consumption is always negative, $\frac{\partial c_1}{\partial \tau^s} < 0$. The mechanism behind this result is similar to the one described in section 3.1.2. Indeed, the tax distortions neutralize the consumption bias caused by temptation.

We now turn to the effect on individuals' savings. Similarly, we consider how individuals optimally adjust their optimal level of savings in response to the introduction of a savings subsidy program. There are two driving forces behind changes in individuals' savings: price effect and wealth effects:

$$\frac{\partial s}{\partial \tau^s} = \frac{1}{\sigma} \overbrace{(1 - \tau^s)^{-(1+\frac{1}{\sigma})} \theta_1 c_1}^{\text{price effect: } >0} + (1 - \tau^s)^{-\frac{1}{\sigma}} \theta_1 \overbrace{\left(\frac{\partial c_1}{\partial \tau^s} \right)}^{<0 \text{ if } \sigma \geq 1}. \quad (19)$$

Qualitatively, it is not clear whether a savings subsidy program can increase savings. The final effect on savings indeed depends on how the two opposing forces play out. If we assume that the price effect dominates the wealth effect, the final savings effect is positive. As discussed in section 3.1.3, subsidies to savings can mitigate the adverse savings effect, i.e. the under-savings problem, caused by temptation.

Incentives to work. We now analyze the tax distortions to individuals' incentives to work. Taking the first derivative of labor supply with respect to subsidy rate yields

$$\frac{\partial n_1}{\partial \tau^s} = \left\{ \begin{array}{l} \overbrace{\left[-\theta_2 (1 - \tau^L)^{-\frac{1}{\sigma}} \overbrace{\left(\frac{\partial c_1}{\partial \tau^s} \right)}^{<0 \text{ if } \sigma \geq 1} \right]}^{>0 \text{ if } \sigma \geq 1} + \left[-\frac{\theta_2 (1 - \tau^L)^{\frac{1}{\sigma}-1} c_1 \overbrace{\left(\frac{\partial \tau^L}{\partial \tau^s} \right)}^{>0}}{\sigma} \right] \end{array} \right. \quad (20)$$

As seen in equation 20, a mix of capital and labor income taxes results in two opposing effects on incentives to work. On one hand, capital tax results in a distortion to the consumption-

leisure wedge and negative wealth effect. If inter-temporal elasticity of substitution is relatively small ($\frac{1}{\sigma} \leq 1$), subsidizing savings induces individuals to work longer; therefore, magnifying the over-supply-of-labor problem. On the other hand, taxing labor income induces individuals to work long hours; therefore, mitigating the distortions caused by temptation as well as by subsidizing savings. The final effect on incentives to work depends on how these two opposing effects play out. If inter-temporal elasticity of substitution is relatively small i.e. $\frac{1}{\sigma} \leq 1$, a mix of capital and labor income taxes indeed mitigates the under-saving problem while keeping the over-supply-of-labor problem in check.

Thus, a combination of capital and labor income taxes as a two-dimensional policy instrument appears to be more effective in dealing with both under-saving and over-supply-of-labor problems at the same time. However, the final welfare outcomes are not qualitatively determined even in our simple setting because of complex interactions between inter- and intra-temporal channels. Next, we conduct a quantitative analysis.

A quantitative analysis. We consider a numerical example with $\sigma = 2$, $\gamma = 3$, $\varphi = 4$, $\lambda = 0.10$, $\beta = 1$ and $r = 0$. Our ultimate goal is to quantify whether a combination of savings subsidies and labor income taxes can correct the distortion caused by the presence of temptation in preferences. To that end, we conduct experiments in which the government collects tax revenue from labor income ($\tau^L n_1 w$) to subsidize individuals' savings. We report the changes in consumption, savings, labor supply and utility in Table 5. To ease our comparison, we compute percentage changes in consumption (dc_1), savings (ds), labor supply (dn_1) and utility (dV) relative to that in the benchmark case when $\tau^s = 0$ and $\tau^L = 0$.

<i>(ii) Elastic Labor: τ^L adjusts ($\gamma = 3, \sigma = 2, \lambda = 0.10$)</i>					
τ^s	τ^L	$dc_1(\%)$	$ds(\%)$	$dn_1(\%)$	$dV(\%)$
0.000	0.0000	0.000	0.000	0.000	0.000
0.010	0.0049	-0.143	0.360	0.103	0.027
0.020	0.0098	-0.287	0.724	0.206	0.042
0.030	0.0148	-0.434	1.094	0.312	0.045
0.035	0.0172	-0.508	1.280	0.364	0.041
0.040	0.0197	-0.582	1.467	0.418	0.035
0.050	0.0247	-0.732	1.846	0.526	0.012
0.060	0.0297	-0.884	2.230	0.636	-0.024
0.075	0.0373	-1.116	2.815	0.803	-0.103

Table 5: Savings Subsidy and Labor Income Taxation, Allocation and Welfare.

As seen in Table 5, subsidizing saving induces tempted individuals not only to save more but also to work longer while consuming less. With a 1 percent subsidy rate (Row 2 of Table 5), savings and labor supply are increased by 0.36 percent and 0.1 percent, respectively, while current consumption is reduced by 0.14 percent. These quantitative results are consistent with our theoretical results stated in Proposition 4. That is, subsidizing savings leads to more

savings and labor supply if $\sigma \geq 1$. However, the increases in savings and labor supply are relatively smaller when the government uses labor income taxes (Comparing Tables 4 and 5). The reason is that labor income tax rates lower the effective wage rate and opportunity cost of leisure. This subsequently encourages individuals to supply less labor to the labor market as predicted in Proposition 5.

When inter-temporal elasticity of substitution is relatively small, $\frac{1}{\sigma} < 1$, the introduction of a savings subsidy program mitigates the under-saving problem but amplifies the over-supply-of-labor problem. However, when labor income taxes are used, the distortions created by labor income taxes mitigate the over-supply-of-labor problem. As a direct result, the welfare effect of a savings subsidy program with labor income taxes dominate that of a savings subsidy program with lump-sum taxes. Compared Table 5 and Table 4, we find that the optimal subsidy rate increases from 1 to 3 percent when replacing lump-sum taxes by labor income taxes. Indeed, a combination of capital and labor income taxation appears to be a more effective policy to help individuals to overcome excessive impatience caused by temptation.

4 General equilibrium channel

We have demonstrated how the presence of temptation affects individuals' intra- and inter-temporal allocation and welfare via our simple two-period model and illustrated via our numerical example. In that partial equilibrium analysis, we keep market prices constant. It has been argued in the previous literature that the economic distortion and welfare consequences caused by taxation are further magnified when allowing for general equilibrium price adjustments. In this section, we examine quantitative importance of general equilibrium channels and implications for macro-aggregates and welfare.

4.1 Environment

We formulate a dynamic general equilibrium model, which consists of households, a representative firm and a government.

Household. There are a large number of individuals in an overlapping generations setting. Every period newborn individuals arrive and live for J periods. Individuals choose a sequence of consumption of final goods c_j , asset holdings in the next period a_{j+1} and labor supply n_j to maximize their lifetime utility. The typical household's utility maximization problem can be recursively formulated as

$$\begin{aligned}
 V_j(a_j) &= \max_{\{a_{j+1}, c_j, n_j\}} \{u(c_j, n_j) + v(c_j, n_j) + \beta V_{j+1}(a_{j+1})\} - \max_{\{\tilde{c}_j^k, \tilde{c}_{j+1}^p\}} \{v(\tilde{c}_j, \tilde{n}_j)\} \\
 &\quad s.t. \\
 c_j + (1 + \tau^s) a_{j+1} &= (1 - \tau^w) w n_j + (1 + r) a_j, \\
 a_1 &= 0, \quad a_{j+1} \geq 0 \text{ and } 0 \leq (1 - n_j) \leq 1,
 \end{aligned}$$

where $u(c_j, n_j) = \frac{c_j^{1-\sigma}}{1-\sigma} + \gamma \frac{(1-n_j)^{1-\varphi}}{1-\varphi}$ and $v(c_j, n_j) = \lambda u(c_j, n_j)$.

Firm. The firm's production technology is given by a Cobb-Douglas production function $Y = F(K, L) = AK^\alpha L^{1-\alpha}$, where K is the input of capital, L is the input of effective labor services and A is the total factor productivity. Capital depreciates at rate δ . The firm chooses capital and labour inputs to maximize its profit according to $\max_{K,L} \{AK^\alpha L^{1-\alpha} - qK - wL\}$, given rental rate, $q = \alpha AK^{\alpha-1} L^{1-\alpha}$, and market wage rate, $w = (1-\alpha) AK^\alpha L^{-\alpha}$.

Government. The government is similar to that described in section 3.3. The government collect income tax to finance a savings subsidy program. The government budget constraint is given by $\sum_{j=1}^J \tau^w w n_j = \sum_{j=1}^J \tau^s a_{j+1}$.

Equilibrium. Given government policy settings for fiscal policy, a steady state competitive equilibrium is such that: (i) a collection of individual household decisions $\{c_j, a_{j+1}, n_j\}_{j=1}^J$ solve the household problem; (ii) the firm chooses labour and capital inputs $\{L, K\}$ to solve the profit maximization problem; (iii) the markets for capital and labor clear $K = \sum_{j=1}^J a_j$ and $L = \sum_{j=1}^J n_j$; (iv) factor prices are determined competitively, i.e., $w = (1-\alpha) AK^\alpha L^{-\alpha}$, $q = \alpha AK^{\alpha-1} L^{1-\alpha}$ and $r = q - \delta$; and (v) the government budget constraint is satisfied.

Calibration. Following previous studies in the literature we choose $A = 1$, $\alpha = .36$, $\delta = .05$. We also assume $\gamma = 3$ and set φ at the value of 4, which implies the average Frisch elasticity of 0.5. We consider $\sigma = [2, 4, 6]$ and $\lambda = [0, 0.05, 0.075, 0.1, 0.125]$. We set $J = 2$ and solve our model numerically. In the benchmark model, we calibrate the time discount factor to match the annual interest rate of 2 percent.

4.2 Macroeconomic aggregates and welfare

We conduct a number of experiments to assess the effects of temptation on macroeconomic aggregates and social welfare. In our experiments, we start from the standard preferences case ($\lambda = 0$) and then gradually increase the value of the temptation parameter ($\lambda > 0$). To highlight the role of the intra-temporal channel in general equilibrium, we consider two distinct settings: (i) inelastic labor ($\gamma = 0$) and (ii) elastic labor ($\gamma > 0$).

We report the results in Table 6. To ease our comparison, we compute percentage deviations in aggregate labor (dL), capital stock (dK), output (dY), consumption (dC_1 and dC_2), and utility (dV) when temptation appears in preferences ($\lambda > 0$) relative to those in the standard preference case ($\lambda = 0$).

Macro-aggregates. We first start with setting (i) when labor is inelastic. As expected, the presence of temptation in preferences causes a present bias that induces individuals to consume more in period 1 and save less. This results in significant decreases in aggregate capital and output in our general equilibrium model. For example, we consider the case with $\sigma = 2$. An increase in the value of the temptation parameter from 0 to .05 reduces capital stock and output by 3.4 percent and 1.2 percent, respectively. The distortions created by temptation

become severer when the strength of temptation λ increases. As the strength of temptation increases to the value of 0.125, capital and output decrease further to 8 percent and 3 percent, respectively. This result indicates that a small deviation from a standard preferences results in a relative big impact on capital accumulation, and subsequently leads to a significant drop in output in a general equilibrium model. Compared to the results from our partial equilibrium analysis, we find that the distortions caused by temptation are much bigger when accounting for general equilibrium adjustments. In addition, we find that the adverse effects on capital accumulation and output are relatively smaller when inter-temporal elasticity of substitution is relatively smaller i.e. bigger σ .

	λ	<i>(i)</i> Inelastic Labor: $\gamma = 0$			<i>(ii)</i> Elastic Labor: $\gamma = 3, \sigma = 2, \lambda = .1$					
		dL	dK	dY	dL	dK	dY	dC_1	dC_2	dV
$\sigma = 2$	0.000	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.050	0	-3.42	-1.24	0.84	-2.61	-0.41	0.78	-0.67	-1.94
	0.075	0	-5.05	-1.85	1.25	-3.86	-0.62	1.15	-1.00	-2.89
	0.100	0	-6.63	-2.44	1.57	-5.08	-0.82	1.50	-1.33	-3.86
	0.125	0	-8.16	-3.02	2.06	-6.27	-1.02	1.83	-1.64	-4.81
$\sigma = 4$	0.000	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.050	0	-2.13	-0.77	0.44	-1.69	-0.33	0.42	-0.49	-2.35
	0.075	0	-3.15	-1.15	0.66	-2.51	-0.49	0.62	-0.74	-3.53
	0.100	0	-4.15	-1.51	0.87	-3.31	-0.66	0.81	-0.97	-4.69
	0.125	0	-5.12	-1.87	1.08	-4.09	-0.81	0.99	-1.21	-5.86
$\sigma = 6$	0.000	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.050	0	-1.54	-0.56	0.29	-1.26	-0.27	0.27	-0.38	-2.53
	0.075	0	-2.29	-0.83	0.43	-1.86	-0.40	0.41	-0.57	-3.78
	0.100	0	-3.01	-1.09	0.57	-2.46	-0.53	0.54	-0.76	-5.03
	0.125	0	-3.72	-1.35	0.71	-3.03	-0.65	0.66	-0.94	-6.28

Table 6: Temptation, Allocation and Welfare in General Equilibrium

We now move to setting *(ii)* when labor is inelastic. We find that the presence of temptation in preferences induces individuals to work longer, and therefore, increases aggregate labor. Particularly, for the case with $\sigma = 2$ and $\lambda = 0.10$ aggregate labor is about 1.6 percent higher, compared to the benchmark case $\lambda = 0$. Similarly, we find capital stock and output both decrease as temptation becomes more severe; however, the decreases in capital stock and output are relatively smaller, compared to setting *(i)* in which labor is inelastic. For the case with $\sigma = 2$ and $\lambda = 0.10$, the adverse effect of temptation on capital accumulation is about 5 percent in setting *(i)*, while it is 6.6 percent in setting *(ii)*.

Comparing setting *(ii)* in Table 1 and setting *(ii)* in Table 6, we find that the distortions created by temptation are much bigger in a general equilibrium model. Considering the case with $\sigma = 2$ and $\lambda = .1$, savings decreases by 1.3 percent in a partial general equilibrium model (Table 1) and by 5 percent in a general equilibrium model (Table 6). Meanwhile, labor

supply increases by 1.2 percent and 1.6 percent in a partial equilibrium model and a general equilibrium model, respectively. This comparison indicates that the general equilibrium price adjustment amplifies the distortions caused by the presence of temptation in preferences.

Welfare. As seen Table 6, the increase in temptation parameter value decreases the social welfare. Considering the case with $\sigma = 2$, an incremental increase in the value of temptation parameter by .025 decreases utility by at least 1 percent. There is a tension between long-term commitment for consumption smoothing and a short-term urge of temptation. The negative welfare effect of temptation is relatively larger when individuals are more risk-averse. An incremental increase in the value of temptation parameter by .025 decreases welfare by 1.2 percent when $\sigma = 4$; meanwhile, an incremental increase in the value of temptation parameter by .025 decreases welfare by almost 1.3 percent when $\sigma = 6$. This quantitative result emphasizes that the cost of self-control is severer when inter-temporal elasticity of substitution is smaller.

Comparing welfare outcomes between setting (i) and setting (ii) in Table 6, we find that welfare losses created by temptation are much bigger in a general equilibrium model with elastic labor. This pattern is also true for all values of the risk aversion parameter σ . Indeed, a “small” distortion to preferences affecting individuals’s inter-temporal allocation results in a “big” distortion on allocation of resources and efficiency at aggregate level in a general equilibrium framework. The underlying reason is that general equilibrium price adjustments amplify the adverse effects, which are created by temptation, on efficiency and welfare. The results in Table 6 illustrate that the presence of temptation significantly reduces capital accumulation. Such efficiency losses subsequently lead to significant declines in welfare.

4.3 Income taxation as a corrective device

In this section we quantify the aggregate and welfare effects of a mix of savings subsidies and labor income taxes in a general equilibrium framework. More specifically, we consider a policy experiment in which the government collects labor income tax at rate τ^L to subsidize savings at rate τ^s . We report results in Table 7.

τ^s	(ii) Elastic Labor: $\gamma = 3, \sigma = 2, \lambda = 0.10$					
	dL	dK	dC_1	dC_2	dY	dV
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.10	-0.28	7.56	0.12	3.05	2.47	0.78
0.20	-0.58	16.32	0.46	6.46	5.20	1.50
0.30	-0.90	26.59	-1.12	10.33	8.23	2.13
0.40	-1.24	38.86	-2.22	14.75	11.64	2.62
0.50	-1.62	53.84	-3.95	19.92	15.55	2.88
0.60	-2.04	72.72	-6.64	26.14	20.14	2.73
0.70	-2.53	97.55	-10.92	33.89	25.69	1.79

Table 7: Income Taxation, Allocation and Welfare in General Equilibrium

Our general equilibrium results in Table 7 are quite similar to the partial general equilibrium

results in Table 5. That is, subsidizing savings make savings more attractive and induces agents to save more for future consumption. This subsequently leads to more capital accumulation and aggregate income. On other hand, labor income tax as a financing instrument induces agents to work less, which results in less aggregate labor. As seen in Table 7, individuals are willing to sacrifice a significant portion of their labor incomes to finance a savings subsidy program. In fact, there is a strong social desire for a savings subsidy program to help individuals to overcome “excessive” impatience caused by temptation. In a general equilibrium model, the corrective function of the savings subsidy is more pronounced because the distortions created by temptation are significantly amplified by general equilibrium price adjustments. The optimal subsidy rate is much higher in a general equilibrium model, compared Table 7 and Table 5. The difference highlights the importance of accounting for general equilibrium channels when evaluating the welfare implications of a savings subsidy program.

5 Conclusion

We study the role of taxation in an environment in which individuals have Gul-Pesendorfer type of temptation and self-control preferences. We demonstrate that inclusion of elastic labor, qualitatively and quantitatively, matters for allocation and welfare. Specifically, the presence of temptation in preferences causes a bias toward present consumption. This then results in welfare losses due to a two-dimensional problem: under-saving and over-supply-of-labor. In the absence of any mechanism for commitment, the intra- and inter-temporal distortions caused by temptation induce preference for government intervention. Income taxation in particular can serve as a corrective device: *(i)* that mitigates the inter- and intra-temporal distortions, and *(ii)* that reduces severity of self-control cost.

We examine whether a savings/investment subsidy program can eliminate the distortions caused by temptation and improve welfare. We find that inclusion of elastic labor introduce a new trade off between welfare gains from correcting incentives to save and welfare losses from distorting incentives to work. As in Krusell et al (2010), savings subsidy is socially desired; however, the optimal subsidy rate is significantly smaller because of extra distortions through the intra-temporal wedges. More importantly, we find that a corrective function of labor income taxation in mitigating the over-supply-of-labor problem caused by temptation. The welfare benefit of taxing labor income is restrained by its adverse effects on savings incentives. Most importantly, we demonstrate that the two-dimensional problem created by temptation requires two-dimensional policies. Indeed, a combination of capital and labor income taxation appears to be a more effective policy.

In this paper, we focus on the corrective function of income taxation (Pigouvian effect), while completely abstracting the redistributive function (Redistributive effect). For a more realistic policy analysis, it is essential to incorporate other sources of agent heterogeneity such as earning uncertainties and capital market imperfections in an integrated framework. We leave

this extension for future research.

References

- Aiyagari, S. Rao. 1995. “Optimal Capital Income Taxation with Incomplete Markets, Borrowing Constraints, and Constant Discounting.” *Journal of Political Economy* 103:1158–1175.
- Ameriks, John, Andrew Caplin, John Leahy and Tom Tyler. 2007. “Measuring Self-Control Problems.” *American Economic Review* 97:966–972.
- Atkinson, Anthony and Joseph E. Stiglitz. 1976. “The Design of Tax Structure: Direct Versus Indirect Taxation.” *Journal of Public Economics* 6(1-2):55–75.
- Buccioli, Alessandro. 2012. “Measuring Self-Control Problems: A Structural Estimation.” *Journal of European Economic Association* 10(5):1084–1115.
- Chamley, C. 1986. “Optimal taxation of capital income in general equilibrium with infinite lives.” *Econometrica* 54:607–622.
- Chamley, Christophe. 2001. “Capital Income Taxation, Wealth Distribution and Borrowing Constraints.” *Journal of Public Economics* 79:55–69.
- Conesa, Juan Carlos, Sagiri Kitao and Dirk Krueger. 2009. “Taxing Capital? Not a Bad Idea after All.” *American Economic Review* 99(1):25–48.
- DeJong, D. N. and M. Ripoll. 2007. “Do self-control preferences help explain the puzzling behavior of asset prices?” *Journal of Monetary Economics* 54:1035–1050.
- Diamond, Peter. 1980. “Income Taxation with Fixed Hours of Work.” *Journal of Public Economics* 13:101–110.
- Fang, Hanming and Dan Silverman. 2009. “Time-Inconsistency and Welfare Program Participation: Evidence From The NLSY.” *International Economic Review* 50:1043–1077.
- Frederick, S., G. Loewenstein and T. O’Donoughe. 2002. “Time discounting and time preference: A critical review.” *Journal of Economic Literature* 40:351–401.
- Gruber, J. and B. Koszegi. 2001. “Is Addiction Rational? Theory and Evidence.” *Quarterly Journal of Economics* 116:261–303.
- Gruber, J. and B. Koszegi. 2004. “Tax Incidence When Individuals are Time Inconsistent: The Case of Cigarette Excise Taxes.” *Journal of Public Economics* 88:959–988.
- Gul, F. and W. Pesendorfer. 2004a. “Self control and theory of consumption.” *Econometrica* 72:119–158.

- Gul, Faruk and Wolfgang Pesendorfer. 2001. "Temptation and Self-Control." *Econometrica* 69:1403–1435.
- Gul, Faruk and Wolfgang Pesendorfer. 2004b. "Self-Control and the Theory of Consumption." *Econometrica* 72:119–158.
- Gul, Faruk and Wolfgang Pesendorfer. 2005. "The Revealed Preference Theory of Changing Tastes." *Review of Economic Studies* 72:429–448.
- Huang, Kevin X. D., Zheng Liu and John Q. Zhu. 2007. "Temptation and self-control: Some evidence and applications." *Working Paper* .
- Judd, Kenneth L. 1985. "Redistributive Taxation in a Simple Perfect Foresight Model." *Journal of Public Economics* 28:59–83.
- Krusell, Perl, Burhanettin Kuruscu and Anthony A. Smith. 2010. "Temptation and Taxation." *Econometrica* 78(6):2063–2084.
- Laibson, D. 1997. "Hyperbolic discounting and golden eggs." *Quarterly Journal of Economics* 112:443–477.
- Laibson, David. 1996. "Hyperbolic Discount Functions, Undersaving, and Savings Policy." National Bureau of Economic Research Working Paper 5635.
- O'Donoghue, T. and M. Rabin. 2003. "Studying Optimal Paternalism, Illustrated by a Model of Sin Taxes." *American Economic Review* 83:186–191.
- O'Donoghue, T. and M. Rabin. 2006. "Optimal Sin Taxes." *Journal of Public Economics* 90:1825–1849.
- Phelps, E. S. and R. A. Pollak. 1968. "On second-best national savings and game-equilibrium growth." *Review of Economic Studies* 35:185–199.
- Saez, Emmanuel. 2001. "Using Elasticities to Derive Optimal Income Tax Rates." *Review of Economic Studies* 68:205–229.
- Shenshiski, Eytan. 1972. "The Optimal Linear Income-tax." *The Review of Economic Studies* 39 (No 3):297–302.
- Strotz, R. H. 1956. "Myopia and inconsistency in dynamic utility maximization." *Review of Economic Studies* 23:165–180.
- Tran, Chung. 2012. "Fiscal Policy as a Temptation Control Device." ANU Working Paper in Economics and Econometrics No. 595.

6 Appendix

6.1 Solution for the basic model

Thus the young's agent problem is simplified to:

$$L(.) = \max_{c_1, n_1, s, \mu} \left\{ (1 + \lambda) \frac{c_1^{1-\sigma}}{1-\sigma} + \gamma \frac{(1-n_1)^{1-\varphi}}{1-\varphi} + \beta V_2(s) + \mu (wn_1 - c_1 - s) \right\} - \lambda \frac{w^{1-\sigma}}{1-\sigma}$$

with μ is the shadow price. Assuming an interior solution, we obtain the corresponding F.O.Cs:

$$\begin{aligned} \frac{\partial L}{\partial c_1} &: (1 + \lambda) c_1^{-\sigma} = \mu, \\ \frac{\partial L}{\partial n_1} &: \gamma (1 - n_1)^{-\varphi} = \mu w, \\ \frac{\partial L}{\partial s} &: \beta \frac{\partial V_2(s)}{\partial s} = \mu \\ \frac{\partial L}{\partial \mu} &: wn_1 - c_1 - s = 0. \end{aligned}$$

Allocation. The demand for leisure and for consumption are given by

$$\begin{aligned} (1 - n_1) &= \frac{\overbrace{\gamma^{\frac{1}{\varphi}}}}{\text{intra-temporal}} \overbrace{\left(\frac{w}{1 + \frac{1}{R} \left(\frac{\beta R}{1+\lambda} \right)^{\frac{1}{\sigma}}} \right)^{\frac{1}{\sigma}}}_{\text{inter-temporal}} n_1^{\frac{\sigma}{\varphi}}, \\ c_1 &= \left(\frac{w(1+\lambda)}{\gamma} \right)^{\frac{1}{\sigma}} (1 - n_1)^{\frac{\varphi}{\sigma}}, \end{aligned}$$

respectively. To simplify the solution we consider a special case $\varphi = \sigma$. The optimal allocation is given by

$$\begin{aligned} c_1 &= \frac{1}{1 + \frac{1}{R} \left(\frac{\beta R}{1+\lambda} \right)^{\frac{1}{\sigma}} + w \left(\frac{\gamma}{(1+\lambda)w} \right)^{\frac{1}{\sigma}}} w, \\ s &= \frac{\frac{1}{R} \left(\frac{\beta R}{1+\lambda} \right)^{\frac{1}{\sigma}}}{1 + \frac{1}{R} \left(\frac{\beta R}{1+\lambda} \right)^{\frac{1}{\sigma}} + w \left(\frac{\gamma}{(1+\lambda)w} \right)^{\frac{1}{\sigma}}} w, \\ (1 - n_1) &= \frac{\left(\frac{\gamma}{(1+\lambda)w} \right)^{\frac{1}{\sigma}}}{1 + \frac{1}{R} \left(\frac{\beta R}{1+\lambda} \right)^{\frac{1}{\sigma}} + w \left(\frac{\gamma}{(1+\lambda)w} \right)^{\frac{1}{\sigma}}} w. \end{aligned}$$

Let $\theta_1 = \frac{1}{R} \left(\frac{\beta R}{1+\lambda} \right)^{\frac{1}{\sigma}}$ and $\theta_2 = w \left(\frac{\gamma}{(1+\lambda)w} \right)^{\frac{1}{\sigma}}$ be the weights on savings and leisure relative to

consumption. The optimal allocation is simplified to

$$\begin{aligned} c_1 &= \frac{1}{1 + \theta_1 + \theta_2} w, \\ s &= \frac{\theta_1}{1 + \theta_1 + \theta_2} w, \\ (1 - n_1) &= \frac{\frac{\theta_2}{w}}{1 + \theta_1 + \theta_2} w. \end{aligned}$$

Welfare measure. The value functions are given by:

$$\begin{aligned} V_2 &= \frac{\left(\frac{\theta_1 R}{1 + \theta_1 + \theta_2}\right)^{1-\sigma}}{1 - \sigma} w^{1-\sigma}, \\ V_1 &= \begin{cases} \left[\left(\frac{1}{1 + \theta_1 + \theta_2}\right)^{1-\sigma} + \gamma \left(\frac{\frac{\theta_2}{w}}{1 + \theta_1 + \theta_2}\right)^{1-\sigma} + \beta \left(\frac{\theta_1 R}{1 + \theta_1 + \theta_2}\right)^{1-\sigma} \right] \frac{w^{1-\sigma}}{1-\sigma} \\ -\lambda \left[1 - \left(\frac{1}{1 + \theta_1 + \theta_2}\right)^{1-\sigma} \right] \frac{w^{1-\sigma}}{1-\sigma}. \end{cases} \end{aligned}$$

Welfare decomposition. The welfare is defined as the young's value function:

$$\begin{aligned} V_1 &= \begin{cases} \left[\overbrace{\left[\left(\frac{1}{1 + \theta_1 + \theta_2}\right)^{1-\sigma} + \beta \left(\frac{\theta_1 R}{1 + \theta_1 + \theta_2}\right)^{1-\sigma} \right]}^{=v^{cs}} \right] \frac{w^{1-\sigma}}{1-\sigma} \\ \left[+\gamma \overbrace{\left[\left(\frac{\frac{\theta_2}{w}}{1 + \theta_1 + \theta_2}\right)^{1-\sigma} \right]}^{=v^{cn}} \right] \frac{w^{1-\sigma}}{1-\sigma} \\ -\lambda \overbrace{\left[1 - \left(\frac{1}{1 + \theta_1 + \theta_2}\right)^{1-\sigma} \right]}^{=v^{scc}} \frac{w^{1-\sigma}}{1-\sigma}, \end{cases} \\ &= (v^{cs} + v^{cn} - v^{scc}) \frac{w^{1-\sigma}}{1 - \sigma}. \end{aligned}$$

The change in welfare due to temptation is given by

$$\begin{aligned} dV_1 &= V_1^{\lambda>0} - V_1^{\lambda=0}, \\ &= \begin{cases} [v^{cs, \lambda>0} + v^{cn, \lambda>0} - v^{scc, \lambda>0}] \frac{w^{1-\sigma}}{1-\sigma} \\ - [v^{cs, \lambda=0} + v^{cn, \lambda=0} - v^{scc, \lambda=0}] \frac{w^{1-\sigma}}{1-\sigma}, \end{cases} \\ &= \left[\overbrace{\left(v^{cs, \lambda>0} - v^{cs, \lambda=0} \right)}^{\text{inter-temporal distortion}} + \overbrace{\left(v^{cn, \lambda>0} - v^{cn, \lambda=0} \right)}^{\text{intra-temporal distortion}} + \overbrace{\left(0 - v^{scc, \lambda>0} \right)}^{\text{self-control distortion}} \right] \frac{w^{1-\sigma}}{1 - \sigma} \end{aligned}$$

6.2 Solution for the model with a savings subsidy program

The government budget is given by $T = \tau^s s$, where T is lump-sum tax and τ^s is a savings subsidy rate. The household problem is given by:

$$L(.) = \max_{c_1, n_1, s, \mu} \left\{ (1 + \lambda) \frac{c_1^{1-\sigma}}{1-\sigma} + \gamma \frac{(1-n_1)^{1-\varphi}}{1-\varphi} + \beta V_2(s) \right\} - \lambda \frac{(w-T)^{1-\sigma}}{1-\sigma} + \mu [wn_1 - T - c_1 - (1-\tau^s)s]$$

where μ is the shadow price. Assuming an interior solution, we obtain the corresponding F.O.Cs:

$$\begin{aligned} \frac{\partial L}{\partial c_1} &: (1 + \lambda) c_1^{-\sigma} = \mu, \\ \frac{\partial L}{\partial n_1} &: \gamma (1 - n_1)^{-\varphi} = \mu w, \\ \frac{\partial L}{\partial s} &: \beta \frac{\partial V_2(s)}{\partial s} = (1 - \tau^s) \mu \\ \frac{\partial L}{\partial \mu} &: wn_1 - T - c_1 - (1 - \tau^s) s = 0. \end{aligned}$$

Allocation. To simplify the solution method we assume that $\sigma = \varphi$. Combining the FOCs and assuming $T = \tau^T w$ yields the optimal allocation:

$$\begin{aligned} c_1 &= \frac{(1 - \tau^T) w}{1 + (1 - \tau^s) \frac{1}{R} \left(\frac{\beta R}{(1+\lambda)(1-\tau^s)} \right)^{\frac{1}{\sigma}} + w \left(\frac{\gamma}{(1+\lambda)w} \right)^{\frac{1}{\sigma}}}, \\ 1 - n_1 &= \frac{\left(\frac{\gamma}{(1+\lambda)w} \right)^{\frac{1}{\sigma}} (1 - \tau^T) w}{1 + (1 - \tau^s) \frac{1}{R} \left(\frac{\beta R}{(1+\lambda)(1-\tau^s)} \right)^{\frac{1}{\sigma}} + w \left(\frac{\gamma}{(1+\lambda)w} \right)^{\frac{1}{\sigma}}}, \\ s &= \frac{1}{R} \frac{\left(\frac{\beta R}{(1+\lambda)(1-\tau^s)} \right)^{\frac{1}{\sigma}} (1 - \tau^T) w}{1 + (1 - \tau^s) \frac{1}{R} \left(\frac{\beta R}{(1-\tau^s)(1+\lambda)} \right)^{\frac{1}{\sigma}} + w \left(\frac{\gamma}{(1+\lambda)w} \right)^{\frac{1}{\sigma}}}. \end{aligned}$$

Using $\theta_1 = \frac{1}{R} \left(\frac{\beta R}{(1+\lambda)} \right)^{\frac{1}{\sigma}}$ and $\theta_2 = w \left(\frac{\gamma}{(1+\lambda)w} \right)^{\frac{1}{\sigma}}$ we can re-write the optimal allocation rule as

$$\begin{aligned} c_1 &= \frac{1}{1 + (1 - \tau^s)^{(1-\frac{1}{\sigma})} \theta_1 + \theta_2} (1 - \tau^T) w, \\ s &= \frac{(1 - \tau^s)^{-\frac{1}{\sigma}} \theta_1}{1 + (1 - \tau^s)^{(1-\frac{1}{\sigma})} \theta_1 + \theta_2} (1 - \tau^T) w, \\ (1 - n_1) &= \frac{(1 - \tau^T) \theta_2}{1 + (1 - \tau^s)^{(1-\frac{1}{\sigma})} \theta_1 + \theta_2}. \end{aligned}$$

The equilibrium tax rates that clear the government budget constraint is given by

$$\frac{\tau^T}{1 - \tau^T} = \frac{\tau^s (1 - \tau^s)^{-\frac{1}{\sigma}} \theta_1}{1 + (1 - \tau^s)^{(1 - \frac{1}{\sigma})} \theta_1 + \theta_2} \frac{1}{R}.$$

6.3 Solution for the model with savings subsidy and labor income tax

The government budget is given by : $\tau^w w n_1 = \tau^s s$. The household problem is given by:

$$L(.) = \max_{c_1, n_1, s, \mu} \left\{ (1 + \lambda) \frac{c_1^{1-\sigma}}{1-\sigma} + \gamma \frac{(1-n_1)^{1-\varphi}}{1-\varphi} + \beta V_2(s) \right\} - \lambda \frac{w^{1-\sigma}}{1-\sigma} + \mu [(1 - \tau^L) w n_1 - c_1 - (1 - \tau^s) s]$$

where μ is the shadow price. Taking the F.O.Cs yields the following system of equations:

$$\begin{aligned} \frac{\partial L}{\partial c_1} &: (1 + \lambda) c_1^{-\sigma} = \mu, \\ \frac{\partial L}{\partial n_1} &: \gamma (1 - n_1)^{-\varphi} = (1 - \tau^L) \mu w, \\ \frac{\partial L}{\partial s} &: \beta \frac{\partial V_2(s)}{\partial s} = (1 - \tau^s) \mu \\ \frac{\partial L}{\partial \mu} &: (1 - \tau^L) w n_1 - c_1 - (1 - \tau^s) s = 0. \end{aligned}$$

Allocation. The optimal allocation is given by:

$$\begin{aligned} c_1 &= \frac{(1 - \tau^L) w}{1 + (1 - \tau^s) \frac{1}{R} \left(\frac{\beta R}{(1+\lambda)(1-\tau^s)} \right)^{\frac{1}{\sigma}} + (1 - \tau^L) w \left(\frac{\gamma}{(1+\lambda)(1-\tau^L)w} \right)^{\frac{1}{\sigma}}}, \\ 1 - n_1 &= \left(\frac{\gamma}{(1 + \lambda) (1 - \tau^L) w} \right)^{\frac{1}{\sigma}} c_1, \\ &= \frac{\left(\frac{\gamma}{(1+\lambda)(1-\tau^L)w} \right)^{\frac{1}{\sigma}} (1 - \tau^L) w}{1 + (1 - \tau^s) \frac{1}{R} \left(\frac{\beta R}{(1-\tau^s)(1+\lambda)} \right)^{\frac{1}{\sigma}} + (1 - \tau^L) w \left(\frac{\gamma}{(1+\lambda)(1-\tau^L)w} \right)^{\frac{1}{\sigma}}}, \\ s &= \frac{1}{R} \left(\frac{\beta R}{(1 + \lambda) (1 - \tau^s)} \right)^{\frac{1}{\sigma}} c_1 \\ &= \frac{1}{R} \frac{\left(\frac{\beta R}{(1-\tau^s)(1+\lambda)} \right)^{\frac{1}{\sigma}} (1 - \tau^L) w}{1 + (1 - \tau^s) \frac{1}{R} \left(\frac{\beta R}{(1-\tau^s)(1+\lambda)} \right)^{\frac{1}{\sigma}} + (1 - \tau^L) w \left(\frac{\gamma}{(1+\lambda)(1-\tau^L)w} \right)^{\frac{1}{\sigma}}}. \end{aligned}$$

Let $\theta_1 = \frac{1}{R} \left(\frac{\beta R}{(1+\lambda)} \right)^{\frac{1}{\sigma}}$ and $\theta_2 = w \left(\frac{\gamma}{(1+\lambda)w} \right)^{\frac{1}{\sigma}}$ be the weights on savings and leisure relative to consumption. The optimal allocation rule becomes

$$\begin{aligned}
c_1 &= \frac{(1 - \tau^L) w}{1 + (1 - \tau^s)^{(1 - \frac{1}{\sigma})} \theta_1 + (1 - \tau^L)^{(1 - \frac{1}{\sigma})} \theta_2}, \\
s &= \frac{(1 - \tau^s)^{-\frac{1}{\sigma}} \theta_1 (1 - \tau^L) w}{1 + (1 - \tau^s)^{(1 - \frac{1}{\sigma})} \theta_1 + (1 - \tau^L)^{(1 - \frac{1}{\sigma})} \theta_2}, \\
(1 - n_1) &= \frac{(1 - \tau^L)^{(1 - \frac{1}{\sigma})} \theta_2}{1 + (1 - \tau^s)^{(1 - \frac{1}{\sigma})} \theta_1 + (1 - \tau^L)^{(1 - \frac{1}{\sigma})} \theta_2}.
\end{aligned}$$