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M. Arvaniti, T. Sjögren

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Temptation in Consumption and Optimal Redistributive Taxation*

Maria Arvaniti[a] and Tomas Sjögren[s]

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Abstract

The purpose of this article is to integrate the class of preferences developed by Gul and Pesendorfer into the theory of optimal redistributive taxation with heterogenous consumers and asymmetric information. The consumers are inclined to over-spend on a commodity for which they experience temptation (TP good). Resisting that temptation gives rise to a utility cost. This cost provides two novel motives for influencing the consumption and labor supply choices; improving the welfare (by reducing the utility cost of exercising self-control) and providing the government with a novel channel via which tax policy can be used to relax a binding self-selection constraint. The welfare motive implies a positive tax on the TP good, as well as a positive (negative) marginal labor income tax rate if the consumer´s marginal valuation of leisure exceeds (falls short of) the marginal valuation of leisure that arises if the consumer would succumb to the temptation. We use iso-elastic and logarithmic utility functional form specifications to exemplify when the self-selection channel may lead to higher/lower commodity and marginal labor income taxes.

JEL: D03, H21, H24, H31

Keywords: Temptation, self-control, optimal taxation, redistribution, commodity taxation, income taxation.

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[a] Chair of Economics/Resource Economics ETH, Zurich. E-mail: marvaniti@ethz.ch. The project was partly carried out when the author was the holder of a fellowship of the Tore Browaldh Foundation (Handelsbanken foundation). Support from the foundation is gratefully acknowledged.

[s] Department of Economics, USBE, Umeå University, Sweden. E-mail: tomas.sjogren@umu.se.

1. Introduction

Much of the literature on optimal taxation is based on the assumption that agents behave in a fully rational way. Yet, there is experimental and empirical evidence that individuals may exhibit behavioral anomalies such as preference reversals, biases or self-control problems in intertemporal decision-making.[1] Such evidence has led to the development of a vast theoretical literature on time inconsistent behavior. Starting with Strotz (1956), and Phelps and Pollak (1968), a common feature in these frameworks is modelling the individual as a sequence of different "selves" who play a dynamic game vis-a-vis each other and where each "self" values the consumption stream in a unique way.[2] The dynamic inconsistency inherent in such models may call for commitment mechanisms.

Gul and Pesendorfer (2001, 2004, 2005) instead suggest a different cause for a preference for commitment. By focusing on preferences over the choice sets rather than choices from the set, Gul and Pesendorfer (henceforth referred to as GP) argue that agents who suffer from, but resist, temptation will always prefer a smaller choice set as it will be associated with a lower cost of exercising self-control, therefore giving rise to a demand for commitment devices.[3] This observation creates an obvious case for government intervention (in the absence of other commitment mechanisms): policies that restrict the choice set of an agent will reduce the cost of exercising self-control, thereby improving welfare. The purpose of the present paper is to analyze

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[1] Frederick, Loewenstein and O'Donoghue (2002) provide an excellent overview of the experimental and empirical literature on this issue.

[2] Strotz (1956) was the first to suggest a model where an agent's future behavior is inconsistent with his/her optimal plan which, in turn, gives rise to a demand for pre-commitment devices. Phelps and Pollak (1968) study second-best national saving when the present generation lacks the power to commit future generations' decisions while Laibson (1997) models time-inconsistency within an individual in the presence of an imperfect commitment technology. In the same spirit, O'Donoghue and Rabin (1999, 2001) explore the welfare and behavioral implications of present-biased preferences and procrastination. Aronsson and Sjögren (2014, 2016) were the first to integrate time-inconsistent preferences into the modern literature on optimal mixed taxation.

[3] Following Kreps (1979), GP develop an axiomatic approach of temptation and self-control preferences over menus together with a representation theorem in a two-period model, which can be summarized as follows. In the first period, agents choose over menus of lotteries while in the second, they choose an alternative from the menu. However, agents are subject to temptation: at the time of actual consumption, they suffer from an urge to deviate from their "commitment" preferences, $u(x)$, which prescribe what they "should" do, and instead evaluate alternatives according to their "temptation" preferences, $h(x)$, which is what they "want" to do. In this framework, an agent´s welfare from a given set is determined by the maximized value of the sum of the commitment and temptation utilities minus the temptation utility evaluated at the most tempting alternative of the menu. Naturally, this representation suggests the following choice behavior in the second period: given a menu A, an agent´s actual choice maximizes $u(x) + h(x)$ while the agent at the same time experiences a cost of exercising self-control which is given by $max_{\tilde{x}\in A}\, h(\tilde{x})$. Therefore, the agent´s second period choice behavior represents a compromise between the utility that could have been achieved under commitment and the cost associated with exercising self-control.

how the appearance of self-control costs modifies the optimal tax structure in a mixed tax framework with a linear commodity tax and nonlinear labor income taxes.

Krusell et al (2010) were the first to study how linear tax-transfer schemes can be used to improve the welfare in a representative consumer economy where agents are tempted towards current consumption, thereby distorting the incentive to save for tomorrow. They showed that a savings subsidy improves welfare by making succumbing to temptation less attractive. Using a multi-period framework with a finite time horizon, they also found that optimal savings subsidies increase over time for a logarithmic utility function. Tran (2018) modified this analysis by allowing for a labor/leisure choice and showed that the inclusion of elastic labor introduces an intra-temporal channel for temptation distortions through a consumption-leisure trade off. In this extended framework with both an intra-temporal and an inter-temporal channel for temptation distortions, a mix of linear labor and capital taxes appears to be more effective in improving welfare than solely relying on capital taxation.[4]

The studies mentioned above have contributed greatly to our understanding of how taxes can be used to improve welfare when agents have GP preferences. However, key aspects remain unexplored when it comes to linking GP preferences to traditional optimal tax theory. One is that representative consumer models typically abstract from the information problem that arises in an economy with heterogenous consumers. The latter feature is accounted for in the literature on optimal nonlinear taxation.[5] In that context, consumers typically differ in terms of their labor market productivities and as long as the latter is private information, the government faces an information constraint when solving the optimal tax and expenditure problem. This information asymmetry imposes a restriction on the government´s ability to redistribute resources between the different consumer types and is an important determinant of tax policy. A natural extension is therefore to incorporate GP preferences into the optimal nonlinear tax framework and analyze how this will affect and modify the optimal policy rules in comparison with those derived in the

[4] There are also some other studies which are concerned with optimal taxation when agents have GP preferences. Kumru and Thanopoulos (2015) quantitatively examine the impact of fiscal policies in a stochastic OLG-model where agents can have standard or GP preferences and are subject to idiosyncratic shocks and borrowing constraints. They find that the presence of self-control agents puts a downward pressure on the optimal capital tax. The size of the tax depends on the share of GP preferences and on the self-control cost but the tax remains positive for all empirically relevant values. Bethencourt and Kunze (2017) study the optimal taxation of education and labor, and show that the size and direction of taxes depends on the strength of temptation, the elasticity of earnings and the sensitivity to taxes. St-Amant, P. A. B., & Garon, J. D. (2015) study optimal redistributive pension schemes when agents are tempted by immediate consumption.

[5] See the seminal work of Stern (1982), Stiglitz (1982), and Edwards, Keen and Tuomala (1994).

conventional framework. Such an extension is important (i) because many real-world tax systems feature nonlinear labor income tax schedules accompanied by linear taxes on other tax bases and (ii) because a government's decision to implement distortionary taxes will in that context be an optimal choice subject to informational constraints; the tax rules will not arise because of arbitrary restrictions on the tax instruments. This means that a model that features nonlinear income taxation provides a suitable framework for analyzing the basic question of how the appearance of GP preferences itself motivates the use of distortionary taxes.[6] In particular, it allows us to study two important issues: to what degree GP preferences themselves motivate the use of distortionary taxes and how GP related components and redistributive components interact in a mixed tax framework.[7]

In line with the discussion above, we extend the analysis of optimal taxation when agents have GP preferences in two directions. The first is by incorporating the GP framework into the theory of optimal nonlinear labor income taxation with two ability types and asymmetric information between the private sector and the government. As such, this is an extension of the two-type optimal income tax model developed by Stern (1982) and Stiglitz (1982). The second is by relating temptation to a consumption good: we will refer to a good for which consumers may experience temptation as a temptation preference good.[8] The policy instruments consist of a linear commodity tax and nonlinear labor income taxes. Note, that if a nonlinear commodity tax would be available, then it would be easy for the government to circumvent the self-control problem by implementing a commodity tax structure, which reduces the consumer's choice set to a singleton.[9] However, since nonlinear commodity taxes are not commonly observed in reality (e.g. because of informational limitations), we follow convention and focus on linear commodity taxation.

[6] Amador et al (2006) also use nonlinear tax instruments but in a different setting: they study the optimal trade-off between commitment and flexibility in a consumption-savings model where agents have GP preferences but are subject to taste shocks. They find that a minimum savings rule is always part of the optimal solution.

[7] Allcott, H., Lockwood, B. B., & Taubinsky, D. (2019) study the interaction between the corrective and redistributive motives in designing the so called "sin" taxes.

[8] There are many examples of when an individual makes a consumption plan which he/she later is tempted to deviate from. Consider, for example, a person who in the morning plans to eat a healthy salad at lunch but when lunchtime actually comes, he may face more tempting alternatives such as fish, burgers, steaks etc. Another example is a person who plans to buy a car with a certain set of attributes and within in a certain price range, but after she has test driven some cars, she may be tempted to buy a fancier and more expensive car than originally planned. Although there is a similar interpretation, our approach differs from models focusing on addictive goods (Gruber and Koszegi 2001, 2004) and sin goods (O´Donoghue and Rabin [2006], Allcott, H., Lockwood, B. B., & Taubinsky, D. (2019)).

[9] As Krusell et al (2010) point out; if a nonlinear capital tax schedule would be available to address the problem of preference reversals related to the consumption/saving decisions, then the self-control/temptation problem could be circumvented by implementing a command policy in which the consumer's choice set is reduced to a singleton which reproduces the first-best outcome. A similar logic applies when the preference reversal is related to a commodity.

The present paper contributes to the literature in at least three ways. First, we derive explicit conditions for when the incentive to improve the welfare in the presence of GP preferences contributes to higher/lower marginal labor income tax rates. It is shown that the sign of this effect depends on the size of the marginal rate of substitution between leisure and disposable income, and when agents have logarithmic utility functions this effect contributes to higher marginal labor income tax rates. Second, since this is the first paper which uses a self-selection approach to analyze optimal taxation in the presence of GP preferences, we are able to focus on novel aspects of the interaction between the welfare improving and the redistributive role of public policy. In particular, we show that the utility cost of exercising self-control provides an additional channel via which the government may relax a binding self-selection constraint. When agents have logarithmic utility functions this effect contributes to higher marginal labor income tax rates. Finally, by relating temptation to a particular commodity, we show that the GP welfare motive provides the government with an incentive to implement a positive tax on that commodity. In addition, it is also shown that the government may have a self-selection motive for implementing a non-zero commodity tax even if consumption and leisure are uncorrelated.

The outline of the study is as follows: In Section 2, we present a benchmark model with fixed labor supply in order to highlight the key mechanism at work via which commodity taxation can improve welfare in the GP framework. In Section 3, we extend the model to include consumer heterogeneity and endogenous labor supply decisions. Subsection 3.1 characterizes the choices made by the consumers while Subsection 3.2 characterizes the optimal tax problem facing the government. In that part we present the optimal commodity and labor income tax policies in a format that aims to facilitate straightforward interpretations and comparisons with earlier literature. We also provide functional form examples to illustrate when key elements in the tax formulas can be signed. The paper is concluded in Section 4 and proofs are presented in the Appendix.

2. A Benchmark Model

We begin by addressing temptation preferences in a simplified model where consumers are homogenous and do not make active labor supply decisions.

2.1 The Consumer

Consider an economy made up of a large number of identical consumers whose number is normalized to one. Each individual consumes c units of a numeraire good and one unit of a non-numeraire good. The non-numeraire good contains an attribute and the quantity of the attribute is captured by a continuous indicator x. If, for example, the non-numeraire good is a car, then the attribute could be engine power and the quantity of the attribute could be the car´s horse-powers. The consumer has Gul-Pesendorfer preferences over c and x which are captured by two utility functions; a commitment utility $u(c,x)$, which prescribes what an agent should do and a temptation utility $h(c,x)$ which shows what he/she is tempted to do. Both utility functions are twice continuously differentiable, increasing and quasi-concave in c and x. The cross-derivatives are assumed to satisfy $u_{cx}, h_{cx} \geq 0$ and the temptation utility is tilted towards buying a temptation good which includes more of x in the sense that $u_x(c,x)/u_c(c,x) < h_x(c,x)/h_c(c,x)$ holds for all c and x. We will therefore refer to the non-numeraire commodity as a temptation preference (TP) good. When deciding how many units of the numeraire good to purchase, and how much of the attribute to include in the temptation good, the consumer maximizes the following Gul-Pesendorfer objective function

$$V = \max_{c,x} \; [u(c,x) + h(c,x)] - \max_{\tilde{c},\tilde{x}} \; h(\tilde{c},\tilde{x}) \tag{1}$$

where c and x denote the *actual* choices made by the consumer while $\tilde{c}$ and $\tilde{x}$ are the *temptation* choices that arise if the consumer would only maximize the temptation utility. This representation implies that the consumer´s actual choices maximize the sum of the commitment and temptation utilities. If we define $max_{\tilde{c},\tilde{x}} \; h(\tilde{c},\tilde{x}) - h(c,x)$ to be the *utility cost of exercising self-control*, it follows that the consumer´s actual choices represent a compromise between the commitment utility and the utility cost of exercising self-control.

The price that a producer charges for the TP good is increasing in x and we assume that this relationship is linear. This means that the producer price is given by px, where p can be interpreted as the fixed producer price per unit of attribute. For notational convenience, we will set p equal to one. By making these assumptions, the tax formulas to be derived below will take the same form as they would if x instead would be interpreted as the number of units consumed of the TP good. This makes it straightforward to compare the tax formulas derived in this paper with those derived in earlier optimal tax literature. The government taxes the TP good at the rate t. This means that the consumer price of the TP good is $(1+t)x$ and we let $q=(1+t)$ denote the consumer price per "unit of attribute". By using this notation, the consumer´s budget constraint can be written as $b=c+qx$, where b is post-tax income. The latter is given by $b=m-T$ where m is an exogenous income endowment and T is a lump-sum tax (transfer if T is negative). Substituting the budget constraint into (1) and maximizing the resulting expression w.r.t. x produces

$$\frac{u_x(c,x)+h_x(c,x)}{u_c(c,x)+h_c(c,x)}=q \qquad (2)$$

Together with the budget constraint, equation (2) implicitly defines the actual demand functions for the numeraire good and for the quantity of the attribute to be included in the TP good as $c^*=c(b,q)=c(m-T,1+t)$ and $x^*=x(b,q)=x(m-T,1+t)$.

The allocation that maximizes the temptation utility is obtained by substituting $b=\tilde{c}+q\tilde{x}$ into $h(\tilde{c},\tilde{x})$ and maximizing the resulting expression w.r.t. $\tilde{x}$. This produces the first-order condition $h_x(\tilde{c},\tilde{x})/h_c(\tilde{c},\tilde{x})=q$. Together with the budget constraint, this equation defines the temptation demand functions; $\tilde{c}^*=\tilde{c}(b,q)=\tilde{c}(m-T,1+t)$ and $\tilde{x}^*=\tilde{x}(b,q)=\tilde{x}(m-T,1+t)$. We will refer to $\tilde{c}^*$ and $\tilde{x}^*$ as the *temptation allocation*. Since the actual choices reflect a compromise between maximizing u and h, whereas this compromise is not present in the determination of the temptation allocation, it follows from the assumptions made above that $c^*>\tilde{c}^*$ and $x^*<\tilde{x}^*$. By using these definitions in equation (1), we can write the consumer´s welfare at the optimum as $V^*=u(c^*,x^*)-[h(\tilde{c}^*,\tilde{x}^*)-h(c^*,x^*)]$, where $h(\tilde{c}^*,\tilde{x}^*)-h(c^*,x^*)\geq 0$ is the utility cost associated with exercising self-control.

2.2 Welfare and Taxes

The first-best outcome is determined in a command optimum where the consumption set is reduced to a singleton. Let (c^{**},x^{**}) denote this consumption bundle. Since there are no other consumption bundles to compare with when the choice set is reduced to a singleton, the utility cost of exercising self-control is zero. This means that the first-best level of welfare will be given by $V^{**}=u(c^{**},x^{**})+h(c^{**},x^{**})-h(c^{**},x^{**})=u(c^{**},x^{**})$. The first-best levels c^{**} and x^{**} are therefore obtained by maximizing the commitment utility subject to the resource constraint $m=c+x$. It would be possible to implement the first-best allocation (c^{**},x^{**}), and to achieve the first-best welfare, in the market economy by designing a commodity tax schedule which is nonlinear in x and which features a crushingly high commodity tax for any $x \neq x^{**}$. Since we rule out nonlinear commodity taxation, the analysis below will instead focus on a how a linear commodity tax can be used to improve the welfare.

In the absence of a nonlinear commodity tax schedule, we note that the government can induce the consumer to choose the first-best consumption bundle c^{**} and x^{**} by implementing a unique combination of the linear commodity tax and the lump-sum tax. Let us denote this unique combination of taxes by t^{**} and T^{**}. These taxes are retrieved by solving the equation system $c^{**} = c(m - T^{**}, 1 + t^{**})$ and $x^{**} = x(m - T^{**}, 1 + t^{**})$. Note, however, that the consumption set cannot be reduced to a singleton as long as the government is restricted to use a linear commodity tax. This means that along with the taxes t^{**} and T^{**}, there exists a temptation allocation, denoted $(\tilde{c}^{**}, \tilde{x}^{**})$, which is defined by the temptation demand functions $\tilde{c}^{**} = \tilde{c}(m - T^{**}, p + t^{**})$ and $\tilde{x}^{**} = \tilde{x}(m - T^{**}, p + t^{**})$. Since the assumptions made above imply that $x^{**} < \tilde{x}^{**}$, it follows that the utility cost of exercising self-control is positive. This, in turn, implies that the actual welfare associated with implementing the consumption bundle (c^{**}, x^{**}) satisfies

$$V = u(c^{**}, x^{**}) - \underbrace{[h(\tilde{c}^{**}, \tilde{x}^{**}) - h(c^{**}, x^{**})]}_{>0} < u(c^{**}, x^{**}) = V^{**} \tag{3}$$

Hence, implementing the first-best allocation in the market economy does not imply that the actual level of welfare will be equal to the first-best welfare.

A natural question is then what tax policy maximizes the actual welfare in the market economy? To address this question, we note that the government´s objective is to maximize the welfare function defined in equation (1) subject to the private and public budget constraints. The public budget constraint is given by $tx^* + T = 0$ and implies that any tax revenue generated by the commodity tax will be redistributed back to the consumer via a negative lump-sum tax (i.e. a lump-sum subsidy). The government also recognizes the functions $c^* = c(b, q)$, $x^* = x(b, q)$, $\tilde{c}^* = \tilde{c}(b, q)$ and $\tilde{x}^* = \tilde{x}(b, q)$, when solving the optimal tax problem. Let us use these demand functions to define the following indirect utility functions

$$U = U(b, q) = u[c(b, q), x(b, q)] \tag{4a}$$

$$H = H(b, q) = h[c(b, q), x(b, q)] \tag{4b}$$

$$\widetilde{H} = \widetilde{H}(b,q) = h[\tilde{c}(b,q), \tilde{x}(b,q)] \tag{4c}$$

$$V = V(b,q) = U(b,q) - \left[\widetilde{H}(b,q) - H(b,q)\right] \tag{4d}$$

In the text below, we will refer to $H = H(b,q)$ as the *actual temptation utility* and to $\widetilde{H} = \widetilde{H}(b,q)$ as the *maximum temptation utility*.

If we let γ denote the Lagrange multiplier associated with the government´s budget constraint, the following result can be derived (see the Appendix);

Proposition 1: *When the consumers are homogenous, the optimal linear commodity tax on the temptation preference good is given by*

$$t = \frac{(x^* - \tilde{x}^*)}{\left(\frac{\partial x^*}{\partial q} + x^* \frac{\partial x^*}{\partial b}\right)} \frac{\widetilde{H}_b}{\gamma} \tag{5}$$

Since $x^* < \tilde{x}^*$, and as long as the compensated price effect on the temptation preference good is negative ($\partial x^*/\partial q + x^* \partial x^*/\partial b < 0$), the optimal commodity tax will be positive. The explanation for this result is that when the tax revenue is redistributed back via a lump-sum transfer, then an increase in t from an initial level of $t = 0$ has a zero marginal effect on $U + H$ but a distinctly negative marginal effect on the maximum temptation utility $\widetilde{H}$. The reason is that the amount paid in tax if the consumer succumbs to the temptation ($t\tilde{x}^*$) exceeds the amount that is transferred back ($-T = tx^* < t\tilde{x}^*$). This means that succumbing to temptation is less attractive than before and the welfare $V = U + H - \widetilde{H}$ is higher. We will refer to this as the *GP welfare motive* for taxing the TP good. Note that there is no corrective motive for implementing this tax; instead the distortionary tax reflects an opportunity to improve the consumer´s welfare by reducing the utility cost of exercising self-control. This result is analogous to a result derived by Krusell et al (2010) where they showed that it is optimal to implement a subsidy on saving in a framework where the temptation reflects impatience between consuming today and tomorrow.

3. Second-Best Mixed Taxation with Endogenous Labor Supply

Can labor income taxes complement the commodity tax to improve the welfare when agents have GP preferences for a temptation preference good, and what are the implications for redistribution? To address these questions, we extend the model outlined above into a framework where the consumers make active labor supply decisions. In line with much of the earlier literature on optimal redistributive taxation, we distinguish between two consumer types who differ in terms of their innate earnings-abilities; a low-ability type ($i = 1$) who faces a lower before-tax hourly wage than a high-ability type ($i = 2$).[10] The output of the numeraire good is produced by a linear technology that employs both types of labor and given competitive markets, the before-tax hourly wage rate facing ability-type i (which is denoted w^i) equals the corresponding marginal productivity, where $w^2 > w^1$. In addition, it is assumed that a TP good with an attribute content of x can be obtained by using up x units of the numeraire good. Since the price of the numeraire good is one, it follows that also the producer price per unit of attribute is one and that the producer price of a TP good with an attribute quantity of x is x. We normalize the number of consumers of each ability-type to one and assume that each consumer is atomistic.

3.1 The Consumers

In addition to having preferences for the numeraire good and the TP good, a consumer of ability-type i now also has preferences for leisure, z^i. This means that the commitment and temptation utility functions are modified to read $u(c^i, x^i, z^i)$ and $h(c^i, x^i, z^i)$. These functions are twice continuously differentiable and increasing in each argument. In addition, consumption and leisure are assumed to be separable in the sense that $u_{cz}^i = u_{xz}^i = h_{cz}^i = h_{xz}^i = 0$. We maintain the assumption that the temptation utility is tilted towards buying a TP good which includes more of x in the sense that $u_x(c^i, x^i)/u_c(c^i, x^i) < h_x(c^i, x^i)/h_c(c^i, x^i)$ holds for all c^i and x^i. In this context, the consumer´s GP objective function is modified to read

$$V^i = \max_{c^i, x^i, z^i} \left[u(c^i, x^i, z^i) + h(c^i, x^i, z^i)\right] - \max_{\tilde{c}^i, \tilde{x}^i, \tilde{z}^i} h(\tilde{c}^i, \tilde{x}^i, \tilde{z}^i) \tag{6}$$

where c^i, x^i and z^i are the actual choices while $\tilde{c}^i$, $\tilde{x}^i$ and $\tilde{z}^i$ are the temptation choices. Actual leisure is defined as a time endowment normalized to one less the actual hours of work, l^i. Hence $z^i = 1 - l^i$. Analogously, temptation leisure is defined as $\tilde{z}^i = 1 - \tilde{l}^i$ where $\tilde{l}^i$ is the temptation choice of the hours of work. The budget constraint associated with the actual choices is modified to read $w^i l^i - T(w^i l^i) = c^i + q x^i$, where $T(w^i l^i)$ denotes an income tax payment (positive or negative). The analogous budget constraint under temptation is given by $w^i \tilde{l}^i - T(w^i \tilde{l}^i) = \tilde{c}^i +$

[10] The two-type version of the Mirrleesian optimal income tax model originates from Stern (1982) and Stiglitz (1982), and was later extended to a model of optimal mixed taxation by Edwards, Keen and Tuomala (1994).

$q\tilde{x}^i$. Following earlier comparable literature on optimal taxation, we interpret $T(\cdot)$ to be a general income tax function, which is flexible enough to allow the government to implement any desirable combination of work hours and disposable income for each ability-type subject to the relevant constraints. We continue by characterizing the consumer´s choices.

3.1.1 The Actual Choices

For purposes of analytical convenience, we follow Christiansen (1984) and solve the individual consumer´s optimization problem for the actual choices in two stages. This approach gives commodity demand functions and indirect utility functions defined conditional on the hours of work, which will be used in the optimal tax problem set out below. In the first stage, the actual consumption choices are determined conditional on the actual choice of leisure, while the latter is determined in a second stage. The first stage optimization problem can be stated as follows

$$\max_{c^i,x^i} \left[u\left(c^i,x^i,z^i\right)+h\left(c^i,x^i,z^i\right)\right]-\widetilde{H}^i \qquad \text{subject to} \qquad b^i=c^i+qx^i \tag{7}$$

where $\widetilde{H}^i$ is the maximum temptation utility, which is defined in equation (12) below, while b^i is the actual post-tax income. The solution to this maximization problem produces the conditional demand functions (in the following we omit the super-index "*")[11]

$$c^i=c\left(b^i,q\right) \qquad x^i=x\left(b^i,q\right) \tag{8}$$

By using these demand functions, we can define the following conditional indirect utility functions

$$U^i=U\left(b^i,q,z^i\right)=u\left[c\left(b^i,q\right),x\left(b^i,q\right),z^i\right] \tag{9a}$$

$$H^i=H\left(b^i,q,z^i\right)=h\left[c\left(b^i,q\right),x\left(b^i,q\right),z^i\right] \tag{9b}$$

$$V^i=V\left(b^i,q,z^i,\widetilde{H}^i\right)=U\left(b^i,q,z^i\right)-\left[\widetilde{H}^i-H\left(b^i,q,z^i\right)\right] \tag{9c}$$

In the second stage, the actual hours of work is derived by maximizing $V\left(b^i,q,z^i,\widetilde{H}^i\right)$ w.r.t. to l^i subject to $z^i=1-l^i$ and $b^i=w^il^i-T\left(w^il^i\right)$. If we let $I^i=w^il^i$ denote the labor income of

[11] The separability assumption implies that these demand functions do not depend on leisure.

a consumer of type i, the first-order condition for l^i can be written as $\left(1-T_I^i\right)w^i V_b^i = V_z^i$. This equation implicitly determines the consumer´s optimal choice of the actual hours of work.

3.1.2 The Temptation Choices

We use a similar two-stage procedure as above to characterize the temptation choices. This means that the consumer in the first stage chooses $\tilde{c}^i$ and $\tilde{x}^i$ conditional on $\tilde{z}^i$. This conditional maximization problem is stated as

$$\max_{\tilde{c}^i,\tilde{x}^i} h\left(\tilde{c}^i,\tilde{x}^i,\tilde{z}^i\right) \qquad \text{subject to} \qquad \tilde{b}^i = \tilde{c}^i + q\tilde{x}^i \tag{10}$$

where $\tilde{b}^i$ is the temptation post-tax income. The solution to this problem implicitly defines the conditional temptation demand functions

$$\tilde{c}^i = \tilde{c}\left(\tilde{b}^i,q\right) \qquad \tilde{x}^i = \tilde{x}\left(\tilde{b}^i,q\right) \tag{11}$$

These temptation demand functions can be used to define the conditional indirect maximum temptation utility function

$$\tilde{H}^i = \tilde{H}\left(\tilde{b}^i,q,\tilde{z}^i\right) = h\left[\tilde{c}\left(\tilde{b}^i,q\right),\tilde{x}\left(\tilde{b}^i,q\right),\tilde{z}^i\right] \tag{12}$$

The temptation choice of the hours of work is determined in the second stage where the agent takes into account that the temptation post-tax income is given by $\tilde{b}^i = w^i\tilde{l}^i - T\left(w^i\tilde{l}^i\right)$. We will return to the determination of $\tilde{l}^i$ in Section 3.2.

3.2 The Government´s Maximization Problem

The government aims to achieve a Pareto efficient resource allocation where the utility of the low-ability type is maximized subject to a given level of utility, denoted $\bar{V}^2$, for the high-ability type. The number of consumers of each type is normalized to one, which means that the government´s budget constraint can be written as $\sum_i\left[T\left(w^i l^i\right) + tx^i\right] = 0$. Since $T\left(w^i l^i\right)$ is a general income tax, the government can implement any desired combination of work hours and disposable income for each individual. Therefore, we follow the convention in the literature on optimal taxation and treat b^1, l^1, b^2 and l^2 as direct decision-variables in the social optimization problem. By using that $T\left(w^i l^i\right) = w^i l^i - b^i$ for $i = 1, 2$, we can rewrite the government´s budget constraint to read $\sum_i \left[w^i l^i + t x^i - b^i\right] = 0$.

We also assume (in line with the convention in the optimal tax literature) that the innate earnings ability (as measured by the before-tax wage rate) is private information. This implies that the government observes the before-tax income ($w^i l^i$) of each consumer but the individual consumer´s productivity level (w^i) and hours of work (l^i) is private information. Hence, the government cannot differentiate taxes by ability. Instead, the government must base its redistribution policy on observable income where the tax policy needs to satisfy a self-selection constraint, which ensures that the high-ability type does not prefer to mimic the before-tax income of the low-ability type[12]

$$V^2 = U^2 - \left(\widetilde{H}^2 - H^2\right) \geq \widehat{U}^2 - \left(\widehat{\widetilde{H}}^2 - \widehat{H}^2\right) = \widehat{V}^2 \tag{13}$$

Let us define each term in (13) and we begin with the left hand side (LHS), which defines the utility of the high-ability type when he/she does not mimic the before-tax income of the low-ability type. This utility is given by $V^2 = U^2 - \left(\widetilde{H}^2 - H^2\right)$ where $U^2 = U(b^2, q, z^2)$, $H^2 = H(b^2, q, z^2)$ and $\widetilde{H}^2 = \widetilde{H}\left(\tilde{b}^2, q, \tilde{z}^2\right)$. To determine the maximum temptation utility of the high-ability type, $\widetilde{H}^2$, we need to specify the temptation labor supply choice; $\tilde{l}^2 = 1 - \tilde{z}^2$. To do this, we note that the government can design the nonlinear labor income tax schedule such that it features a crushingly high tax payment for all labor incomes that deviate either from $w^1 l^1$ or from $w^2 l^2$, thereby rendering all other labor income choices non-optimal for the consumers. This means that the high ability-type´s temptation labor supply choice is either equal to his/her actual labor supply choice (l^2) or the temptation labor supply is chosen such that the high-ability type mimics the labor income of the low-ability type ($w^1 l^1 / w^2$). Since the LHS in (13) gives the utility of the high-ability type when he/she does <u>not</u> mimic the labor income of the low-ability-type, the temptation labor supply choice is in this case given by $\tilde{l}^2 = l^2$. This, in turn, implies that $\tilde{b}^2 = b^2$ and $\tilde{z}^2 = z^2$. Using $\tilde{b}^2 = b^2$ in (11) allows us to define the conditional temptation demand functions as $\tilde{c}^2 = \tilde{c}(b^2, q)$ and $\tilde{x}^2 = \tilde{x}(b^2, q)$, respectively. It then follows from equation (12), that the high-ability type´s maximum temptation utility is determined by

[12] The other possible self-selection constraint, which serves to prevent low-ability individuals from mimicking the high-ability type, is assumed not to be binding. This is a common assumption in the optimal tax literature.

$$\widetilde{H}^2 = \widetilde{H}(b^2, q, z^2) = h[\tilde{c}(b^2, q), \tilde{x}(b^2, q), z^2] \tag{14a}$$

By using an analogous argument, the low-ability type´s maximum temptation utility (which appears in the Lagrange function stated below) is determined by

$$\widetilde{H}^1 = \widetilde{H}(b^1, q, z^1) = h[\tilde{c}(b^1, q), \tilde{x}(b^1, q), z^1] \tag{14b}$$

Let us now turn to the right hand side (RHS) of equation (13), which defines the utility of the high-ability type when he/she mimics the before-tax income of the low-ability type. The utility of a potential mimicker is given by $\hat{V}^2 = \widehat{U}^2 - \left(\widehat{\widetilde{H}}^2 - \widehat{H}^2\right)$ where "∧" denotes the mimicker. Let us begin by defining $\widehat{U}^2$ and $\widehat{H}^2$ in this expression. Here we note that if the high-ability type mimics the before-tax income of the low-ability type then the mimicker´s actual labor supply is determined by $\hat{l}^2 = \phi l^1$, where $\phi = w^1/w^2 < 1$. The corresponding level of leisure is given by $\hat{z}^2 = 1 - \hat{l}^2$ where we note that $\hat{z}^2 > z^1$. By substituting b^1 and $\hat{z}^2$ into equations (9a) and (9b), it follows that $\widehat{U}^2 = U(b^1, q, \hat{z}^2)$ and $\widehat{H}^2 = H(b^1, q, \hat{z}^2)$.

To determine the mimicker´s maximum temptation utility, which is denoted $\widehat{\widetilde{H}}^2$, we first need to determine the mimicker´s temptation labor supply, which is denoted $\hat{\tilde{l}}^2$. To do this, we use the fact that the mimicker chooses the hours of work to replicate the labor income of the low-ability type. Hence $\hat{\tilde{l}}^2 = \phi l^1 = \hat{l}^2$.[13] This implies that the mimicker´s temptation post-tax income equals the post-tax income of the low-ability type, $\hat{\tilde{b}}^2 = b^1$, and that the mimicker´s temptation leisure is given by $\hat{\tilde{z}}^2 = \hat{z}^2$. By substituting $\hat{\tilde{b}}^2 = b^1$ into the equations defined in (11), we can define the mimicker´s conditional temptation demand functions as $\hat{\tilde{c}}^2 = \tilde{c}(b^1, q)$ and $\hat{\tilde{x}}^2 = \tilde{x}(b^1, q)$. Substituting these functions into equation (12) allows us to define the mimicker's maximum temptation utility as

$$\widehat{\widetilde{H}}^2 = \widetilde{H}(b^1, q, \hat{z}^2) = h[\tilde{c}(b^1, q), \tilde{x}(b^1, q), \hat{z}^2] \tag{15}$$

The Lagrange function associated with the government´s optimization problem can be written as

[13] Recall that the government can implement a crushingly high tax payment for all labor incomes that deviate from $w^1 l^1$ or $w^2 l^2$. The mimicker´s temptation labor supply is therefore either equal to the high-ability type´s actual choice of the hours (l^2) or equal to the mimicker´s actual choice of the hours of work ($\hat{l}^2 = \phi l^1$). Since the former labor supply choice is not relevant under mimicking, the mimicker´s temptation choice of hours of work is given by $\hat{\tilde{l}}^2 = \hat{l}^2$.

$$L = U^1 + H^1 - \widetilde{H}^1 + (\eta + \lambda)\left(U^2 + H^2 - \widetilde{H}^2\right) - \lambda\left(\widehat{U}^2 + \widehat{H}^2 - \widehat{\widetilde{H}}^2\right) + \gamma \sum_i \left[w^i l^i + t x^i - b^i\right]$$

where η, λ and γ are Lagrange multipliers associated with the minimum utility restriction, the self-selection constraint and the government´s budget constraint, respectively. The first-order conditions are presented in the Appendix where we also derive all results to be presented below.

3.2.1 Commodity Taxation

Let us begin by characterizing the Pareto efficient commodity tax when the consumers have Gul-Pesendorfer preferences. To do this, we introduce the following short notations

$$\theta^i = -\frac{\left(\frac{\partial x^i}{\partial q} + x^i \frac{\partial x^i}{\partial b^i}\right)}{\Omega}, \quad \Omega = -\sum_i \left(\frac{\partial x^i}{\partial q} + x^i \frac{\partial x^i}{\partial b^i}\right), \quad t^1 = \frac{(x^1 - \tilde{x}^1)}{\left(\frac{\partial x^1}{\partial q} + x^1 \frac{\partial x^1}{\partial b^1}\right)} \frac{\widetilde{H}_b^1}{\gamma}, \quad t^2 = \frac{(x^2 - \tilde{x}^2)}{\left(\frac{\partial x^2}{\partial q} + x^2 \frac{\partial x^2}{\partial b^2}\right)} \frac{\eta \widetilde{H}_b^2}{\gamma}$$

where θ^i reflects the relative size of agent type i´s compensated price sensitivity in relation to the compensated price sensitivity summed over both agent types. The definitions above imply that $\theta^1 + \theta^2 = 1$, and if we maintain the assumption from Section 2 that the compensated price effects are negative, it follows that $\theta^1, \theta^2, \Omega > 0$. The term t^i is the tax rule for the optimal linear commodity tax that the government would implement for agent type i if type-specific linear commodity taxes were be available. This tax rule is equivalent to the tax formula defined in Proposition 1,[14] and reflects the *GP welfare motive* for taxing the TP good which was discussed in Subsection 2.2. Given these definitions, we can derive the following general formula for the second-best commodity tax in the mixed tax framework (see the Appendix);

Proposition 2: *The Pareto efficient second-best linear commodity tax on the TP good is given by*

$$t = \sum_i \theta^i t^i + \frac{\lambda \widehat{V}_b^2}{\gamma \Omega}(\hat{x}^2 - x^1) + \lambda \Psi \tag{16}$$

where

$$\Psi = \underbrace{\frac{\widetilde{H}_b^2}{\gamma \Omega}(\tilde{x}^2 - x^2)}_{\text{SC1} > 0} \underbrace{- \frac{\widehat{\widetilde{H}}_b^2}{\gamma \Omega}\left(\hat{\tilde{x}}^2 - \hat{x}^2\right)}_{\text{SC2} < 0} \tag{17}$$

[14] The inclusion of the term η in the equation for t^2 reflects the welfare weight that the government attaches to agent type 2. Underlying the tax formula presented in Proposition 1 was the assumption that all agents have the same welfare weight and that this weight was normalized to one.

The first term on the right hand side (RHS) in equation (16) is positive and reflects the *GP welfare motive* for taxing the TP good. This term is a weighted average of the type-specific GP commodity tax rules for the two agent types, and the agent type who has the highest price sensitivity w.r.t. x is attached the highest weight in the calculation of this weighted average. Turning to the second and third terms on the RHS of equation (16), we note that they are proportional to the shadow price associated with the self-selection constraint; λ. This means that the motives underlying these two terms are related to how the commodity tax affects the self-selection constraint. We will refer to the second term on the RHS as the *standard self-selection motive* for implementing a non-zero commodity tax while the third term, $\lambda\Psi$, will be referred to as the *GP self-selection motive* for taxing the TP good.

Note first that if the consumers would not have GP preferences, which is the case in the conventional optimal tax model, then equation (16) reduces to

$$t = \frac{\lambda \hat{U}_b^2}{\gamma\Omega}(\hat{x}^2 - x^1) \qquad (16´)$$

Equation (16´) shows that the government has an incentive to use the commodity tax to relax the self-selection constraint if $\hat{x}^2 \neq x^1$. However, if consumption and leisure are uncorrelated then $\hat{x}^2 = x^1$, in which case the *standard self-selection motive* (i.e. the standard redistributional motive) for taxing a commodity vanishes. This result is well known in the optimal tax literature (see e.g. Edwards et al [1994], and Pirttilä and Tuomala [2001]). Since we assume that $u_{cz}^i = u_{xz}^i = h_{cz}^i = h_{xz}^i = 0$, it follows that $\hat{x}^2 = x^1$ holds in our framework. This implies that the second term on the RHS in equation (16) (which reflects the *standard self-selection motive*) is zero.

Let us now turn to the term $\lambda\Psi$ in equation (16). This term is novel and captures a self-selection motive (i.e. a redistributional motive) for implementing a non-zero commodity tax, which is directly related to the presence of GP preferences. This *GP self-selection motive* reflects that the commodity tax affects the utility cost of exercising self-control both for the high-ability type and for the potential mimicker. This provides the government with two additional channels, compared with the conventional optimal tax model, via which the commodity tax can be used to relax a binding self-selection constraint. These channels are reflected in the definition of Ψ. The first term on the RHS of equation (17) reflects a channel that works via the utility cost of exercising self-control for the high-ability type whereas the second term reflects a channel that works via the mimicker´s utility cost of exercising self-control. We will refer to these as self-control cost 1 (SC1) and self-control cost 2 (SC2), respectively.

To interpret SC1, recall that the high-ability type´s temptation demand for x exceeds his/her actual demand, i.e. $\tilde{x}^2 > x^2$. This implies that a higher tax on the TP good will have a larger negative impact on $\widetilde{H}^2$ than on H^2 which, in turn, reduces the high-ability type´s utility cost of exercising self-control; $\widetilde{H}^2 - H^2$. The reduction in $\widetilde{H}^2 - H^2$, in turn, has a positive impact on $V^2 = U^2 - \left(\widetilde{H}^2 - H^2\right)$ which contributes to relaxing the self-selection constraint if it is initially binding. As such, this mechanism provides the government with an incentive to implement a higher commodity tax than otherwise and explains why SC1 is positive.

As for SC2, it is related to the potential mimicker´s utility cost of exercising self-control. To interpret this term, we can use a similar argument as above. Also here we begin by noting that the mimicker´s temptation demand for x exceeds his/her actual demand, i.e. $\hat{\tilde{x}}^2 > \hat{x}^2$. Therefore, a higher tax on the TP good will have a larger negative impact on $\widehat{\widetilde{H}}^2$ than on $\widehat{H}^2$. This pushes down the mimicker´s utility cost of exercising self-control, (i.e. $\widehat{\widetilde{H}}^2 - \widehat{H}^2$ is reduced) which has a positive impact on the mimicker´s utility, $\hat{V}^2 = \hat{U}^2 - \left(\widehat{\widetilde{H}}^2 - \widehat{H}^2\right)$. Since an increase in $\hat{V}^2$ tightens the self-selection constraint, this mechanism provides the government with an incentive to set the commodity tax lower than otherwise and explains why SC2 is negative.

Since SC1 and SC2 go in opposite directions, the net sign of Ψ in the commodity tax formula is indeterminable without making functional form assumptions. Let us therefore consider the following iso-elastic functional forms for the consumption parts of the commitment and temptation utility functions

$$u(c,x,z) = \begin{Bmatrix} \frac{c^{1-\sigma}}{1-\sigma} + \beta\frac{x^{1-\sigma}}{1-\sigma} + f(z) & \sigma > 0, \sigma \neq 1 \\ ln(c) + \beta ln(x) + f(z) & \sigma = 1 \end{Bmatrix} \tag{18a}$$

$$h(c,x,z) = \begin{Bmatrix} \frac{c^{1-\sigma}}{1-\sigma} + \beta\frac{x^{1-\sigma}}{1-\sigma} + f(z) & \sigma > 0, \sigma \neq 1 \\ ln(c) + \tilde{\beta} ln(x) + f(z) & \sigma = 1 \end{Bmatrix} \tag{18b}$$

where $0 < \beta < \tilde{\beta}$ and where we do not specify a functional form for the leisure part of the utility function, $f(z)$. In this case, we can derive the following result (see the Appendix);

Corollary 1: *With the iso-elastic functional form specifications in (18), the* <u>*GP self-selection motive*</u> *provides the government with*

- *(i)* *an incentive to implement a higher commodity tax if* $\sigma < 1$ *(i.e.* $\Psi > 0$*),*
- *(ii)* *an incentive to implement a lower commodity tax if* $\sigma > 1$ *(i.e.* $\Psi < 0$*),*
- *(iii)* *no incentive to influence the commodity tax if* $\sigma = 1$ *(i.e.* $\Psi = 0$*).*

Recall that when consumption and leisure are uncorrelated, then a key result in the conventional optimal tax literature is that the commodity tax cannot be used to relax the self-selection constraint. Corollary 1, illustrates that this result need not hold when agents have GP preferences because there are circumstances when the commodity tax affects the high-ability agent´s utility cost of exercising self-control by a different magnitude compared with how the tax affects the potential mimicker´s utility cost of exercising self-control.

3.2.2 Labor Income Taxation

Let us now look at how GP preferences affect marginal income taxation. To do this, let us first define the following measures of the marginal rate of substitution between leisure and disposable income

$$MRS^i_{z,b} = \frac{U^i_z + H^i_z}{U^i_b + H^i_b}, \qquad \widetilde{MRS}^i_{z,b} = \frac{\tilde{H}^i_z}{\tilde{H}^i_b}, \qquad \widehat{MRS}^2_{z,b} = \frac{\hat{U}^2_z + \hat{H}^2_z}{\hat{U}^2_b + \hat{H}^2_b}, \qquad \widehat{\widetilde{MRS}}^2_{z,b} = \frac{\hat{\tilde{H}}^2_z}{\hat{\tilde{H}}^2_b} \tag{19}$$

We can now derive the following results (see the Appendix);

Proposition 3: *When the agents have temptation preferences for the non-numeraire good, the Pareto efficient marginal labor income tax rates for the two ability types will be given by*

$$\begin{aligned} T^1_I &= \frac{\tilde{H}^1_b}{\gamma w^1}\left(MRS^1_{z,b} - \widetilde{MRS}^1_{z,b}\right) - \frac{\lambda\phi\hat{\tilde{H}}^2_b}{\gamma w^1}\left(\widehat{MRS}^2_{z,b} - \widehat{\widetilde{MRS}}^2_{z,b}\right) \\ &\quad + \frac{\lambda\hat{V}^2_b}{\gamma w^1}\left(MRS^1_{z,b} - \phi\widehat{MRS}^2_{z,b}\right) - t\,\frac{MRS^1_{z,b}}{w^1}\frac{\partial x^1}{\partial b^1} \end{aligned} \tag{20a}$$

$$T^2_I = \frac{\eta\tilde{H}^2_b}{\gamma w^2}\left(MRS^2_{z,b} - \widetilde{MRS}^2_{z,b}\right) + \frac{\lambda\tilde{H}^2_b}{\gamma w^2}\left(MRS^2_{z,b} - \widetilde{MRS}^2_{z,b}\right) - t\,\frac{MRS^2_{z,b}}{w^2}\frac{\partial x^2}{\partial b^2} \tag{20b}$$

To interpret these marginal labor income tax formulas let us, as a benchmark, first consider what they look like in a conventional model where agents do not have GP preferences. In this case, the temptation utility is redundant and equations (20a) and (20b) reduce to

$$T_I^1 = \frac{\lambda \hat{U}_b^2}{\gamma w^1}\left(MRS_{z,b}^1 - \phi \widehat{MRS}_{z,b}^2\right) - t\,\frac{MRS_{z,b}^1}{w^1}\frac{\partial x^1}{\partial b^1}, \qquad T_I^2 = -t\,\frac{MRS_{z,b}^2}{w^2}\frac{\partial x^2}{\partial b^2} \qquad (20´)$$

where $MRS_{z,b}^1 = U_z^1/U_b^1$ and $\widehat{MRS}_{z,b}^2 = \hat{U}_z^2/\hat{U}_b^2$. In the absence of a commodity tax ($t = 0$), the marginal income tax formulas in (20´) coincide with those derived by Stiglitz (1982), who showed that the government implements a positive marginal labor income tax for the low-ability type and a zero marginal income tax for the high-ability type. The term that is proportional to the commodity tax in each of the marginal income tax formulas reflects that the government may use marginal income taxation to compensate the consumers for the distortionary effect caused by the commodity tax.[15] These motives are well known in the conventional optimal tax literature[16] and will not be discussed here.

Two novel terms appear in each of the tax formulas presented in equations (20a) and (20b), and let us begin with the first term on the RHS in each tax formula. This term reflects that labor income taxation can complement commodity taxation as a policy tool to improve welfare when consumers have GP preferences. As such, this reflects a *GP welfare motive* for influencing a consumer´s labor supply decision. To interpret this term, assume to begin with that consumer type i´s actual marginal valuation of leisure is larger than his/her temptation marginal valuation of leisure, i.e. $MRS_{z,b}^i > \widetilde{MRS}_{z,b}^i$. An increase in leisure will in this situation have a larger positive impact on $U^i + H^i$ than on $\widetilde{H}^i$. This is welfare improving for the consumer since $V^i = U^i + H^i - \widetilde{H}^i$ increases. This provides the government with an incentive to increase the consumer´s leisure by implementing a higher marginal tax on labor than otherwise. The incentive to implement a lower marginal tax on labor when $MRS_{z,b}^i < \widetilde{MRS}_{z,b}^i$ is analogous. This *GP welfare motive* for influencing the labor supply decision verifies the conclusion made by Tran (2018) that labor taxation can be used to further improve the welfare when consumers have GP preferences.[17] Our contribution is that we

[15] Recall that consumption and leisure are assumed to be uncorrelated, which implies $\partial x^i/\partial z^i = 0$. If consumption and leisure instead would be correlated, then $\partial x^i/\partial z^i \neq 0$, in which case the last terms in the tax formulas would be given by $\frac{t}{w^i}\left(\frac{\partial x^i}{\partial z^i} - MRS_{z,b}^i \frac{\partial x^i}{\partial b^i}\right)$.
[16] See e.g. Aronsson and Sjögren (2018).
[17] Tran (2018) refers to this as the corrective role of income taxation.

explicitly show how the *GP welfare motive* affects marginal labor income taxation and relates the sign of this term to the difference between the actual marginal valuation of leisure (as measured by $MRS_{z,b}^{i}$) and the temptation marginal valuation of leisure (as measured by $\widetilde{MRS}_{z,b}^{i}$).

The second term on the RHS in each tax formula reflects a *GP self-selection motive* (i.e. a redistribution motive) for influencing the consumer´s choice of labor supply. The interpretation of this term differs in the two formulas. We begin to interpret the term that appears in the marginal income tax formula for the low-skilled consumer. Here this term reflects that the marginal labor income tax for the low-skilled agent can be used to relax the self-selection constraint via the mimicker´s temptation utility. To illustrate this mechanism, consider first a situation where the mimicker´s actual marginal valuation of leisure is larger than the mimicker´s temptation marginal valuation of leisure; $\widehat{MRS}_{z,b}^{2} > \widehat{\widetilde{MRS}}_{z,b}^{2}$. An increase in leisure will in this situation, ceteris paribus, have a larger positive impact on $\hat{U}^2 + \hat{H}^2$ than on $\hat{\tilde{H}}^2$. This causes $\hat{V}^2 = \hat{U}^2 + \hat{H}^2 - \hat{\tilde{H}}^2$ to increase, which tightens the self-selection constraint if it is initially binding. To avoid this, the government has an incentive to stimulate the labor supply of the potential mimicker by implementing a lower marginal income tax rate for the low-skilled agent. The incentive to reduce the labor supply for the potential mimicker by implementing a higher marginal tax on labor when $\widehat{MRS}_{z,b}^{2} < \widehat{\widetilde{MRS}}_{z,b}^{2}$ is analogous.

Let us now turn to the corresponding term in the marginal labor income tax formula for the high-skilled agent. As mentioned above, this term reflects that the marginal income tax for the high-skilled agent can be used to relax the self-selection constraint. To see this, let us consider a situation where the high-skilled agent´s actual marginal valuation of leisure is larger than his/her temptation marginal valuation of leisure; $MRS_{z,b}^{2} > \widetilde{MRS}_{z,b}^{2}$. An increase in leisure will then, ceteris paribus, have a larger positive impact on $U^2 + H^2$ than on $\tilde{H}^2$. This causes $V^2 = U^2 + H^2 - \tilde{H}^2$ to increase, which relaxes the self-selection constraint if it is initially binding. This provides the government with an incentive to reduce the labor supply of the high-skilled agent by implementing a higher marginal income tax rate than otherwise. If instead $MRS_{z,b}^{2} < \widetilde{MRS}_{z,b}^{2}$, then the argument for a lower marginal income tax rate is analogous.

Whether the *GP welfare motive* provides an incentive for higher or lower marginal taxation of labor for ability type *i* depends on the sign of the term $MRS_{z,b}^{i} - \widetilde{MRS}_{z,b}^{i}$. Analogously, whether the *self-selection motive* provides an incentive for higher or lower marginal taxation of labor for the low-ability type depends on the sign of $\widehat{MRS}^2_{z,b} - \widehat{\widehat{MRS}}^2_{z,b}$, while the corresponding effect for the high-ability type is determined by the sign of the term $MRS^2_{z,b} - \widetilde{MRS}^2_{z,b}$. Let us therefore proceed and use the functional form specifications in (18) to provide an example of when these terms can be signed. In the Appendix, we show the following result;

Corollary 2: *When $\sigma = 1$ in the functional form specifications in (18) (logarithmic utility), then $MRS^i_{z,b} > \widetilde{MRS}^i_{z,b}$ and $\widehat{MRS}^2_{z,b} > \widehat{\widehat{MRS}}^2_{z,b}$. In this case both the <u>GP welfare motive</u> and the <u>GP self-selection motive</u> provide incentives to implement a <u>positive</u> marginal labor income tax for agent type i.*

An implication of Corollary 2 is that the classic result highlighted in the conventional optimal tax literature, namely that the top-income earner should face a zero marginal tax on his/her income, need not hold when the consumers have GP preferences. Instead, Corollary 2 shows that the GP framework may provide the government with an incentive to tax also the top-income earner.

4. Summary and Conclusions

As far as we know, this article is the first to consider optimal redistributive taxation in a second-best economy with asymmetric information, where people have temptation and self-control problems. The consumers have preferences for a numeraire good and for how much of an attribute to include in a non-numeraire good for which the consumers experience temptation. We began by analyzing a benchmark model where the consumers are homogenous and do not make active labor supply decisions. The government can impose a linear commodity tax on the good for which the consumers experience temptation and use a lump-sum transfer to redistribute tax revenue back to the consumers. It was shown that the solution to the optimal tax problem in this benchmark model features a positive commodity tax on the temptation good. The intuition is that this tax reduces the cost of exercising self-control, which is welfare improving.

In the general model, there are two consumer types who differ in terms of their innate earnings-abilities and who make active labor supply decisions. The government cannot observe individual productivities, which means that the optimal tax policy must satisfy incentive compatibility constraints. The solution to the mixed tax problem, where a linear commodity tax on the temptation preference good is determined simultaneously with a nonlinear labor income tax schedule, features a commodity tax which is made up of three main components. Two of these are novel compared with the conventional optimal tax model and appear as a direct consequence of the fact that the consumers have temptation preferences. The first novel component reflects the basic motive highlighted in the benchmark model; a positive tax on the temptation good improves the consumers´ welfare since this reduces the utility cost of exercising self-control. The second novel component in the commodity tax formula reflects that since the commodity tax can influence the utility cost of exercising self-control this, in turn, provides a novel channel via which the government can affect the self-selection constraint. In this context, it was shown that one of the key results highlighted in the conventional optimal tax literature, namely that there is no self-selection motive for implementing a non-zero commodity tax when there is no correlation between consumption and leisure, need not hold when agents have GP preferences. Instead, it was shown that if the utility function is iso-elastic in consumption (while maintaining the assumption that there is no correlation between consumption and leisure), then the incentive to implement a positive or negative commodity tax depends on the shape of the utility function.

Turning to the taxation of labor income, it was shown that the presence of GP preferences among the consumers provides the government with two novel motives for using the marginal income tax to influence the consumers´ labor supply decisions. One reflects a welfare motive where the labor income tax can be used to improve the utility for a consumer by reducing his/her cost of exercising self-control. If the consumer´s marginal valuation of leisure associated with the actual choices is higher (lower) than the marginal valuation of leisure associated with the potential temptation choices, then the consumer´s welfare can, ceteris paribus, be improved by implementing a positive (negative) marginal tax on labor income. The second motive for influencing the consumers´ labor supply decisions is that GP preferences provide a novel channel via which the government can relax the self-selection constraint for a high-ability type if that constraint is initially binding. In this context, it was shown that the additional component in the formula for the marginal labor income tax facing the low-ability type is related to whether the mimicker´s marginal valuation of leisure associated with the actual choices is higher (lower) than the mimicker´s marginal valuation of leisure associated with the potential temptation choices. The additional component in the formula for the marginal labor income tax facing the high-ability type is, instead, related to whether the high-ability type´s marginal valuation of leisure associated with the actual choices is higher (lower) than the marginal valuation of leisure associated with the potential temptation choices. Here it was shown that if the consumers have additive and logarithmic preferences for consumption, and if leisure is additive in the utility function, then the GP framework provides the government with an incentive to implement higher marginal tax rates than otherwise.

Although this article generalizes the literature on optimal taxation by incorporating Gul-Pesendorfer preferences into the analysis, there are still many important aspects left to explore. Examples include the role of optimal nonlinear labor income taxation when agents are tempted to under-save, and combining Gul-Pesendorfer preferences with positional preferences in an optimal tax framework.

Appendix

The Benchmark Model

Substituting the private budget constraint $m - T = c + qx$ into the objective function defined in equation (1) produces

$$W = \max_{x} \; [u(m - T - qx, x) + h(m - T - qx, x)] - \max_{\tilde{x}} \; h(m - T - q\tilde{x}, \tilde{x}) \tag{A1}$$

Equation (2) in the text gives the private first-order condition associated with the actual choice of x while the first-order condition associated with the temptation choice is given by $\tilde{h}_x - q\tilde{h}_c = 0$. The Lagrange function associated with the government´s maximization problem becomes

$$L = \underbrace{u[m - T - qx(m - T, q), x(m - T, q)]}_{U(m-T,q)} + \underbrace{h[m - T - qx(m - T, q), x(m - T, q)]}_{H(m-T,q)}$$

$$- \underbrace{h[m - T - q\tilde{x}(m - T, q), \tilde{x}(m - T, q)]}_{\widetilde{H}(m-T,q)} + \gamma[tx(m - T, q) + T] \tag{A2}$$

where the government recognizes that $b = m - T$ and $q = 1 + t$. The first-order conditions w.r.t. T and t become (where we use equation [2] and $\tilde{h}_x - q\tilde{h}_c = 0$ to simplify)

$$\frac{\partial L}{\partial T} = \gamma\left(1 + t\frac{\partial x^*}{\partial T}\right) - \left(U_b + H_b - \widetilde{H}_b\right) = 0 \tag{A3}$$

$$\frac{\partial L}{\partial t} = \gamma\left(x + t\frac{\partial x^*}{\partial q}\right) - (U_b + H_b)x^* + \widetilde{H}_b\,\tilde{x}^* = 0 \tag{A4}$$

Multiplying (A3) by x^* and subtracting the resulting expression from (A4), using that $\partial x^*/\partial b = -\partial x^*/\partial T$ and solving for t in the resulting expression produces the tax formula in Proposition 1.

The First-Order Conditions Associated with the Second-Best Tax Problem

Differentiating the Lagrange function defined in Section 3.2 w.r.t. b^1, l^1, b^2, l^2 and t, while using that $\partial x^i/\partial z^i = 0$, produces

$$\frac{\partial L}{\partial b^1} = \left(U_b^1 + H_b^1 - \widetilde{H}_b^1\right) - \lambda\left(\widehat{U}_b^2 + \widehat{H}_b^2 - \widehat{\widetilde{H}}_b^2\right) + \gamma\left(t\frac{\partial x^1}{\partial b^1} - 1\right) = 0 \tag{B1}$$

$$\frac{\partial L}{\partial l^1} = -\left(U_z^1 + H_z^1 - \widetilde{H}_z^1\right) + \lambda\phi\left(\widehat{U}_z^2 + \widehat{H}_z^2 - \widehat{\widetilde{H}}_z^2\right) + \gamma w^1 = 0 \tag{B2}$$

$$\frac{\partial L}{\partial b^2} = (\eta + \lambda)\left(U_b^2 + H_b^2 - \widetilde{H}_b^2\right) + \gamma\left(t\frac{\partial x^2}{\partial b^2} - 1\right) = 0 \tag{B3}$$

$$\frac{\partial L}{\partial l^2} = -(\eta + \lambda)\left(U_z^2 + H_z^2 - \widetilde{H}_z^2\right) + \gamma w^2 = 0 \tag{B4}$$

$$\frac{\partial L}{\partial t} = -\left[x^1(U_b^1 + H_b^1) - \tilde{x}^1\widetilde{H}_b^1\right] + \lambda\left[\hat{x}^2\left(\widehat{U}_b^2 + \widehat{H}_b^2\right) - \hat{\tilde{x}}^2\widehat{\widetilde{H}}_b^2\right]$$
$$-(\eta + \lambda)\left[x^2(U_b^2 + H_b^2) - \tilde{x}^2\widetilde{H}_b^2\right] + \gamma\left[x^1 + x^2 + t\left(\frac{\partial x^1}{\partial q} + \frac{\partial x^2}{\partial q}\right)\right] = 0 \tag{B5}$$

where we have used Roy´s identity so simplify equation (B5).

The Optimal Commodity Tax
Multiplying (B1) by x^1 and (B3) by x^2, and adding the resulting expressions to (B5), produces

$$\gamma t\Omega = \lambda\left(\widehat{U}_b^2 + \widehat{H}_b^2\right)(\hat{x}^2 - x^1) + \widetilde{H}_b^1(\tilde{x}^1 - x^1) + (\eta + \lambda)\widetilde{H}_b^2(\tilde{x}^2 - x^2) - \lambda\widehat{\widetilde{H}}_b^2\left(\hat{\tilde{x}}^2 - x^1\right) \tag{C1}$$

Add and subtract $\lambda\hat{x}^2\widehat{\widetilde{H}}_b^2$ to (C1) and then solve for t. This produces

$$t = \frac{\lambda\left(\widehat{U}_b^2 + \widehat{H}_b^2 - \widehat{\widetilde{H}}_b^2\right)}{\gamma\Omega}(\hat{x}^2 - x^1) + \frac{\widetilde{H}_b^1}{\gamma\Omega}(\tilde{x}^1 - x^1) + \frac{\eta\widetilde{H}_b^2}{\gamma\Omega}(\tilde{x}^2 - x^2)$$
$$+ \frac{\lambda\widetilde{H}_b^2}{\gamma\Omega}(\tilde{x}^2 - x^2) - \frac{\lambda\widehat{\widetilde{H}}_b^2}{\gamma\Omega}\left(\hat{\tilde{x}}^2 - \hat{x}^2\right) \tag{C2}$$

Multiply and divide the second term on the RHS by $\left(\frac{\partial x^1}{\partial q} + x^1\frac{\partial x^1}{\partial b^1}\right)$. Similarly, multiply and divide the third term on the RHS by $\left(\frac{\partial x^2}{\partial q} + x^2\frac{\partial x^2}{\partial b^2}\right)$. By using the definitions of θ^1, θ^2, t^1 and t^2, we obtain the commodity tax formula presented in Proposition 2.

The Marginal Labor Income Tax Rates
To derive the marginal income tax for the **low-ability type**, we write (B1) and (B2) as follows

$$U_b^1 + H_b^1 = \widetilde{H}_b^1 + \lambda\left(\widehat{U}_b^2 + \widehat{H}_b^2\right) - \lambda\widehat{\widetilde{H}}_b^2 + \gamma\left(1 - t\frac{\partial x^1}{\partial b^1}\right) \tag{D1}$$

$$U_z^1 + H_z^1 = \widetilde{H}_z^1 + \lambda\phi\left(\widehat{U}_z^2 + \widehat{H}_z^2\right) - \lambda\phi\widehat{\widetilde{H}}_z^2 + \gamma w^1 \tag{D2}$$

Divide (D2) by (D1) and use the definition of $MRS_{z,b}^1$ in (19)

$$MRS_{z,b}^1 = \frac{\widetilde{H}_z^1 + \lambda\phi\left(\widehat{U}_z^2 + \widehat{H}_z^2\right) - \lambda\phi\widehat{\widetilde{H}}_z^2 + \gamma w^1}{\widetilde{H}_b^1 + \lambda\left(\widehat{U}_b^2 + \widehat{H}_b^2\right) - \lambda\widehat{\widetilde{H}}_b^2 + \gamma\left(1 - t\frac{\partial x^1}{\partial b^1}\right)} \tag{D3}$$

Multiply up the denominator in (D3) and rearrange

$$0 = \lambda\left(\widehat{U}_b^2 + \widehat{H}_b^2\right)\left(MRS_{z,b}^1 - \phi\frac{\widehat{U}_z^2 + \widehat{H}_z^2}{\widehat{U}_b^2 + \widehat{H}_b^2}\right) - \gamma\left(w^1 - MRS_{z,b}^1\right) - \gamma t MRS_{z,b}^1\frac{\partial x^1}{\partial b^1}$$

$$+\left(MRS_{z,b}^{1}\tilde{H}_{b}^{1}-\tilde{H}_{z}^{1}\right)+\lambda\left(\phi\hat{\tilde{H}}_{z}^{2}-\hat{\tilde{H}}_{b}^{2}MRS_{z,b}^{1}\right) \tag{D4}$$

Add and subtract $\lambda\phi\widehat{MRS}_{z,b}^{2}\hat{\tilde{H}}_{b}^{2}$. Then use $MRS_{z,b}^{1}=(1-T_{I}^{1})w^{1}$ and the definitions in (19). Solving for T_{I}^{1} in the resulting expression produces equation (20a) in the text. The marginal income tax for the **high-ability type** is derived analogously.

Functional Form Specifications

When the agent has the iso-elastic commitment and temptation utility functions defined in (18a) and (18b), the agent´s GP utility function can be written as

$$V=2\frac{c^{1-\sigma}}{1-\sigma}+\left(\beta+\tilde{\beta}\right)\frac{x^{1-\sigma}}{1-\sigma}+2f(z)-\frac{\tilde{c}^{1-\sigma}}{1-\sigma}-\tilde{\beta}\frac{\tilde{x}^{1-\sigma}}{1-\sigma}-f(\tilde{z}) \tag{E1}$$

Let us now use the two-stage procedure outlined in the text to determine the **actual consumption choices**. The first stage optimization problem can be stated as

$$\max_{x}\ u(b-qx,x,z)+h(b-qx,x,z)=2\frac{(b-qx)^{1-\sigma}}{1-\sigma}+2B\frac{x^{1-\sigma}}{1-\sigma}+2f(z) \tag{E2}$$

where $B=\left(\beta+\tilde{\beta}\right)/2$. Solving this problem produces the following conditional demand function

$$c(b,q)=\frac{\alpha(q)}{\alpha(q)+q}b, \qquad x(b,q)=\frac{1}{\alpha(q)+q}b \tag{E3}$$

where $\alpha(q)=(B/q)^{-\frac{1}{\sigma}}$. Substituting these expressions back into the commitment and the temptation utility functions and differentiating the resulting expressions w.r.t. b produces

$$U_{b}=\left[\left(\frac{\alpha(q)}{\alpha(q)+q}\right)^{1-\sigma}+\beta\left(\frac{1}{\alpha(q)+q}\right)^{1-\sigma}\right]b^{-\sigma}, \quad H_{b}=\left[\left(\frac{\alpha(q)}{\alpha(q)+q}\right)^{1-\sigma}+\tilde{\beta}\left(\frac{1}{\alpha(q)+q}\right)^{1-\sigma}\right]b^{-\sigma} \tag{E4}$$

Let us continue with the **temptation allocation**. Using the two-stage procedure outlined in the text, the first stage optimization problem is stated as

$$\max_{\tilde{x}}\ h\left(\tilde{b}-q\tilde{x},\tilde{x},\tilde{z}\right)=\frac{\left(\tilde{b}-q\tilde{x}\right)^{1-\sigma}}{1-\sigma}+\tilde{\beta}\frac{\tilde{x}^{1-\sigma}}{1-\sigma}+f(\tilde{z}) \tag{E5}$$

The conditional temptation demand functions become

$$\tilde{c}\left(\tilde{b},q\right)=\frac{\tilde{\alpha}(q)}{\tilde{\alpha}(q)+q}\tilde{b}, \qquad \tilde{x}\left(\tilde{b},q\right)=\frac{1}{\tilde{\alpha}(q)+q}\tilde{b} \tag{E6}$$

where $\tilde{\alpha}(q)=\left(\tilde{\beta}/q\right)^{-\frac{1}{\sigma}}$. Substituting these expressions back into the temptation utility function and differentiating w.r.t. b produces

$$\tilde{H}_{b}=\left[\left(\frac{\tilde{\alpha}(q)}{\tilde{\alpha}(q)+q}\right)^{1-\sigma}+\tilde{\beta}\left(\frac{1}{\tilde{\alpha}(q)+q}\right)^{1-\sigma}\right]\tilde{b}^{-\sigma} \tag{E7}$$

Next, we want to evaluate the **sign of Ψ**, which captures the GP self-selection motive in the commodity tax formula. Substituting

$$\widetilde{H}_b^2 = \frac{\partial H(\tilde{b}^2,q,\tilde{z}^2)}{\partial \tilde{b}^2} = \frac{\partial H(b^2,q,z^2)}{\partial b^2} = \left[\left(\frac{\tilde{\alpha}(q)}{\tilde{\alpha}(q)+q}\right)^{1-\sigma} + \tilde{\beta}\left(\frac{1}{\tilde{\alpha}(q)+q}\right)^{1-\sigma}\right](b^2)^{-\sigma},$$

$$\widehat{\widetilde{H}}_b^2 = \frac{\partial H(\hat{\tilde{b}}^2,q,\hat{\tilde{z}}^2)}{\partial \hat{\tilde{b}}^2} = \frac{\partial H(b^1,q,\hat{z}^2)}{\partial b^1} = \left[\left(\frac{\tilde{\alpha}(q)}{\tilde{\alpha}(q)+q}\right)^{1-\sigma} + \tilde{\beta}\left(\frac{1}{\tilde{\alpha}(q)+q}\right)^{1-\sigma}\right](b^1)^{-\sigma}$$

$$x^2 = x(b^2,q) = \frac{1}{\alpha(q)+q}b^2, \qquad \tilde{x}^2 = \tilde{x}(\tilde{b}^2,q) = \tilde{x}(b^2,q) = \frac{1}{\tilde{\alpha}(q)+q}b^2$$

$$\hat{x}^2 = x(b^1,q) = \frac{1}{\alpha(q)+q}b^1, \qquad \hat{\tilde{x}}^2 = \tilde{x}\left(\hat{\tilde{b}}^2,q\right) = \tilde{x}(b^1,q) = \frac{1}{\tilde{\alpha}(q)+q}b^1 \tag{E8}$$

into equation (17) and simplifying produces

$$\Psi = \frac{1}{\gamma\Omega}\left[\left(\frac{\tilde{\alpha}(q)}{\tilde{\alpha}(q)+q}\right)^{1-\sigma} + \tilde{\beta}\left(\frac{1}{\tilde{\alpha}(q)+q}\right)^{1-\sigma}\right]\left[\frac{1}{\tilde{\alpha}(q)+q} - \frac{1}{\alpha(q)+q}\right]\left[(b^2)^{1-\sigma} - (b^1)^{1-\sigma}\right] \tag{E9}$$

Since $B < \tilde{\beta}$, it follows that $\tilde{\alpha}(q) = \left(\tilde{\beta}/q\right)^{-\frac{1}{\sigma}} < \alpha(q) = (B/q)^{-\frac{1}{\sigma}}$. Hence, the expression inside the second pair of square brackets is positive. Since $\Omega > 0$, it follows that the sign of Ψ depends on the sign of $(b^2)^{1-\sigma} - (b^1)^{1-\sigma}$. Since $b^2 > b^1$, it follows that $\Psi > 0$ if $\sigma < 1$ and $\Psi < 0$ if $\sigma > 1$. When the agent instead has logarithmic preferences, the functions in (E8) are modified to read

$$\widetilde{H}_b^2 = \frac{\partial H(\tilde{b}^2,q,\tilde{z}^2)}{\partial \tilde{b}^2} = \frac{\partial H(b^2,q,z^2)}{\partial b^2} = \frac{1+\tilde{\beta}}{b^2}, \qquad \widehat{\widetilde{H}}_b^2 = \frac{\partial H(\hat{\tilde{b}}^2,q,\hat{\tilde{z}}^2)}{\partial \hat{\tilde{b}}^2} = \frac{\partial H(b^1,q,\hat{z}^2)}{\partial b^1} = \frac{1+\tilde{\beta}}{b^1}$$

$$x^2 = x(b^2,q) = \frac{B}{1+B}\frac{b^2}{q}, \qquad \tilde{x}^2 = \tilde{x}(\tilde{b}^2,q) = \tilde{x}(b^2,q) = \frac{\tilde{\beta}}{1+\tilde{\beta}}\frac{b^2}{q}$$

$$\hat{x}^2 = x(b^1,q) = \frac{B}{1+B}\frac{b^1}{q}, \qquad \hat{\tilde{x}}^2 = \tilde{x}\left(\hat{\tilde{b}}^2,q\right) = \tilde{x}(b^1,q) = \frac{\tilde{\beta}}{1+\tilde{\beta}}\frac{b^1}{q} \tag{E10}$$

Substituting these expressions into (17) and simplifying produces $\Psi = 0$. Hence $\Psi = 0$ if $\sigma = 1$. These results verify the claims in Corollary 1.

To verify the claims in Corollary 2, we consider the case when the commitment and temptation utility functions are given by

$$u(c,x,z) = ln(c) + \beta ln(x) + f(z) \tag{E11}$$

$$h(c,x,z) = ln(c) + \tilde{\beta} ln(x) + f(z) \tag{E12}$$

In this case, the actual and temptation conditional demand functions will be given by

$$c(b) = \frac{1}{1+B}b, \qquad x(b,q) = \frac{B}{1+B}\frac{b}{q} \tag{E13}$$

$$\tilde{c}(\tilde{b}) = \frac{1}{1+\tilde{\beta}}\tilde{b}, \qquad \tilde{x}(\tilde{b}, q) = \frac{\tilde{\beta}}{1+\tilde{\beta}}\frac{\tilde{b}}{q} \tag{E14}$$

Substituting these functions into the commitment and temptation utility functions and differentiating the resulting expressions w.r.t. b and z produces

$$U_b = \frac{1+\beta}{b}, \qquad H_b = \frac{1+\tilde{\beta}}{b}, \qquad U_z = f_z(z), \qquad H_z = f_z(z) \tag{E15}$$

$$\tilde{H}_b = \frac{\partial H(\tilde{b}, q, \tilde{z})}{\partial b} = \frac{1+\tilde{\beta}}{\tilde{b}}, \qquad \tilde{H}_z = \frac{\partial H(\tilde{b}, q, \tilde{z})}{\partial z} = f_z(\tilde{z}) \tag{E16}$$

Let us now evaluate the sign of $\boldsymbol{MRS_{z,b} - \widetilde{MRS}_{z,b}}$ which appears in the marginal labor income tax formulas. First, we observe that

$$U_b + H_b = 2\frac{(1+B)}{b} \tag{E17}$$

where we have used that $\beta + \tilde{\beta} = 2B$. Next, we use that $\tilde{b} = b$ and $\tilde{z} = z$ which implies $\tilde{H}_z = f_z(z)$ and $\tilde{H}_b = (1+\tilde{\beta})/b$. By using these definitions, it follows that

$$MRS_{z,b} = \frac{U_z + H_z}{U_b + H_b} = \frac{bf_z(z)}{1+B}, \qquad \widetilde{MRS}_{z,b} = \frac{\tilde{H}_z}{\tilde{H}_b} = \frac{bf_z(z)}{1+\tilde{\beta}} \tag{E18}$$

We can now use use these expressions to calculate $MRS_{z,b}/\widetilde{MRS}_{z,b} = (1+\tilde{\beta})/(1+B) > 1$. Hence, $MRS_{z,b} - \widetilde{MRS}_{z,b} > 0$.

Finally, we want to evaluate $\boldsymbol{\widehat{MRS}^2_{z,b} - \widehat{\widetilde{MRS}}^2_{z,b}}$. First, we recognize that

$$\hat{U}^2 = U(b^1, q, \hat{z}^2) = ln\left(\frac{b^1}{1+B}\right) + \beta ln\left(\frac{B}{1+B}\frac{b^1}{q}\right) + f(\hat{z}^2)$$

$$\hat{H}^2 = H(b^1, q, \hat{z}^2) = ln\left(\frac{b^1}{1+B}\right) + \tilde{\beta} ln\left(\frac{B}{1+B}\frac{b^1}{q}\right) + f(\hat{z}^2)$$

$$\hat{\tilde{H}}^2 = \tilde{H}(b^1, q, \hat{z}^2) = ln\left(\frac{b^1}{1+\tilde{\beta}}\right) + \tilde{\beta} ln\left(\frac{\tilde{\beta}}{1+\tilde{\beta}}\frac{b^1}{q}\right) + f(\hat{z}^2)$$

Hence

$$\hat{U}^2_b = \frac{1+\beta}{b^1}, \qquad \hat{H}^2_b = \frac{1+\tilde{\beta}}{b^1}, \qquad \hat{\tilde{H}}^2_b = \frac{1+\tilde{\beta}}{b^1}, \qquad \hat{U}^2_z = \hat{H}^2_z = \hat{\tilde{H}}^2_z = f_z(\hat{z}^2)$$

This implies

$$\widehat{MRS}^2_{z,b} = \frac{\hat{U}^2_z + \hat{H}^2_z}{\hat{U}^2_b + \hat{H}^2_b} = \frac{2b^1 f_z(\hat{z}^2)}{1+\beta+1+\tilde{\beta}} = \frac{b^1 f_z(\hat{z}^2)}{1+B}, \qquad \widehat{\widetilde{MRS}}^2_{z,b} = \frac{\hat{\tilde{H}}^2_z}{\hat{\tilde{H}}^2_b} = \frac{b^1 f_z(\hat{z}^2)}{1+\tilde{\beta}} \tag{E19}$$

This implies $\widehat{MRS}^2_{z,b}/\widehat{\widetilde{MRS}}^2_{z,b} = (1+\tilde{\beta})/(1+B) > 1$. Hence $\widehat{MRS}^2_{z,b} - \widehat{\widetilde{MRS}}^2_{z,b} > 0$.

These results verify the claims in Corollary 2.

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