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Tax evasion and Prospect Theory in a OLG economy

Francesco Busato[1] Francesco Giuli[2] Enrico Marchetti[3]

Abstract: This paper presents a simple Overlapping Generation Model (OLG), augmented with Prospect Theory elements in the spirit of al-Nowaihi and Dhami (2007). The model tackle several open questions in the analysis of tax evasion and compliance decisions. In particular, the paper presents a new and complementary approach to address tax compliance decision in a OLG economy with behavioral components. Our main results are the following: there exists an equilibrium with a tax evasion level which can be coherent with the empirical estimates for the US economy; for our calibrations we find that the relationship between the tax rate and the evasion rate is a positive one (i.e., the model offers a solution to the Yitzhaki puzzle); we can highlight the role played in the context of tax evasion by an essential component of Prospect Theory, the framing effect, which was precluded to simple individual choice models.

JEL Classification: E210; D030; D810; H030.
Keywords: Tax evasion, OLG models, Prospect theory.

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1 Introduction

> Tax evasion is the illegal concealment of a taxable activity [...]. Measuring how much economic activity is concealed will always be difficult since those who engage in evasion have every motivation to hide their activities. This emphasizes the importance of the understanding the decision process of a taxpayer when choosing whether to comply with tax law or to engage in evasion. A good theory of the compliance decision is essential for designing a tax structure that deters evasion (Hashimzade et al., 2013).

The economic analysis of an individual taxpayer's compliance decision can be traced back to the pioneering work of Allingham and Sandmo (1972). Empirical and experimental evidence suggests a positive relationship between evasion and the tax rate (see, e.g., Yaniv 1999). Traditional theory seems predicting that Declining Absolute Risk Aversion (DARA) preferences cast into a model of expected utility theory (EUT) maximization cannot justify the low level of tax evasion and the correspondingly high tax compliance. In other, rude, terms, as tax rate increases, this class of models predicts a decrease in tax evasion. These two, conflicting, observations identify the main issue of the so-called *Yitzhaki paradox* or *Yitzhaki puzzle* (from Yitzhaki 1974; see also al-Nowaihi and Dhami, 2007 for a discussion).

The recent literature mainly follows two routes to address the puzzle. A former line of research focuses on the role of tax morale[4] in explaining the (high) level of fiscal compliance by the taxpayers. Tax morale is typically considered as an intrinsic motivation to pay taxes, and it may vary under different and historical circumstances, providing a possible explanation for the observed levels of degree of tax evasion, at a macroeconomic level. A more recent approach hinges on the role of behavioral elements into more classical frameworks. This approach augments or modifies the standard EUT model according to a wide corpus of results stemming form behavioral economics.[5] These extensions and modification are (or should) be able to provide viable explanations to (at least) some of the aforementioned aspects of the tax evasion puzzle. In these context several papers claimed that introducing Prospect Theory (PT in the sequel) helps improving models' prediction along the side of Yitzhaki puzzle.

This paper presents a new and complementary approach to address tax compliance decision in a OLG economy with behavioral components. It also examines the role of PT in solving the Yitzhaki puzzle, while following a different and more general route, compared to the current literature. Technically, this paper frames the problem in a more general context, with attention to a fully microfounded partial-equilibrium model. In extreme synthesis, our model is made up of two main building blocks: we adopt a simplified version of the framework developed by Ciccarone and Marchetti (2013) in another context and

[4]See Torgler (2007) for an overview.

[5]See, e.g., Yaniv (1999); Bernasconi and Zanardi (2004); Arcand and Rota Graziosi (2005); al-Nowaihi and Dhami (2007); Rablen (2010); Cullis et al. (2012). See also Pickhardt and Prinz (2013) or Hashimdaze at al. (2013) for a extensive surveys.

add to it the main elements of tax compliance decisions as described in al-Nowaihi and Dhami (2007).

Our main results are the following.

First, we show that in equilibrium the representative agent always chooses - under suitable conditions - a positive but limited amount of tax evasion[6]. We obtain interior (closed form stationary) solutions under an exogenous and constant probability of being detected evading; this improves upon the assumption of endogenous probability, which is typically considered a weakness of individual choice models.

Second, the model, after a calibration exercise is capable to properly fit the US economy key characteristics, relevant for our issues, with particular attention to the evasion rate. The model predicts that an increase in the tax rate leads to an increase in tax evasion, in line with the empirical evidence, while allowing us to investigate the relevance and the impact of the framing effect in the context of the tax compliance decision. We uncover an inverse relationship between the parameter determining the framing effect and that representing the weight of social customs and stigma. In other words, there exists of trade-off between these two dimensions in the context of tax evasion: a given level of tax evasion can be related either to a low level of framing coupled to a high level of social stigma or to a weak framing - high stigma combination. Furthermore, the slope of this trade off is affected by the elasticity of labor supply: the higher the elasticity, the lower the level of framing needed to support a given amount of tax evasion.

The structure of the paper goes as follow. Section 2 describes the model. Section 3 develops the numerical exercise for the United States economy and discusses the results. Finally Section 4 offers some conclusion.

2 The model

The economy is made up of a multitude of agents in an overlapping generations scheme; there is an exogenous fiscal authority which collects taxes on produced income, and tackles possible tax evasion schemes by enforcing deterrence policies and random audits; it furthermore balance its budget in expected terms *via* wasteful public expenditure.

The representative agent living at time t has the biperiodal (expected) utility function:

$$E_t\left(U_t\right) = E_t\left(\frac{C_{t+1}^{\gamma}}{\gamma}\right) - \xi\frac{L_t^{\psi}}{\psi} + \beta E_t v\left(W_{D,nD}\right) \tag{1}$$

where C_t is real consumption of the unique type of good, L_t is the amount of labor needed to produce it and $0 < \gamma < 1$, $\psi > 1$, $\xi > 0$ and $\beta > 0$ are parameters; the function

[6]The original al-Nowaihi and Dhami (2007) model derives a bang-bang solution for tax evasion; hence it properly describes and explains the phenomen at a microeconomic level, but is not well equipped for macroeconomic analysis.

$v(\cdot)$, which includes the behavioral elements, is detailed in the sequel. The two quantities C^γ/γ and L^ψ/ψ are the traditional ones (utility form consumption stream and disutility for labor services). Each agent - when young - can be thought as consumer-producer, so that he/she carries out current production Y_t by using the technology:

$$Y_t = L_t \tag{2}$$

We assume the same generation framework of Lucas (1972), as simplified and adapted by Benassy (1999), in which only the young agents work and produce and the old agents only consume.

The agent can transfer wealth produced when young to the next period through a real asset B_t, exogenously supplied[7] and evolving as follows:

$$B_t = X_t B_{t-1}$$

where X_t is an exogenous real stochastic return factor (i.i.d. with $E(X_t) = 1$ and fixed variance). B_t is held by the old generation at time t. The old agent budget constraint is:

$$C_{t+1} = X_{t+1} B_t$$

The young agent disposable income is, in expected terms, denoted by Y_t^E, which takes into account taxation and an audit scheme.

The fiscal mechanism acts in the following way: gross resources Y_t are taxable and the young agent declares to the Internal Revenue Service (IRS) an amount $D_t \in [0, Y_t]$ for each t. The government levies a tax on declared resources D_t at the constant marginal rate $0 < \tau < 1$. When a taxpayer evades ($0 \leq D_t < Y_t$), he/she is detected with probability $p \in (0, 1)$. If caught evading, the agent pays a constant surcharge $s > 0$ on the outstanding tax liabilities $Y_t - D_t$. Thus his/her final amount of resources is given by the following binary scheme, $\tilde{Y}_t = \left\{Y_t^{N-Det}; Y_t^{N-NonD}\right\}$, where:

Detected $_{(\sim p)}$	$Y_t^{N-Det} = (1-\tau) Y_t - s\tau (Y_t - D_t)$,
Not **D**etected $_{\sim(1-p)}$	$Y_t^{N-NonD} = Y_t - \tau D_t$

Then, the expected amount of net income stems from the linear projection:

$$Y_t^E = [1 - p\tau(1+s)] Y_t - \tau [1 - p(1+s)] D_t$$

The young agent needs to store this expected disposable resources into the real asset B_t so as to bring it into the next period: $Y_t^E = B_t$. We now define the bi-periodal budget constraint:

$$C_{t+1} = X_{t+1} B_t = X_{t+1} Y_t^E = X_{t+1} \left\{[1 - p\tau(1+s)] Y_t - \tau [1 - p(1+s)] D_t\right\} \tag{3}$$

[7]It could be thought, for example, as a real money market account.

In the spirit of Ciccarone and Marchetti (2013), the role of B_t as the only storage of value allows us to introduce all the basic elements of PT by adopting Barberis et al.'s (2001) scheme in which the agent's carriers of utility are given not only by consumption levels, but also by changes in his/her financial wealth, as compared to a reference point.

We can describe the features of the utility function (1) by following the general idea of Barberis and Huang (2009), i.e., that agent are usually subject to *narrow framing*, which is a well-known result of PT and of behavioral economics in general. In the EUT model, the agent evaluates a new gamble he/she is offered by merging the new gamble with other risks he/she is already facing, so as to determine its overall effect on the distribution of his/her future wealth or consumption. Then he/she evaluates the new distribution so as to ascertain possible improvements or worsenings.

Nevertheless, a wide experimental literature highlights many deviations from this behavior: agents tend to evaluate a new gamble in isolation, separately from their other risks. This behavior is named "narrow framing" (Khanemann and Lovallo 1993; Khanemann 2003) because the decision taken by the agent can be affected by the way the decision problem is posited (framing effect). Also the new gamble is evaluated by considering the distribution of (the gamble's) outcomes taken alone, rather than considering the overall distribution of wealth/resources. In this sense (and coherently with Barberis and Huang 2009) we may assume that the agent derives utility from the gamble's contributions to the overall profile of wealth/resources and consumption (the term C^γ/γ, as in the standard models) and also directly from a narrow framing effect, as represented by the term $\beta v\left(W_{D,nDt}\right)$.[8] The parameter β can then be interpreted as a quantitative measure of the narrow framing effect.

The term $v\left(W_{D,nD}\right)$ (the *value function*, in PT terminology) in equation (1) is adapted from al-Nowaihi and Dhami (2007) and encapsulates the remaining four fundamental elements of (cumulative) PT: reference dependence, constant sensitivity, loss aversion, and probability weighting.[9] We define the gains and losses as $W_{D,nD} = X_{t+1}\left(\tilde{Y}_t - R_t\right)$, where R_t is the reference value of total resources/wealth and it is equal to the *legal after-tax wealth*:

$$R_t = (1-\tau)Y_t$$

Following al-Nowaihi and Dhami (2007), we define the gains-losses $W_{D,nD}$ by including a social stigma component, s_{soc}, when the agent is caught evading. Hence $W_{D,nD}$ can be

[8]Notice that a rational agent - in the traditional sense of economic rationality - should only consider the term C^γ/γ.

[9]Reference dependece implies that the agent is interested only in gains and losses form a reference point. Declining sensitivity makes the utility function concave in the domain of gains and convex in the domain of losses. Loss aversion captures the idea that, in the agent's eyes, losses loom larger that gains. Finally, non-linear probability weighting implies that the agent sistematically overestimates the probability of rare events, while underestimating the probability of more frequent ones.

split into:

$$\begin{aligned} W_{\text{det}} &= -X_{t+1}\left(s_{\text{soc}} s\tau\right)\left(Y_t - D_t\right) \\ W_{\text{N-det}} &= X_{t+1}\tau\left(Y_t - D_t\right) \end{aligned}$$

Our definition of W_{det} is different from that adopted by al-Nowaihi and Dhami (2007): in their paper the expression for W_{det} is: $(s_{\text{soc}} + s\tau)(Y_t - D_t)$, i.e., the social stigma is added to the tax surcharge. Nevertheless we justify our choice of W_{det} by noting that, on one side, in the calibration analysis of section 3 s_{soc} plays the role of a *deep parameter*, which is not pinned down by independent empirical evidence.[10] On the other hand, we also performed simulations with a version of the model where $W_{\text{det}} = -X_{t+1}(s_{\text{soc}} + s\tau)(Y_t - D_t)$ and the results do not qualitatevely change.

As for the function v, it is defined as:

$$\begin{aligned} v\left(W_{D,nD}\right) &= \mathbb{E}\left(W_{D,nD}\right) \\ &= E_w \begin{cases} W_{\text{N-det},t} & \text{with } W_{\text{N-det},t} \geq 0 \text{ and probability } w\left(1-p\right) \\ -\theta\left(-W_{\text{det},t}\right) & \text{with } W_{\text{det},t} < 0 \text{ and probability } w\left(p\right), \end{cases} \end{aligned} \tag{4}$$

where the E_w is the expected value operator in which the "true" probabilities p and $1-p$ are replaced by the subjective weightings $w(p)$ and $w(1-p)$. Our function v is linear in its arguments $W_{D,nD}$ implying *a constant sensitivity* property as in Barberis et al. (2001). The parameter $\theta > 0$ represents the *loss aversion*: possible losses ($W_{D,nD} < 0$) are more salient than equivalent gains ($W_{D,nD} > 0$). The probability weighting function w is chosen so as to meet the fourth requirement: *non-linear weighting*. The most common choice for the function w is the one proposed by Prelec (1998):

$$w(p) = e^{-(-\ln p)^b} \text{ for } p \in (0,1],\ w(0) = 0 \text{ and } 0 < b < 1$$

Given these specifications, we can compute the value function v as follows:

$$\begin{aligned} v\left(W_{D,nD}\right) &= \left[w\left(1-p\right)\tau - w\left(p\right)\theta\left(s_{\text{soc}} s\tau\right)\right] X_{t+1}\left(Y_t - D_t\right) \\ &= \left[e^{-(-\ln(1-p))^b}\tau - e^{-(-\ln p)^b}\theta\left(s_{\text{soc}} s\tau\right)\right] X_{t+1}\left(Y_t - D_t\right) \\ &= hX_{t+1}\left(Y_t - D_t\right) \end{aligned} \tag{5}$$

where h is a function of parameters only, and where the social stigma is represented by parameter $s_{\text{soc}} \in (1, \infty)$.

[10]Furthermore, reliable empirical estimates of this parameter are difficult to obtain.

2.1 Model's equilibrium

We characterize the model's equilibrium by maximizing the following objective function, comprehensive of the constraint:

$$\begin{aligned}\max_{Y_t,D_t} E_t\left(U_t\right) &= E_t\left(X_{t+1}^{\gamma}\frac{\left\{\left[1-p\tau\left(1+s\right)\right]Y_t-\tau\left[1-p\left(1+s\right)\right]D_t\right\}^{\gamma}}{\gamma}\right)+ \\ &\quad -\xi\frac{Y_t^{\psi}}{\psi}+\beta E_t\left[hX_{t+1}\left(Y_t-D_t\right)\right]\end{aligned} \tag{6}$$

Before moving to the solution, Lemma 1 deals with the Concavity of the optimization problem (6), which is a delicate issue for this class of models. The sketch of the proof is the following: we first compute the Hessian matrix of U_t (i.e., equation (1) under the certainty equivalent) with respect to the three endogenous variables: C, Y and D. Then, by computing the gradient of the constraint (3) with respect to the same three variables, we assemble the bordered Hessian; the proof is completed by checking that the bordered Hessian is definite seminegative.

Lemma 1 *Problem (6) is concave.*

Proof. upon request. ■

Now, deriving first order conditions, and after some algebra, we obtain the following equilibrium values for D_t and Y_t :

$$\begin{aligned}D_t &= \left(\frac{1-p\tau\left(1+s\right)}{\tau\left[1-p\left(1+s\right)\right]}\right)\left[\frac{-\beta h\left(1-\tau\right)}{\xi\tau\left[1-p\left(1+s\right)\right]}E_t\left(X_{t+1}\right)\right]^{\frac{1}{\psi-1}}+ \\ &\quad -\frac{1}{\tau\left[1-p\left(1+s\right)\right]}\left[\left(\frac{E_t\left(X_{t+1}\right)}{E_t\left(X_{t+1}^{\gamma}\right)}\right)\frac{-\beta h}{\tau\left[1-p\left(1+s\right)\right]}\right]^{\frac{1}{\gamma-1}} \\ Y_t &= \left[-\beta h\frac{\left(1-\tau\right)}{\xi\tau\left[1-p\left(1+s\right)\right]}E_t\left(X_{t+1}\right)\right]^{\frac{1}{\psi-1}}\end{aligned}$$

To ensure economically reasonable solutions, we must have $h<0$.

In the market equilibrium we impose certainty equivalence, and a government balanced budget on a period by period basis, i.e. $G_t=\tau\left[1-p\left(1+s\right)\right]D_t+p\tau\left(1+s\right)Y_t$. This implies that, for each t,

$$L_t=Y_t=C_t+G_t$$

Now, we focus on a stationary equilibrium; the stationary solutions, rewritten in a more compact notation, would be:

$$
\begin{aligned}
Y &= \left[-\left(1-\tau\right) A_0\right]^{\frac{1}{\psi-1}} & (7)\\
D &= A_1 Y - \frac{1}{\tau\left[1-p\left(1+s\right)\right]}\left(-A_0\right)^{\frac{1}{\gamma-1}} & (8)\\
\text{where } A_0 &= \frac{\beta h}{\xi\tau\left[1-p\left(1+s\right)\right]};\quad A_1 = \frac{1-p\tau\left(1+s\right)}{\tau\left[1-p\left(1+s\right)\right]}\\
h &= e^{-(-\ln(1-p))^b}\tau - e^{-(-\ln p)^b}\theta s_{\text{soc}} s\tau
\end{aligned}
$$

3 Calibration and model analysis

We apply the model to the United States (US) economy, as plenty of empirical estimates of the relevant parameters are available for this economic system. The aim of our analysis is threefold:

- we first want to verify that our model, given the average tax rate τ for the US, can replicate the empirically estimated amount of tax evasion (as represented by the ratio $\frac{Y-D}{Y}$) for plausible values of the remaining parameters.
- Next, we perform a numerical exercise in order to determine the response of our model to changes in tax rate τ, i.e. to test its ability to solve this dimensiones of the Yitzhaki puzzle. We explore this issue under two different assumptions on the features of labour supply: an economy with a rigid labor supply and another one in which an elastic labor supply prevails.[11]
- We also explore the model's behavior when the two most important parameters (for our approach, i.e.: β and s_{soc}) changes. We then consider different values for β and s_{soc} and verify the existence of an positive relationship between $\frac{Y-D}{Y}$ and τ.

There are nine parameters in the model: γ, ξ, ψ, p, s, θ, b, $\mathbf{s}_{\text{soc}}$ and β. We first assume a log specification for consumption utility (i.e. $\gamma = 0$), which is commonly adopted in standard macroeconomic modelling (our results would not qualitatively change under a strictly positive value of γ). Equilibrium conditions now read:

$$
\begin{aligned}
Y &= \left[-\left(1-\tau\right) A_0\right]^{\frac{1}{\psi-1}} & (9)\\
D &= A_1 Y + \frac{1}{\beta h} & (10)\\
\text{where} &: \quad A_0 = \frac{\beta h}{\xi\tau\left[1-p\left(1+s\right)\right]};\quad A_1 = \frac{1-p\tau\left(1+s\right)}{\tau\left[1-p\left(1+s\right)\right]}
\end{aligned}
$$

[11] A *rigid* labor market is characterised by a high ψ, while an *elastic* one by a low ψ.

In order to undertake a rigorous calibration exercise, we pin down five parameters from existing literature (ψ, p, s, θ, b), relying on commonly accepted figures. The remaining two parameters are the social stigma s_{soc} and the framing parameter β; these are *truly* deep parameters and we work on these, to understand whether reasonable figures are capable to endorse our targets.

It is first necessary to find a figure for the evasion rate $\frac{Y-D}{Y}$. This is a challenging empirical estimate due to the natural difficulty of estimating an unofficially reported quantity. Here we use as a benchmark the widely accepted estimates of the ratio of the underground economy over total GDP (for the US), provided by Schneider and Enste (2000) and Schneider et al. (2010), who set this ratio in the range of 8.4% to 8.8% in the recent years. This should be properly thought of as the ratio of the *aggregate income* evaded over total income. In particular, taking into account the possibility of specific forms of evasion for wealth (such as migration in fiscal paradise, etc.) it appears reasonable to assume 8.8% as a plausible figure.

As for the benchmark value of the tax rate τ we first rely on official data from the Bureau of Economic Analysis[12] to compute the stationary Government Receipt/GDP ratio: $GovE/Y = 0.2755$, over the period 1950-2011 and then set $\tau = GovE/Y$.

We discuss, next, the calibration of the other five parameters.

1. The *loss aversion parameter* θ is set to $\theta = 2.25$, as justified by a wide amount of empirical research (e.g. Tversky and Kahneman, 1992).

2. The *parameter of the Prelec weighting function* is set to $b = 0.35$, which is the benchmark value in al-Nowaihi and Dhami (2007) analysis.

3. The *surcharge rate or penalty rate* s is set to $s = 0.5$, which is a viable empirical estimate for the additional payment after an audit in the USA (see Alm et al. 1992; Andreoni et al. 1998).

4. *Probability of being detected* p is set to $p = 0.02$, which is the average value of the range of realistic values for the US economy: $p \in [0.01; 0.03]$, as reported by al-Nowaihi and Dhami (2007).[13],

5. Parameter ψ is a measure of *inverse total labor supply elasticity*, which we use for discussing two scenarios for the labor market. A rigid labor market scenario (i.e. $\psi = 7$ or 10) and an elastic labor market scenario (i.e. $\psi = 1.2$). The latter seems consistent with the estimates of Kimball and Shapiro (2008) who obtain a Frisch elasticity close to 1.

[12]The tables are: GDP (nominal), NIPA table 1.1.5; Government receipt, (nominal) NIPA table 3.1. $GovE$ and Y are computed as long run averages.

[13]See also Alm et al (1992); Andreoni et al. (1998) and Bernasconi (1998).

Finally, the scaling parameter ξ of the disutiltiy of labor is calibrated so as to ensure that, in the subsequent analysis all endogenous variables (notably Y and D and their ratios) are positive and, when required, capable to match the targets.

We can now use the two parameters controlling the social stigma and the framing effect s_{soc} and β, respectively. The calibrations for the two labor market scenario are summarized in the following table and discussed in the next section.

Table 1

Scenario # 1: rigid labor market $\psi = 7; 10$			
Fixed parameters	$\tau = 0.2755$	$s = 0.5$	$\theta = 2.25$
	$p = 0.02$	$b = 0.35$	
Adjusted parameters	s_{soc}; β; ξ.		
Scenario # 2: elastic labor market $\psi = 1.2$			
Fixed parameters	$\tau = 0.2755$	$s = 0.5$	$\theta = 2.25$
	$p = 0.02$	$b = 0.35$	
Adjusted parameters	s_{soc}; β; ξ.		

In this framework we investigate the model's response (with attention to the equilibrium evasion rate) after changes in the tax structure; we also analyze the role played by the agents' main behavioral components β and s_{soc}. From a technical perspective, we undertake a perturbation of the parameter space in the two scenarios.

3.1 Scenario # 1: PT in a rigid labor market

We consider, in this context, two different calibration schemes, differing only along the social stigma and framing dimensions: the first one refers to an economy with relative *low social stigma* in evasion and relatively *strong framing effects*; the second one represents an economy with relative *high social stigma* in evasion and relatively *low framing effects.* Table 2 summarizes the first calibration scheme:

Table 2

strong framing effects; low social stigma		
Standard calibration:	as in Table 1	
Labor market:	$\xi = 0.04$	$\psi = 7$
Deep parameters:	$s_{soc} = 4$	$\beta = 6.68$

By plugging this calibration into equations (9)-(10) we confirm that we are reasoning around the empirically estimated evasion rate $\frac{Y-D}{Y} \simeq 0.088$. A simulation of the numerical versions of (9)-(10) is presented in Figure 1 below.

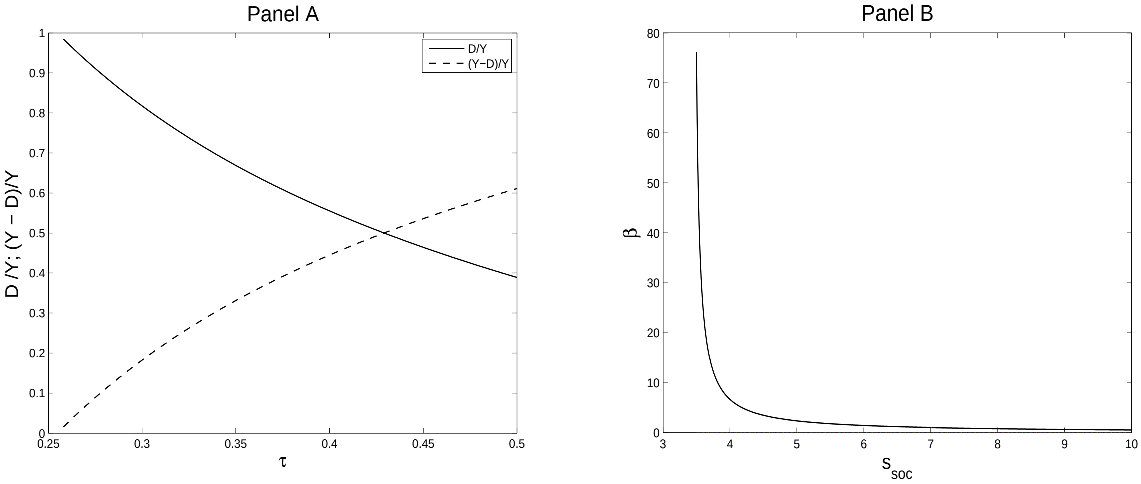

Figure 1: Panel A: the relationship between $\frac{D}{Y}$ and $\frac{Y-D}{Y}$ as dependent variables and τ where the values of $(\beta, \theta, \xi, \psi, p, b, s, s_{\text{soc}})$ are those of Table 2, with $\tau \in [0.25;\ 0.5]$. Panel B: the trade-off between β and s_{soc} according to equation (11) and the values of $\left(\frac{Y-D}{Y}, \theta, \xi, \psi, \tau, p, b, s\right)$ of Table 2. Notice that in both Panels the value of h is always negative.

Panel A shows the positive relation between tax rate increases and evasion rate, which is our proposed solution to the Yitzhaki puzzle, qualitatively in line with the empirical evidence. In addition, once the tax rate and the evasion rate are pinned down, it is possible to draw an inverse relation between β and s_{soc} (Panel B).

It interesting to mention that qualitatively similar results arise in a calibration with weak framing effects and high social stigma, such as the one shown in Table 3 below. The model predicts the empirically consistent evasion rate, and solves the Yitzhaki puzzle (positive relationship between $\frac{Y-D}{Y}$ and τ).

Table 3

weak framing effects; high *social stigma*		
Standard calibration	as in Table 1	
Labor market:	$\xi = 0.03$	$\psi = 10$
Deep parameters	$s_{\text{soc}} = 8$	$\beta = 0.8975$

The results we just presented suggest that there exist a trade-off between s_{soc} (included in $h(s_{\text{soc}})$) and β. This comment can be formally derived from the stationary equations for Y and D; computing $\frac{Y-D}{Y}$, after some algebra, we obtain the following relation:

$$\beta = \left[\frac{Y-D}{Y} + \left(\frac{1-\tau}{\tau\left[1-p(1+s)\right]}\right)\right]^{-\frac{\psi-1}{\psi}} \left[\frac{(1-\tau)}{\xi\tau\left[1-p(1+s)\right]}\right]^{-\frac{1}{\psi}} \frac{1}{(-h(s_{\text{soc}}))} \tag{11}$$

This means that the Yitzhaki puzzle (i.e., the slope of the relationship between $\frac{Y-D}{Y}$ and τ) can be solved by analyzing the behavior of equation (11). In other words in our macroeconomic model, evasion rates positively respond to an increase in tax rates (as evidences suggest) either with strong framing effects and low social stigma, or with weak framing effects and high social stigma. We think, however, it would be interesting to explore the possibility to preserve this result with an even smaller framing effect.

3.2 Scenario # 2: PT in an elastic labor market

The analysis of the elastic labor market scenario can be carried out along the same lines of the previous section. Table 4 presents the calibration for an elastic labor market (i.e. a low value of ψ, coherent with macroeconomic estimates):

Table 4

very weak framing effects; high social stigma		
Standard calibration	as in Table 1	
Labor market:	$\xi = 0.03$	$\psi = 1.2$
Deep parameters	$s_{\text{soc}} = 9$	$\beta = 0.057555$

The numerical results are presented in Figure 2: Panel A shows a positive relationship between τ and $\frac{Y-D}{Y}$, analogous to that of Figure 1; the trade-off between β and s_{soc} is also confirmed (Panel B).

There are two interesting results. First, the model offers an empirically consistent prediction for the $\left(\tau; \frac{Y-D}{D}\right)$ relationship for a smaller range of τ rates. Second, in a "high-elasticity economy" a very small deviation from rationality is sufficient for having a positively sloped relation between tax rates and evasion rates; we think that this a particularly welcome result.

3.3 Discussion: the economic intuition

We think that this model makes an interesting point in theory, with a straightforward economic intuition. It is convenient to discuss the mechanism by recalling the equilibrium values of D_t and Y_t, as given by equations (9)-(10) and taking the ratio $\frac{D}{Y}$:

$$\frac{D}{Y} = \frac{1 - p\tau\,(1+s)}{\tau\,[1 - p\,(1+s)]} + \frac{1}{\left[-\beta h \frac{(1-\tau)}{\xi\tau[1-p(1+s)]}\right]^{\frac{1}{\psi-1}} \beta h}$$

Since $h < 0$, we rewrite the ratio as

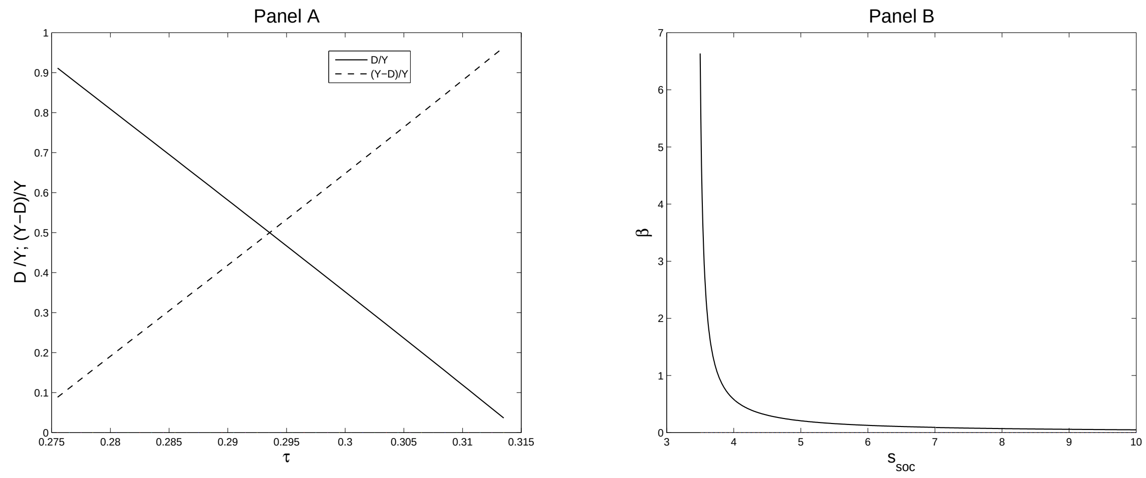

Figure 2: Panel A: the relationship between $\frac{D}{Y}$ and $\frac{Y-D}{Y}$ as dependent variables and τ where the values of $(\beta, \theta, \xi, \psi, p, b, s, s_{\text{soc}})$ are those of Table 4, with $\tau \in [0.275;\ \ 0.313]$. Panel B: the trade-off between β and s_{soc} according to equation (11) and the values of $\left(\frac{Y-D}{Y}, \theta, \xi, \psi, \tau, p, b, s\right)$ of Table 4. Notice that in both Panles the value of h is always negative.

$$\frac{D}{Y} = \frac{1 - p\tau\,(1+s)}{\tau\,[1 - p\,(1+s)]} - \frac{1}{\left[\frac{(1-\tau)}{\xi\tau[1-p(1+s)]}\right]^{\frac{1}{\psi-1}} (\beta\,|h|)^{\frac{\psi}{\psi-1}}} \tag{12}$$

This last expression allows us to discuss the economic mechanism. Consider, first, a model without PT, i.e. $\beta = 0$ and notice that in this case $\frac{D}{Y} \to -\infty$; this means that $D = 0$, in the sense that the tax payer will declare nothing. This is the corner solution that depicts the puzzling question "why do people pay taxes?".

When PT is included (i.e. imagine we make β slowly increasing), the loss aversion component incentivates the tax payer to declare more. This is a key result of our model, which improves upon the current state of the art. While in al-Nowaihi and Dhami (2007), under constant detection probability, the agent switches from one corner to the other (no compliance, full compliance), our framing effect (in the spirit of Barberis and Huang 2009) convexifies, through the market mechanism, the equilibrium compliance choice. In our model, the additive structure of the utility function (1) allows the agents to compare the contributions of the choice variables (e.g., D and Y) to the different additive components, so as to prevent the bang-bang solution. But the introduction of the additive elements into (1) requires, in its turn, to cast the analysis in a proper context of market equilibrium. More precisely, the reason why in our model evasion increases as tax rate raises stems from the fact that the tax payer, when young, feels poorer: then he/she will produce less and send a smaller amount of resources for consumption in the next period. The agent also foresees a lower level of consumption utility and finds himself/herself in the region of losses ($h < 0$); hence he/she is keen in taking more risk and therefore evades more.

In a flexible economy (i.e. the elastic labor market, scenario #2), tax payers react more quickly to changes in fundamentals. Consider an increase in τ. First, youngs are willing to work less (and therefore to produce less); as a direct consequence, they will declare less income. Since the equilibrium decisions are strongly sensitive and reactive, it is sufficient a relatively small framing effect (i.e. β) to activate the mechanism previously discussed. This effect is also evident by direct inspection of equations (9), (10) and (12): a low ψ implies a high value of the exponent in the terms of these equations and this, for example in the case of Y in (9), means that a change in τ brings about a stronger response of the equilibrium output.

Finally, the origin of the trade-off between β and s_{soc} can also be explained by a straightforward argument. For having an economically viable solution, the term h in the equilibrium equations (9)-(10) must be negative; as the same term is equal to: $h = e^{-(-\ln(1-p))^b}\tau - e^{-(-\ln p)^b}\theta\,(s_{\text{soc}} s\tau)$ and it is multiplied by β, it is evident that, for matching the empirical target of $\frac{Y-D}{Y}$, a reduction of β can be compensated by an increase of s_{soc}.

4 Conclusions

This paper presents a novel modelling framework in which PT is integrated into an otherwise simple and standard model of market equilibrium with a representative agent and an OLG scheme, in the context of tax compliance choices. The aim is to tackle the main issues and puzzles of the tax evasion/compliance behavior with a theoretical instrument which is innovative with respect to previous attempts on the same route. The market equilibrium environment, together with the OLG scheme, allows us to define the choice problem so as to take into account all the relevant features of PT and in particular the framing effect, which proved to be difficult for the existing models based on the individual-choice approach.

In our model the role of the framing effect is encapsulated into a single parameter (β), and this is in line with the general strategy recently proposed by Rabin (2013) in order to extend and increase the explanatory power of current economic theory. This strategy, called PEEM (portable extensions of existing models), is based on the modification of an existing model by means of different psychological assumptions to be represented in terms of parameter values. In our scheme, by setting the framing parameter β to zero, a completely standard model would result, so that the comparison with the standard theory is made straightforward. By assuming a positive value for the parameter β, behavioral PT elements can play a role, and we can show that the resulting equilibrium can be coherent with quantitative estimations of the amount evaded in US economy. That is, the numerical version of the model efficiently predicts the overall amount of tax evasion and generates a positive relationship between the tax rate and the evasion rate, thus providing a solution for the Yitzhaki puzzle. Furthermore, we explore the interaction of the framing effects - as represented by β - with the social stigma, and find that there exists a trade-off between the two phenomena: the same amount of tax evasion (relative to the GDP) is compatible either with a low level of framing coupled to a high level of social stigma or with a low framing - high stigma combination.

As the model includes the equilibrium choice of the labor input to be used in production, we can investigate the role of the elasticity of labor supply in shaping the tax compliance behavior. We find that in the presence of a highly elastic labor supply, even a very small level of framing, and hence a very small deviation from standard rational behavior, can support the observed level of tax evasion, provided that the social stigma is sufficiently strong. This is due to the fact that in a high-elasticity economy the agents reactions are stronger, and this magnifies the effects predicted by PT.

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