

# Tax Evasion: Does the tax burden matter?

## Lessons from behavioral economics\*

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### Abstract

We study the effects of the tax burden on tax evasion both theoretically and experimentally. We develop a model of tax evasion decision that is based on two ideas from behavioral economics: 1) taxpayers are endowed with reference dependent preferences that are subject to hedonic adaptation; and 2) in making their choices, taxpayers are affected by ethical concerns. The model generates new predictions about the effects of a change in the tax rate on the decision to evade taxes. Contrary to the classical expected utility model, but consistently with previous applications of reference dependent preferences to taxpayers' decisions, an increase in the tax rate increases tax evasion. However, the converse is not true. Moreover, as taxpayers adapt to the new legal tax rate, the decision to evade taxes becomes independent from the tax rate. We present results from a laboratory experiment that support the main predictions of the model.

Keywords: Tax Evasion, Prospect Theory, Adaptation.

JEL classification: H26, D03, C91.

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# 1 Introduction

How does the tax burden affect tax compliance? Is the level of the tax burden important? Or do people mainly respond to changes in the tax rate? And how does tax evasion respond to an increase/decrease of the tax rate?

Although these are fundamental questions for the design of the fiscal system, they have not been considered with the same attention by the economic literature. Following conventional economic arguments, scholars have generally assumed a well-defined relationship between the tax rate and the incentive to evade. The benchmark analysis in this respect is the classical expected utility model of Allingham and Sandmo (1972) and Yitzhaki (1974). It implies a positive relationship between the tax rate and taxpayer's compliance. However, this prediction has been criticized by many authors, who believe that a rise in the tax burden tends to stimulate (rather than discourage) evasion. Moreover, there are several empirical studies that are not sympathetic with the theoretical prediction of the classical model, though the overall evidence is not conclusive (see Section 2.2 for references).

A possible explanation for the empirical shortcoming of the classical model is that taxpayers' behavior is more complex than what economic theory postulates. For instance, tax compliance can depend on frames and reference points, which in turn adapt to circumstances and events. In fact, psychologists use the term *hedonic adaptation* to refer to "*processes that attenuate the long-term emotional or hedonic impact of favorable and unfavorable circumstances*" (Frederick and Loewenstein, 1999, p. 302). Hedonic adaptation implies that changes in pre-existing conditions are absorbed by reference dependent utilities such that behavioral responses to repeated stimulus can be limited in time.

The Cumulative Prospect Theory (Tversky and Kahneman, 1992) represents the leading approach to incorporate in behavioral economic models the notion of reference dependent preferences. According to this theory, rather than being measured in absolute levels, economic outcomes are evaluated as gains or losses relatively to a reference point. Applications of Prospect Theory to tax evasion have recently been proposed by various researchers (e.g., Bernasconi and Zanardi, 2004; Kirchler, 2007; Dhami and al-Nowaihi, 2007; Rablen, 2010). These contributions have investigated specific aspects of the theory, such as the *subjective weighting of probabilities*, the *diminishing sensitivity* of gains and losses, the property of *loss-aversion*.<sup>1</sup>

Less attention has been devoted to analyze how taxpayers react and adapt to fiscal changes over time. In particular, while studies have proposed reasonable assumptions on how individuals formulate their reference in tax evasion decisions, the issue of adaptation has been largely ignored. In this paper, we theoretically and experimentally extend the existing analysis by considering the process of adaptation of the reference tax rate.

In recent years, hedonic adaptation has become a very hot topic in behavioral economics for its capacity to improve understanding in many aspects of human life, including consumers' habit formation, responses to changes in health conditions, savings and investment decisions (Frederick and Loewenstein 1999). Moreover, re-

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<sup>1</sup>These analytical features of Prospect Theory are well-known and well-documented by the behavioral literature. In this paper we make use of these features, but we are not going to discuss them in details. For a recent comprehensive treatment of these analytic properties of Prospect Theory with several references to the behavioral literature see Wakker (2010).

cent evidence has shown that reference points adapt to favorable and unfavorable events at different speed and this can explain various asymmetries observed in human behavior (Arkes et al. 2008 and 2010; Lyubomirsky, 2011).

Our analysis offers new insights on how hedonic adaptation affects taxpayers' perception of fiscal variables and tax compliance. First, we show that, once adaptation is completed, the level of fiscal burden does not affect tax compliance, a prediction that is also consistent with the old adage in public finance saying that "an old tax is no tax" (Bastable, 1892, III.VII.18).<sup>2</sup> Second, we study how a change of the tax rate influences evasion. Overall, we find that an increase in the tax rate discourages taxpayers' compliance. Our experimental results also confirm the existence of asymmetries in taxpayers' adaptation to an increase rather than to a decrease in the tax rate.

The paper is structured as follows. In Section 2, we briefly review the literature analyzing the relationship between evasion and the tax burden. In Section 3, we present our theoretical framework for the taxpayer's decision based on reference dependent preference with adaptation and derive the main predictions of the model. In Section 4, we describe the experimental design and present the results. We conclude in Section 5 with a discussion of the policy implications of our analysis.

## 2 Background

### 2.1 Classical Expected Utility Approaches

The benchmark model of tax evasion is based on the seminal contributions of Allingham and Sandmo (1972) and Yitzhaki (1974). A taxpayer with gross income  $Y > 0$  is required to pay taxes according to a flat tax rate  $0 < \tau < 1$ . The tax authorities cannot directly observe the taxpayer's income, but they can audit the taxpayer with probability  $p \in (0, 1)$ . If audited and found to have concealed part of her income, the taxpayer is convicted to pay the taxes evaded plus a sanction.<sup>3</sup> Thus, the taxpayer's disposable incomes in the two states of the world, not audited and audited, are given by:

$$Y_{na} = Y - \tau d, \tag{1}$$

$$Y_a = Y - \tau d - s\tau(Y - d), \tag{2}$$

where  $s > 1$  and  $d \in [0, Y]$  are the sanction rate inclusive of the penalty surcharge and the reported income, respectively.

Allingham and Sandmo (1972) developed the model as a contribution in the field of the economics of crime. By assuming that the taxpayer maximizes her expected utility, they provide important insights on the determinants of tax evasion, including the predictions on the deterrent effects of both the audit probability and the level of sanctions. However, some implications of the model have been criticized. First, the

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<sup>2</sup>A related adage often quoted in public finance is that "an old tax is a good tax" (see, e.g. Buchanan 1967). The interest for these adages in the tax evasion literature has been brought to our attention by Dhami and al-Nowaihi (2007). However, as we argue below, we consider the previous analyses imperfect in regard to capturing the precise sense of these adages, precisely because they don't take into account the importance of adaptation.

<sup>3</sup>In Allingham and Sandmo (1972), sanctions are computed on evaded income; however, Yitzhaki (1974) noted that sanctions more usually are computed on evaded taxes.

model predicts that the taxpayer will under-report a part of her income whenever the expected return from one dollar of evaded tax is positive. In contrast with this theoretical result, although in many countries the fiscal parameters entail a positive expected return from evading, not all taxpayers evade taxes.<sup>4</sup> Another controversial prediction is that when  $\tau$  increases, a taxpayer characterized by decreasing absolute risk aversion would increase tax compliance.<sup>5</sup>

Subsequent research has extended the basic setting. In addition to analyze the impact on tax compliance of labour supply decisions, of progressive tax rules, of endogenous audit probability, several contributions have extended the basic setting by introducing assumptions on the role of stigma, social norms, the quality of public expenditure, taxpayers' moral attitude, the perceived fairness of the tax system (see Andreoni, Erard and Feinstein, 1998; Slemrod and Yitzhaki, 2002; Torgler, 2007). Although the flourishing literature, how the tax burden affects taxpayers' compliance is still an open question.

## 2.2 Empirical Evidence

The empirical evidence is not conclusive and, to some large extent, it seems to depend on the empirical strategy entailed. Time-series econometric studies using either aggregate or average measures of non compliance generally found a negative correlation between the tax rate and tax compliance (e.g. Crane and Nourzad, 1987; Poterba, 1987; Pommerehne and Weck-Hannemann, 1996).<sup>6</sup> Cross-sectional studies based on individual audited tax returns data have reported more mixed results. Indeed, while Clotfelter (1983) found that the level of the tax burden is positively associated with evaded incomes, other contributions found either no significant relationship (among others, Cox, 1984; Slemrod, 1985; Kamdar, 1995) or even a negative relationship (Feinstein, 1991).

Even experimental studies have provided some incoherent evidence. Two of the earliest studies conducted by Friedland, Maital and Rutenberg (1978), and Baldry (1987) using within-subject designs found that evaded incomes increased with the level of the tax rate. This result was replicated in a between-subject design with US students by Alm, Jackson and McKee (1992). However, a subsequent study (Alm, Sanchez and de Juan, 1995) with Spanish subjects did not confirm the previous finding.

The incapacity of the empirical literature to assess a clear relationship between the tax burden and compliance can depend on the different features of the identification strategies entailed. For example, while in econometric time-series analyses

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<sup>4</sup>See Andreoni, Erard and Feinstein (1998) and below for references on this puzzle.

<sup>5</sup>In particular, when fine  $s$  is related to evaded tax, increasing  $\tau$  has only an income effect making the individual poorer. If the individual is decreasing absolute risk averse (*dara*), she will respond by choosing a less risky position. The prediction becomes instead ambiguous when the taxpayer is not *dara*, or when the fine  $s$  is related to evaded income so that increasing  $\tau$  has both an income and a substitution effect (as in the original paper by Allingham and Sandmo 1972).

<sup>6</sup>Various empirical analyses have also been conducted to study the relationship between fiscal pressure and the size of the shadow economy, which does not coincide with tax evasion, but is related. Times-series analyses of individual countries in general document a negative effect (among others, Johnson, Kaufmann and Shleifer, 1997; Giles, Werkneh, and Johnson, 2001; Dell'Anno 2007). On the contrary, cross-sectional analyses find either a very weak or a no-significant relationship between the size of the underground economy of various countries around the world and their fiscal burdens (evidence and references in e.g. Schneider and Enste, 2000; Torgler and Schneider, 2009).

and within-subjects experiments identification is usually pursued by looking at the effects of a change in the tax rate on the observed behavior, in cross-sectional analyses and between-subjects experiments it is mainly inferred by comparing observed data from different countries or different subject pools. Clearly, from the view point of standard economic theory, the sign of the correlation between tax burden and evasion should be the same under the two approaches. However, if taxpayers' reaction to fiscal shocks is reabsorbed over time through adaptation, conclusions can change substantially. We shed light on these potential confounding effects in the next sections.

### 3 Tax Evasion with Reference Dependent Preference and Adaptation

Under reference dependent preferences (as entailed by the classical version of the Cumulative Prospect Theory, see Tversky and Kahneman, 1992), the objective function of the taxpayer can be written as:

$$V(d) = \pi(p)v(Y_a - r) + (1 - \pi(p))v(Y_{na} - r) \quad (3)$$

where  $r$  is a 'reference' income used by the taxpayer to make her reporting decision, while  $v(\cdot)$  is the reference dependent value function, concave in 'gains' and convex in 'losses'. In particular, we assume the original specification of  $v(\cdot)$ :

$$v(x) = \begin{cases} x^\gamma & \text{iff } x \geq 0 \\ -\lambda(-x)^\gamma & \text{iff } x < 0 \end{cases} \quad (4)$$

where  $\gamma \in [0, 1]$  and  $\lambda$  is the parameter capturing loss aversion, typically greater than 1.<sup>7</sup>  $\pi(p)$  and  $(1 - \pi(p))$  are subjective weights obtained as non-linear transformations of  $p$  and  $(1 - p)$ , respectively.<sup>8</sup>

As anticipated in the introduction, various contributions have focused on specific features of the Prospect Theory to accommodate puzzles associated with the standard expected utility approach. First, several studies (Alm, McClelland and Schulze, 1992; Erard and Feinstein, 1994; Bernasconi, 1998) have shown that the tendency to overweight small probabilities according to the transformation function  $\pi(\cdot)$  can explain why many taxpayers fully comply, even when the expected return of one dollar of evaded tax is positive. This result does not depend on the assumptions introduced to model the reference point.

Applications of reference dependent preferences based on equation (3) require the specification of the reference income,  $r$ . Bernasconi and Zanardi (2004) developed the analysis for an arbitrary  $r$ , included between 0 and the taxpayer's gross income,  $Y$ . While this approach offers useful insights about what the taxpayer can do depending on the value of the reference income - for example, when  $r$  is above/below  $Y_{na}$  and  $Y_a$  -, it fails to predict what the taxpayer actually does.

<sup>7</sup>For example, Tversky and Kahneman (1992) estimated a value of  $\lambda$  equal to 2.25.

<sup>8</sup>We adopt a rank-dependent specification of the probability weighting function. A large literature has discussed various alternative models, with some authors treating the function in the domain of gains and losses, separately (see Wakker, 2010, for discussion and references). See Dhimi and al-Nowaihi (2007) for a different specification allowing for the probability of detection to depend on the amount of evaded income.

In some earlier studies, Elffers and Hessing (1997) and Yaniv (1999) assumed that the taxpayer’s reference is determined by the difference between her gross income and any advance tax payment. This hypothesis accounts for the so called “withholding phenomenon”, namely the tendency of taxpayers who are under-withheld when filing to evade more than those who are over-withheld (see also Schepanski and Shearer, 1995). However, a doubtful implication of these models is that when advance tax payments are null, the reference income always coincides with  $Y$ .

Dhami and al-Nowaihi (2007) use the current legal after-tax income  $Y(1 - \tau)$  to specify taxpayers’ reference. This is consistent with the idea that taxpayers treat the current legal taxes as the status quo. Therefore, any tax cut with respect to the status quo represents a gain while any tax increase is seen as a loss. An important implication of their model is that the reference point is endogenous to the fiscal policy. While we find this argument convincing, we still believe that there are important issues that require further research.

A first controversial aspect is whether the reference should be defined according to the taxes legally due or, rather, (only) those the taxpayer feels in her duty to pay. For example, Rablen (2010) has recently argued that taxpayer’s perception of the taxes - as either losses or gains - may depend on the nature of the public expenditure financed through taxation. More generally, there are several dimensions (institutional, ethical, emotional) that influence taxpayers’ perception of the “fair” taxes to pay and contribute to the definition of the reference income.

A second issue concerns the assumption that the current legal tax rate always coincides with the status quo. As also highlighted by traditional theories of public finance (see Buchanan, 1967), when a change in the tax rate occurs, taxpayers may require time to adapt to the new fiscal conditions and, during the adjustment process, the status quo can differ from the current legal tax rate. In psychological terms, the problem consists of specifying the adaptive process followed by taxpayers to adjust their reference to the actual tax rate after a fiscal shock.

### 3.1 Hedonic Adaptation of the Reference Point and Tax Reporting Decisions

Given the previous considerations, we model the reference  $r$  in equation (3) as follows:

$$r = Y(1 - \beta\tau_r), \tag{5}$$

$$\tau_r = \alpha\tau + (1 - \alpha)\tau_{r-1}. \tag{6}$$

In words, by equation (5), the taxpayer’s reference income,  $r$ , depends on her gross income,  $Y$ , a reference tax rate,  $\tau_r$ , and a parameter  $\beta \in [0, 1]$  capturing her ‘moral’ attitude to pay taxes. As shown by equation (6),  $\tau_r$  evolves over time according to a first order adaptive process of the current legal tax rate  $\tau$  and the reference tax rate in the previous reporting period,  $\tau_{r-1}$ .<sup>9</sup> Clearly, in a stationary context,  $\tau_r = \tau$ , and the current tax rate coincides with the reference level. However, when a change in the tax rate occurs, the reference level  $\tau_r$  may differ from the current rate  $\tau$ . In this case, the reference rate adjusts over time to the current tax rate at a speed

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<sup>9</sup>Since all variables other than the reference tax rate refer to the current reporting period, in the following analysis we omit the time index.

which depends on the parameter  $\alpha$ . The parameter  $\beta$  represents the fraction of taxes (computed according to the reference tax rate) that the taxpayer feels obliged to pay for ethical or related reasons. Clearly, when  $\beta = 1$ , the taxpayer's ethical duty is to pay the full tax burden. On the other hand, if  $\beta < 1$ , she feels morally entitled to pay less than the full amount.

Weighted average adaptation processes similar to equation (6) abound in the behavioral economic literature (see, e.g., Frederick and Loewenstein, 1999; Bowman, Minehart and Rabin, 1999; Wathieu, 2004). Nevertheless, it is important to remark that perfect weighted average adaptation processes represent a simplification of the reality. An interesting refinement that finds empirical support suggests that while people quickly incorporate gains from improved positions in their reference, the adaptation to losses can require more time and even result in an incomplete process (see Diener, Lucas and Sollow, 2006; Arkes et al. 2008 and 2010; Lyubomirsky, 2011).<sup>10</sup> In our context, this implies that the value of  $\alpha$  is context dependent, being higher in the case of gains and lower in the case of deteriorations (Frederick and Loewenstein, 1999). Without loss of generality, the following theoretical analysis is developed under a constant  $\alpha$ . Nevertheless, we will come back to the possible asymmetry of  $\alpha$  in discussing the experimental evidence.<sup>11</sup>

Another important qualification concerns the parameter  $\beta$  capturing taxpayer's moral attitude. Although we treat  $\beta$  as exogenously given and fixed, the model can be generalized to a situation in which the taxpayer's moral attitude depends on various behavioral artifacts such as peer effects, social norms, stigma, the quality of fiscal institutions, the perceived fiscal equity, emotions. Indeed, rather than providing a novel analysis of the role of these factors for tax compliance (see Torgler, 2007 for a review), here our aim is to ascertain the channel through which they can exert their effects in a model of reference dependent preference with adaptation.

### 3.1.1 Static Solutions

By equation (5), the outcomes in the two states of the world, not audited and audited, are given by:

$$Y_{na} - r = -\tau d + \beta\tau_r Y, \quad (7)$$

$$Y_a - r = -\tau d + \beta\tau_r Y - s\tau(Y - d). \quad (8)$$

We now compute the taxpayer's optimal reported income by plugging the previous two expressions in the reference dependent value function. We first derive the optimal reported income in a static context when  $\tau$  and  $\tau_r$  are fixed. Then, we use the

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<sup>10</sup>Strahilevitz and Loewenstein (1998) showed that while a person becomes attached to an object almost instantly after receiving it, adaptation to the loss of its possession requires time and depends on the length of time the object remained in her possession. In an experiment on security trading, Arkes et al. (2008) found that subjects adapt their reference price used to evaluate financial assets both upwards following financial gains, and downwards as a consequence of financial losses. However, they noticed that adaptation to gains is faster and larger in size. They also showed that the asymmetry is robust across trading situations and cultures (Arkes et al. 2010).

<sup>11</sup>A different issue concerns the role of expectations, which are known to also affect the process of the formation of reference points (Kahneman and Tversky 1979). Clearly, weighted average adaptation processes are coherent with models of adaptive expectations. However, the model can be easily modified to take into account the role of exogenous shocks on expectations, like for example those coming from a policy announcement. (More on this in the conclusions).

static solution to analyze the effects of a change in the legal tax rate on the reported income given the adaptive process of the reference tax rate.<sup>12</sup>

In order to determine the static solution, we consider two cases, namely  $\tau \geq \beta\tau_r$  and  $\tau < \beta\tau_r$ . The first two propositions summarize the main static results when  $\tau \geq \beta\tau_r$ .

**Proposition 1.** *When  $\tau \geq \beta\tau_r$ , the optimal reported income,  $d$ , either coincides with the gross income,  $Y$ , or is in the interval  $d \in [0, \beta\frac{\tau_r}{\tau}Y]$ .<sup>13</sup> Moreover, when  $\tau = \tau_r$ , the optimal reported income,  $d$ , only depends on  $(Y, p, s, \beta)$  and is independent from the current tax rate,  $\tau$ .*

Proposition 1 applies when  $\tau \geq \beta\tau_r$ . On the one hand, the condition implies that, if audited, the taxpayer is always in the loss domain, namely  $Y_a - r = -\tau d + \beta\tau_r Y - s\tau(Y - d) < 0$ ; on the other hand, since  $Y_{na} - r = -\tau d + \beta\tau_r Y$ , it follows that in order to be in the gain domain if not audited, the taxpayer must report a fraction of gross income  $d/Y$  not greater than  $\beta\frac{\tau_r}{\tau}$ .

Notice that, since  $\beta \in [0, 1]$ , this solution also applies to the stationary context in which the reference tax rate is equal to the legal tax rate,  $\tau = \tau_r$ . When this occurs, the model implies that evasion is not affected by the level of tax rate, consistently with the adage that “an old tax is no tax”.

**Proposition 2.** *When  $\tau \geq \beta\tau_r$  and  $\tau \neq \tau_r$ , the optimal reported income,  $d$ , is increasing in the ratio between the reference tax rate and the current tax rate, namely  $\frac{\tau_r}{\tau}$ .*

Proposition 2 applies to two possible situations: one occurring when the legal tax rate,  $\tau$ , is higher than the reference tax rate,  $\tau_r$ ; the other when  $\tau$  is lower than  $\tau_r$ , but not as much as to leave, for *any* level of reported income, the taxpayer in the gain domain if not audited. In both cases, the model predicts that the evaded income is increasing in the ratio  $\frac{\tau_r}{\tau}$ . Intuitively, the greater the distance between  $\tau$  and  $\beta\tau_r$ , the higher the perceived losses associated with the payment of taxes are. We now move to the case when  $\tau < \beta\tau_r$ .

**Proposition 3.** *When  $\tau < \beta\tau_r$ , the optimal solution is either at  $d = 0$ , or in the interval  $d \in [\frac{s-\beta\frac{\tau_r}{\tau}}{s-1}Y, Y]$ . Compared to the stationary context where  $\tau = \tau_r$ , optimal reported income  $d$  can be either higher or lower. In both cases, optimal reported income is decreasing in the ratio  $\frac{\tau_r}{\tau}$ .*

Proposition 3 applies when  $\tau < \beta\tau_r$ . In this case, if not audited, the taxpayer is always in the gain domain while, if audited, she may end up in the gain or in the loss domain depending on whether her optimal reported income,  $d$ , is higher or lower than  $\beta\frac{s\tau - \beta\tau_r}{\tau(s-1)}$ . Together with the previous results, this implies that, due to the kink in the objective function, for  $\tau$  approaching  $\beta\tau_r$  from the left or from the right,

<sup>12</sup>The algebra to prove the Propositions of this Section is in the Appendix.

<sup>13</sup>The condition for the corner solution  $d = 0$  is  $\frac{1-\pi}{\pi\lambda(s-1)} > \left(\frac{\beta\tau_r}{s\tau - \beta\tau_r}\right)^{1-\gamma}$ . When  $\frac{1-\pi}{\pi\lambda(s-1)} < \left(\frac{\beta\tau_r}{s\tau - \beta\tau_r}\right)^{1-\gamma}$ , the conditions for the optimal solution to be in the interval  $d \in (0, \beta\frac{\tau_r}{\tau}Y)$  or at  $d = Y$ , are not straightforward and they in general require to compare the value of the objective at  $d = \beta\frac{\tau_r}{\tau}$  and at  $d = Y$ .

the optimal reported income exhibits a discontinuity. The discontinuity also implies that the optimal  $d$  when  $\tau < \beta\tau_r$  can be higher or lower than the corresponding level when  $\tau = \tau_r$ .<sup>14</sup> In any case, the optimal reported income,  $d$ , is, for fixed  $\tau_r$ , an increasing function of the legal tax rate  $\tau$ . Intuitively, when  $\tau < \beta\tau_r$  and the taxpayer is in the concave domain of the objective function, she tends to behave for a fixed reference point similarly to a standard expected utility maximizer.<sup>15</sup>

### 3.2 The Effects of Changing the Legal Tax Rate

The effects of a change in the legal tax rate on evasion are derived by combining the results in Propositions 2 and 3 with the adaptive process of the reference tax rate in equation (6).

Starting from a situation in which  $\tau = \tau_r$ , suppose that, in the reporting period  $t$ , the fiscal authority permanently increases  $\tau$ . By Proposition 2, the taxpayer reacts to the shock by reducing her reported income,  $d$ . However, due to adaptation, the reference tax rate,  $\tau_r$ , adjusts upwards to the new level of  $\tau$  in the following reporting periods. Clearly, during the adjustment process,  $d$  increases until it reaches the initial level. Figure 1 shows three possible adjustment processes (examples 1-3) in case of a piecewise linear value function (namely, when  $\gamma = 1$  in equation 4) and an increase in the legal tax rate from 0.27 to 0.38.

Opposite effects may occur when, starting from a situation in which  $\tau = \tau_r$ , the fiscal authority permanently decreases  $\tau$ . Results depend on whether, after the tax cut, the taxpayer ends up in a situation in which  $\tau \geq \beta\tau_r$  or  $\tau < \beta\tau_r$ . Let us start from the first case. By Proposition 2, the optimal reported income initially increases. However, by the adaptive process of the reference tax rate, the initial increase in  $d$  is reabsorbed in the following periods. Example 4 in Figure 1 illustrates the process for a piecewise linear value function and an hypothesized permanent reduction in the legal tax rate from 0.38 to 0.27.

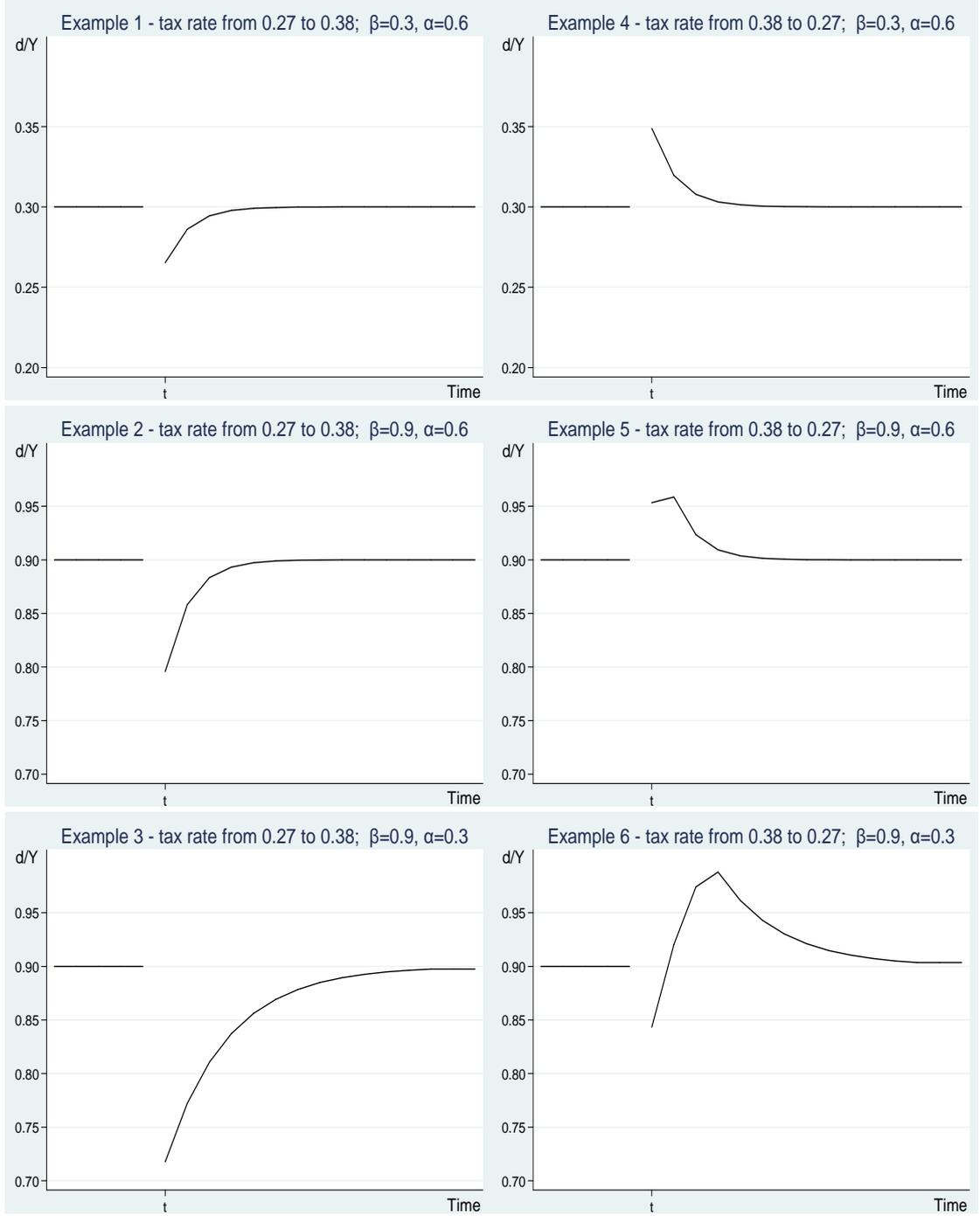
More complex patterns may arise when the reduction in the legal tax rate implies  $\tau < \beta\tau_r$ . By Proposition 3, the taxpayer can react to the shock by either increasing or decreasing her optimal reported income. By the adaptive process and as long as  $\tau < \beta\tau_r$ , the reported income increases as  $\tau_r$  adjusts downwards to the new value of  $\tau$ . At some point, however, the adaptive process in equation (6) will imply  $\tau \geq \beta\tau_r$ ; from that point onwards, as long as the reference tax rate continues adjusting to the legal level, the reported income decreases as implied by Proposition 2. Examples based on a piecewise linear value function that are consistent with these considerations are reported in examples 5 and 6 of Figure 1.

The likelihood of these patterns to emerge depends on the parameters of the model, including the speed of adaptation,  $\alpha$ . As discussed in Section 3.1, we remark that there may exist asymmetries in the value of  $\alpha$ , depending on whether the fiscal shock are internalized by the taxpayer as improvements or deteriorations of her economic conditions. In particular, while the positive effects of an increase in  $\tau$  on tax evasion can persist for a long interval of time, adaptation to a tax cut can be

<sup>14</sup>Put it differently, we know from Proposition 1 that the interval for the optimal internal solution when  $\tau = \tau_r$  is  $d \in [0, \beta Y]$ . This interval can overlap or be disjoint from the interval of the optimal internal solution when  $\tau < \beta\tau_r$ , namely  $d \in [\frac{s-\beta\tau_r}{s-1} Y, Y]$ .

<sup>15</sup>In fact, we recall that the reference dependent value function  $v(x) = x^\gamma$  in equation (4) is, for  $x \geq 0$  and  $\gamma \in [0, 1]$ , not only concave, but also decreasing absolute risk-averse.

FIGURE 1: Predictions of optimal reported income  $d/y$  for a piecewise linear value function ( $\gamma = 1$ ).



Examples of adjustments processes based on a piecewise linear value function  $v$  and a loss aversion parameter  $\lambda = 2.25$  as estimated by Kahneman and Tversky (1992). The optimal reported incomes are computed for the various parameters indicated in the examples (and  $s = 2$ ) using the following internal solutions. In Examples 1-4, the optimal internal solutions are always at the kink  $d = \beta \frac{\tau_r}{\tau} Y$ , applying when  $\tau \geq \beta \tau_r$  (see Propositions 1 and 2). In Examples 5 and 6, the optimal internal solutions are initially at the kink  $d/Y = \beta \frac{\tau_r}{\tau}$ , then at the kink  $d/Y = \frac{s - \beta \frac{\tau_r}{\tau}}{s - 1}$  applying when  $\tau < \beta \tau_r$  (see Proposition 3), and finally at  $d/Y = \beta \frac{\tau_r}{\tau}$ .

significantly faster and the effects on reported incomes negligible.

## 4 Experimental Analysis

### 4.1 Design

In this section, we present experimental evidence on the main theoretical predictions of our model. Our experiment is designed to address directly the issues of reference dependence and adaptation. More in details, in each session of our experiment, twenty subjects participated in two consecutive phases of 12 periods each.<sup>16</sup> The two phases were clearly separated and subjects received information about the experimental rules of the second phase only at the end of the first phase. In every period of the two phases, the computer randomly assigned to each subject a gross income included between 120 and 180 tokens. On the basis of her gross income, each subject decided how many tokens to report knowing that, on the reported amount, she had to pay taxes according to a flat tax rate that was kept constant across the 12 periods of the corresponding phase. Varying subjects' gross incomes over time was intended to rule out potential anchoring effects across repetitions that involved the same decisional task. In order to control for potential income effects due to the size of the gross income, we kept the variance of gross incomes sufficiently small.

At the end of each period, two subjects were randomly selected with equal probability and their choices audited. Subjects were informed that the probability of being audited did not depend on either actual and past choices or previous auditing procedures. This corresponds to an audit probability  $p = 0.1$  in each period. Being audited implied a sanction rate  $s = 2$  in the case the subject under-reported her gross income. At the end of each period, subjects were informed about their earnings and whether their choices were selected for auditing. Audited subjects also received feedbacks about the auditing procedure. Final monetary earnings were determined according one phase and one period only. In particular, at the end of each session, the phase and the period used to determine subjects' payments were selected by tossing a coin and randomly picking one of 12 cards, respectively.

The only difference between experimental sessions concerned the tax rates used in the two phases of the experiment. In particular, we ran four treatments with the following tax rates in the two phases: 27% and 38% in the first treatment; 38% and 27% in the second treatment; 27% and 27% in the third treatment; 38% and 38% in the fourth treatment.

Table 1 summarizes the main features of the experimental design. Overall we ran six experimental sessions: two sessions for treatment 1 and treatment 2 and one session for treatment 3 and treatment 4. The experiment was conducted at Bocconi University, Milan, between April and May 2010, with 120 participants, mainly undergraduate students in economics. Each subject participated to one session only. At their arrival, subjects were randomly assigned to a computer terminal. Once seated, instructions of the first phase were read aloud by an experimenter. Before the first phase started, control questions were administered and subjects' answers privately checked by experimenters. Instructions with the parameters for the second phase were handled at the end of the first phase and, again, read aloud. To minimize computational mistakes, subjects were also provided with a calculator on the

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<sup>16</sup>Instructions of the experiment can be found in the Appendix.

TABLE 1: Experimental Design

Treat.	Phase 1	Phase 2	All periods					
	Period 1-12	Period 13-24	Tokens drawn	Fine	Audit prob.	Subj. per session	Numb. of sessions	Total subj.
	Tax rate	Tax rate	per period					
1	0.27	0.38	120-180	s=2	2/20	20	2	40
2	0.38	0.27	120-180	s=2	2/20	20	2	40
3	0.27	0.27	120-180	s=2	2/20	20	1	20
4	0.38	0.38	120-180	s=2	2/20	20	1	20

computer screen. At the end of the experiments, subjects filled a questionnaire containing socio-demographic questions.<sup>17</sup> The experiment was computerised using the z-Tree software (Fischbacher, 2007). Final earnings, paid in private to participants, were based on an exchange rate of 10 tokens per euro. Subjects’ average earning was 12.77 euro for sessions lasting about 45 minutes.

## 4.2 Experimental Hypotheses

Our analysis focuses on treatments 1 and 2, that are based on the same parameters used in the simulations reported in Figure 1. We use treatments 3 and 4, in which the tax rates were kept constant between the two phases as controls. We remark that, regardless whether the tax rate changed between the two phases, the four treatments were equivalent in terms of both the saliency of the restart in the second phase and the procedures implemented.

Under the assumption that subjects’ initial reference is set to the legal tax rate given to subjects in the first twelve periods (i.e. 0.27 in treatments 1 and 3; 0.38 in treatments 2 and 4),<sup>18</sup> the first testable prediction of our model is that, in the first phase, subjects’ decisions are independent from the tax rate. Therefore, reported incomes do not differ between treatments in the first phase.

Moving to phase 2, we are interested in assessing (a) how tax compliance changes in the first period of the second phase (period 13) when subjects observe a change in the tax rate and (b) whether behaviors dynamically adjust as suggested by the adaptive process of the reference tax rate. In particular, we expect that the increase in the tax rate introduced in treatment 1 will cause a decrease in the reported incomes in period 13. Due to the more complex analysis associated with a tax cut, the effects on the reported incomes of the decrease in the tax rate in treatment 2 are more uncertain. In any case, as implied by the adaptive process of the reference tax rate, any change in the reported incomes observed at the beginning of the second phase of treatments 1 and 2 are temporary and expected to vanish over repetitions. Finally, we do not expect any change in reported incomes between the two phases in treatments 3 and 4 in which the tax rates are kept constant throughout the experiment.

<sup>17</sup>The full questionnaire is available from the authors.

<sup>18</sup>It is worth noticing that the tax rates 27% and 38% used in our experiment correspond to the central marginal tax rates of personal income taxation in Italy. This was done in order to support the adoption of such references at the beginning of the first phase.

### 4.3 Results

**Overview** Figure 2 plots the average reported incomes as a percentage of the gross endowment over periods for each treatment. Reported incomes decrease over repetitions in the first phase in all treatments, passing from the 40%-46% of the gross endowment in the first period to the 22%-28% in period 12. In the first period of the second phase (period 13), we observe a contraction of the average reported income in treatment 1 (around 18% of the gross income), while it increases in treatments 2, 3 and 4 (as a proportion of the gross income, around 31% in treatment 3 and 35% in treatments 2 and 4). Over repetitions in the second phase, average reported incomes remains virtually unchanged in treatment 1 while it decreases in treatments 2, 3, and 4.

Consistently with our theoretical predictions, the average reported incomes in the first phase do not present any remarkable difference between treatments. Moreover, by looking at the first period of the second phase, while the average reported income decreases in treatment 1 in which the tax rate raises from 27% to 38%, an opposite evidence emerge in treatment 2 in which the tax rate passes from 38% to 27%. Finally, in line with the effects of the adaptation of the reference tax rate, differences in the average reported incomes between treatments seem to disappear at the end of phase 2.

Nevertheless, Figure 2 also reveals some unpredicted behaviors. First, in all treatments, the average reported incomes tend to decrease over periods. Reasonably, by repeating the decisional task over periods, subjects might have learnt the high (expected) incentive to evade (90 cents per euro of evaded tax). Similar patterns over repetitions are observed in other tax evasion experiments (among others, Antonides and Robben, 1995; Maciejovsky, Kirchler and Schwarzenberger, 2007 and references therein). Second, we observe a ‘restart effect’ in treatments 3 and 4 where the tax rate did not change between phases.<sup>19</sup> This might be explained by the fact that subjects tend to reset a ‘trial and error’ strategy at the beginning of a new sequence of decisions.

These unpredicted effects imply that it is necessary to analyze more carefully the behavior of subjects in the main treatments 1 and 2. Among other things, a question to be considered concerns how much of the variations in average reported income observed between the two phases of these treatments are actually due to changes in the tax rates and how much to restart effects. We now present an econometric analysis aimed at disentangling the effects of various controls in the different experimental treatments.

**Regression analysis** Table 2 reports results from two random-effects Tobit models. Both models use subjects’ reported incomes as dependent variable, present left and right censoring limits and account for potential individual dependency over periods.<sup>20</sup>

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<sup>19</sup>Andreoni (1988) was the first paper to report a “restart effect” between two identical phases in a public good experiment that could not be related to strategic reasons.

<sup>20</sup>The left censoring endpoint is equal to 0, while the right censoring point coincides with the income of the period. The random effect is integrated using Gauss-Hermite quadrature with 64 points. The variances of the estimators are computed using the Hessian. The procedure was implemented in the statistical software R building on a previous function written by Arne Henningsen.

FIGURE 2: Average reported incomes per periods across treatments

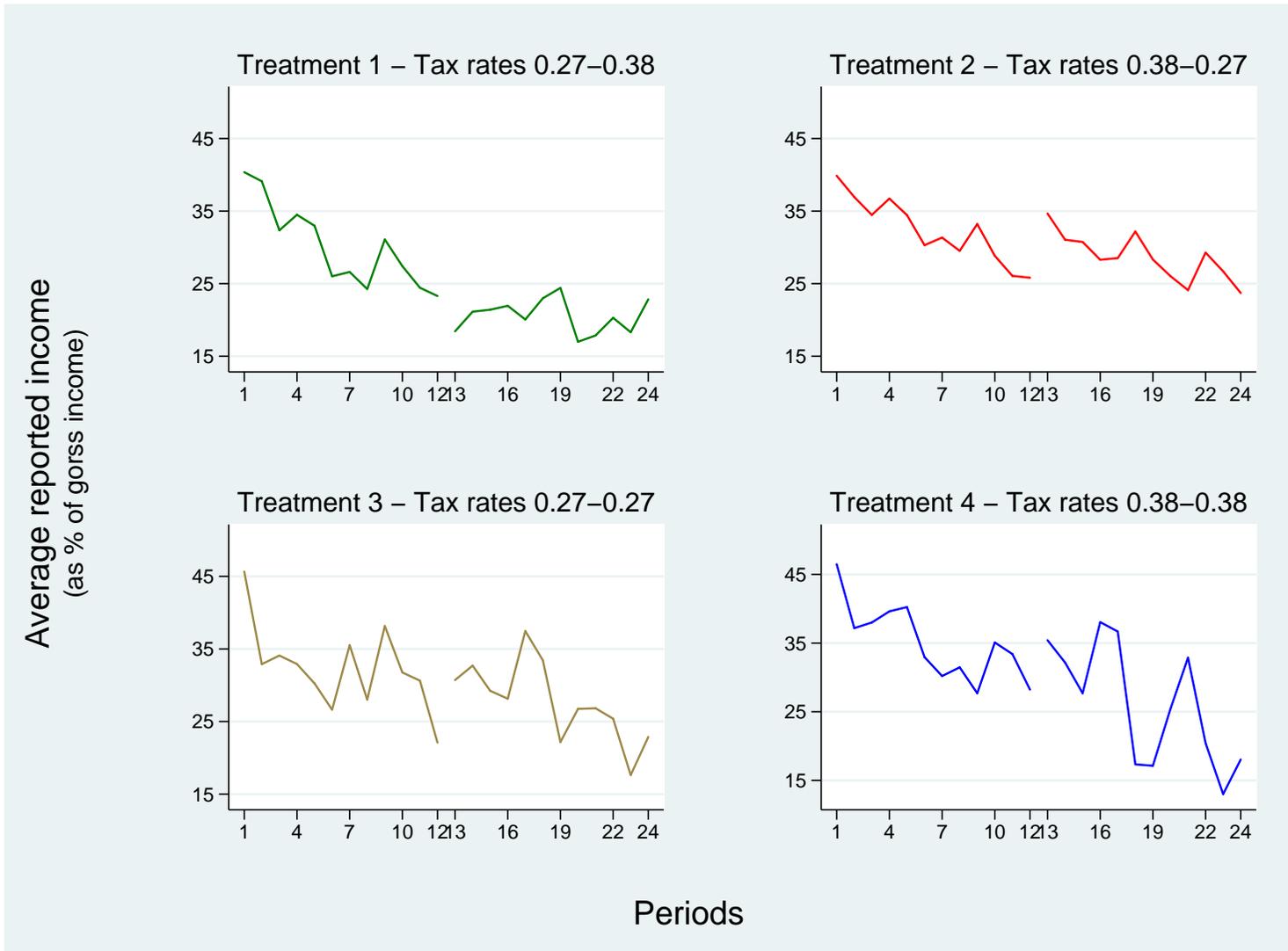


TABLE 2: TOBIT regressions (random effects)

Dependent variable: reported income	Unrestricted model		Restricted model	
	coeff.	(se)	coeff.	(se)
<i>General controls</i>				
Income	0.0976	(0.0876)	0.09553	(0.0876)
Audit in (t-1) (dummy=1)	-27.8094***	(5.4374)	-28.2605***	(5.4518)
Female (dummy=1)	67.6924***	(11.5772)	66.5056***	(9.2118)
Risk attitude (self reported)	-15.7706***	(2.3348)	-11.2089***	(1.9991)
Constant			68.5931***	(19.2031)
Period			-3.4697***	(0.4702)
<i>Controls phase 1 (periods 1-12)</i>				
Dum. 0.27 - (treat. 1,3, ph. 1)	83.1929***	(25.6638)		
Dum. 0.38 - (treat. 2,4, ph. 1)	98.5262***	(24.8352)		
Period×Dum. 0.27 - (treat. 1,3, ph. 1)	-3.8761***	(0.8604)		
Period×Dum. 0.38 - (treat. 2,4, ph. 1)	-3.2076***	(0.8330)		
<i>Controls phase 2 (periods 13-24)</i>				
Dummy phase 2 ("restart" effect)			26.8078***	(6.6809)
Dum. 0.27-0.38 - (treat. 1, ph. 2)	26.9624	(26.2346)	-39.9368***	(9.9418)
Dum. 0.38-0.27 - (treat. 2, ph. 2)	83.4403***	(25.7650)		
Dum. 0.27-0.27 - (treat. 3, ph. 2)	69.3152**	(28.2387)		
Dum. 0.38-0.38 - (treat. 4, ph. 2)	82.5320***	(25.8224)		
Period×Dum. 0.27-0.38 - (treat. 1, ph. 2)	-0.8789	(1.1255)	2.5686**	(1.2219)
Period×Dum. 0.38-0.27 - (treat. 2, ph. 2)	-2.4281**	(1.0604)		
Period×Dum. 0.27-0.27 - (treat. 3, ph. 2)	-4.4215***	(1.4283)		
Period×Dum. 0.38-0.38 - (treat. 4, ph. 2)	-4.3446***	(1.6128)		
<i>N</i>	2880		2880	
Subjects	120		120	
LL	-7887.022		-7890.637	
Wald $\chi^2$	327.30		218.5	
Prob> $\chi^2$	0.0000		0.0000	

Standard errors in parentheses; \* p< 0.1, \*\* p< 0.05, \*\*\* p< 0.01.

In both models we include a limited number of general controls and two groups of phase specific covariates to study the effects of the tax rate on subjects' reported incomes. As general controls, we include subject's gross endowment in the period (*Income*), a dummy assuming value 1 if the subject was audited in the previous period (*Audit in (t-1)*), a dummy to control for gender effects that assumes value 1 if the subject is female (*Female*), a measure of subjects' general propensity to undertake risky decisions (*Risk attitude*) based on individual self-assessments in the questionnaire.<sup>21</sup> As expected, the coefficient of *Income* is positive, though not significant. The effect of being audited in the previous period is negative and highly significant, as reported by previous experiments.<sup>22</sup> Women tend to evade less than men and the coefficient of *Risk attitude* is negative and highly significant.

In order to test the main predictions of the theory, the unrestricted model includes phase specific dummies. As controls for the first phase, we use two intercept dummies, *Dum. 0.27* and *Dum. 0.38* that take value 0 in periods 13-24 and value 1 if the tax rate in periods 1-12 was 0.27 (treatments 1 and 3) and 0.38 (treatments 2 and 4), respectively. We also add two interaction terms between a linear time trend, called *Period*, and the intercept dummies (*Period × Dum. 0.27*, *Period × Dum. 0.38*) to test whether the effect of the time trend on reported incomes in the first phase depends on the corresponding tax rate. In line with the theoretical prediction that, when  $\tau = \tau_r$ , the tax rate does not affect tax evasion, the difference between the coefficients of *Dum. 0.27* and *Dum. 0.38* is not significant (*diff* = -15.3333,  $t = -1.24$ ,  $p = 0.2148$ ). Similar conclusions emerge when we compare the coefficients of the interactions terms *Period × Dum. 0.27* and *Period × Dum. 0.38* (*diff* = -0.6685,  $t = -0.56$ ,  $p = 0.5764$ ).

Moving to the controls for the second phase, we include four dummies, *Dum. 0.27-0.38*, *Dum. 0.38-0.27*, *Dum. 0.27-0.27*, and *Dum. 0.38-0.38* that take value 0 in periods 1-12 and value 1 in periods 13-24 according to the corresponding treatment. As before, we also include interaction terms between the previous dummies and *Period*. As shown by the regression, subjects' behavior in the second phase of treatments 2, 3, and 4 is similar to what observed in the first phase: *Dum. 0.38-0.27*, *Dum. 0.27-0.27*, and *Dum. 0.38-0.38* are positive and significant and reported incomes decrease significantly across repetitions. Moreover, as shown by Tables 3 and 4, treatment dummies as well as interaction terms do not significantly differ between treatments 2, 3, and 4.

Focusing on treatment 1, we detect remarkable differences: the coefficient of *Dum. 0.27-0.38* is positive but not significant, and there is no significant decreasing trend (*Period × Dum. 0.27-0.38*) in phase 2. Moreover, as highlighted by Tables 3 and 4, we find significant differences between these estimated coefficients and those

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<sup>21</sup>In particular, the variable is constructed with the answers to one question of the questionnaire where subjects were asked to report on a scale from 1 to 10 their attitude towards risk. The specific question was: "in a scale from 1 to 10, how would you rate your attitude towards risk: are you a person always avoiding risk or do you love risk-taking behaviour?" 0 was described "I always choose the safest option and try to avoid any possible risk" and 10 was described "I love risk and I always choose the more risky alternative".

<sup>22</sup>Two possible explanations have been considered for this effect: one is that subjects may fail to apply basic principles of probability calculus and misperceive that an audit is less likely immediately after a previous audit (see Mittone 2006, for the first description of the phenomenon); another is that subjects who are audited in a period may try to recover the loss incurred by reducing reported income in the following period (Maciejovsky, Kirchler, and Schwarzenberger 2007).

TABLE 3: Comparisons of coefficients for intercepts in phase 2

		Dum. 0.38-0.38	Dum. 0.27-0.27	Dum. 0.27-0.38
Dum. 0.38-0.27	diff.	0.9082	14.1251	56.4779***
	t	(0.07)	(0.75)	(3.97)
Dum. 0.38-0.38	diff.		13.2168	55.5696***
	t		(0.67)	(3.59)
Dum. 0.27-0.27	diff.			42.3528***
	t			(2.63)

TABLE 4: Comparisons of coefficients for trends in phase 2

		Period× Dum. 0.38-0.38	Period× Dum. 0.27-0.27	Period× Dum. 0.27-0.38
Period×Dum. 0.38-0.27	diff.	1.9165	1.9934	-1.5491
	t	(0.99)	(1.12)	(-1.00)
Period×Dum. 0.38-0.38	diff.		0.077	-3.4657*
	t		(0.04)	(-1.77)
Period×Dum. 0.27-0.27	diff.			-3.5426*
	t			(-1.95)

associated with the other three treatments. These differences are consistent with the prediction that people respond to an increase in the tax rate by reducing compliance, but also that with repetitions the differences in behavior tend to disappear.

This evidence confirms the existence of an asymmetry in the reactions to changes in the tax rates. In particular, while we observe a negative and significant effect of an increase in the tax rate on tax compliance in treatment 1, we do not find any significant effect of the tax cut in treatment 2 — as reported incomes in treatment 2 do not differ from those observed in treatments 3 and 4. Thus, the results are consistent with the idea that subjects adapt very quickly to improvements in their conditions, but not to deteriorations ( $\alpha \simeq 1$  for gains;  $\alpha < 1$  for losses).

In order to further validate the above findings, we conducted a regression of a restricted model shown in the last column of Table 2. The restricted specification does not include any control to account for differences in the tax rates in the first phase of the experimental treatments. The model includes a general *Constant* term (positive and highly significant) and the time trend *Period* (that, as implied by the previous specifications, turns to be negative and highly significant). To characterize subjects' behavior in the second phase of the experiments, the restricted model includes a dummy variable assuming value 1 only in periods 13-24 (*Phase 2*) to capture the restarting effect observed in the data. No dummies are introduced for treatments 2, 3 and 4, as we found that subjects behaved similarly in these treatments. The restricted model maintains *Dum. 0.27-0.38* and *Period × Dum. 0.27-0.38* for phase 2 of treatment 1. Both coefficients are highly significant and with the predicted sign: negative the dummy and positive the trend.<sup>23</sup>

<sup>23</sup>We also conducted a likelihood ratio test which indicates that the restricted model is an accepted restriction of the unrestricted specification ( $LR = 7.2301$ ,  $df = 7$ ,  $p = 0.4053$ ).

## 5 Concluding remarks: policy implications

The analysis developed in this paper has policy implications. It is widely thought that the problem of tax evasion has been exacerbated in many countries by the increase of the tax burdens occurred in various phases of the second half of the last century (Tanzi and Schuknecht 1997). A classical question therefore considered in the literature concerns the possibility of using a reduction in the tax rates as a valid instrument to influence tax evasion (Clotfelter 1983).

Our analysis has shown that, in a model with reference dependent preferences, it is reasonable to expect that the taxpayers will in the long run adapt to different levels of fiscal pressures. This implies that it is not possible to consider the *levels* of the tax rates as responsible for the *levels* of tax evasion. We believe that even our simple experiment has given support to this intuition. At the same time, our theory does not contradict the idea that a *rise* in the tax rates can cause an increase in tax evasion. In particular, the notion that adaptation to losses needs time implies that during a transition period an increase in the tax rate will bring about more tax evasion than otherwise occurring, which is a prediction also documented by our experiment. How long can be the transition period in the real world is an empirical issue, but it is clear that if the tax rates are continuously raised over time (perhaps in an attempt to catch up with an increased tax evasion), a sort of vicious circle could even occur in our model, with increasing tax rates which keep tax evasion artificially high.

However, for the reasons related to the asymmetry in people behavior between positive versus negative changes, our model does not support the idea that a policy of reduction of the tax rates could have long-lasting success to increase tax compliance. In fact, a natural refinement of our model implies that the announcement of such type of policy could in some cases be even detrimental. For example, a large literature on reference dependence has emphasized that reference points are also affected by expectations. Reference adaptation processes are obviously coherent with models of adaptive expectations. Nevertheless, policy announcements like the proposal to cut the tax burden may exogenously affect the taxpayers' expectations, e.g. by lowering the reference tax rate. The asymmetry in adaptation then implies that if the fiscal authorities realize promptly what they have announced, the positive effect for compliance of the reduction in the tax rates may anyway be negligible; but if the fiscal authorities do not realize promptly and completely what they have announced, the reference tax rate may remain lower than the legal one with evasion staying high simply because of the promise of the tax cut.

Therefore, the final lesson to be learned from our analysis is that the tax rates should be kept relatively stable and not used to influence tax compliance. For the latter, and in particular for long-run tax compliance, our theory maintains that other factors, including those related to classical deterrent instruments and those capable to sustain the taxpayers' tax morale (incorporated in parameter  $\beta$  of our model), are more likely to be pivotal.

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# Appendix

## A Proofs

In this appendix, we present the theoretical framework to solve the maximization problem stated in equation (5) that is used to derive the propositions stated in section 3.1. The taxpayer chooses the reported income,  $d$ , that maximizes the objective function:

$$V(d) = \pi(p) \cdot v(Y_a - r) + (1 - \pi(p)) \cdot v(Y_{na} - r) \quad (9)$$

with  $v(x)$  given by:

$$v(x) = \begin{cases} x^\gamma & \text{iff } x \geq 0, \\ -\lambda(-x)^\gamma & \text{iff } x < 0, \end{cases} \quad (10)$$

where  $Y_{na} - r = -\tau d + \beta\tau_r Y$  and  $Y_a - r = -\tau d + \beta\tau_r Y - s\tau(Y - d)$ . In order to solve the maximization problem, we have to specify which part of the value function  $v(x)$  — either the gain or the loss domain — is relevant for the arguments  $(Y_{na} - r)$  and  $(Y_a - r)$ . For this purposes it is useful to distinguish between two cases: a) when  $\tau \geq \beta\tau_r$ ; b) when  $\tau < \beta\tau_r$ . Moreover, since  $Y_{na} \geq Y_a$ , it is useful to specify the following three possibilities:

1.  $V(d) = -\lambda \cdot \pi \cdot [\tau d - \beta\tau_r Y + s\tau(Y - d)]^\gamma + (1 - \pi)[- \tau d + \beta\tau_r Y]^\gamma$ , when  $Y_{na} \geq 0 > Y_a$ ;
2.  $V^-(d) = -\lambda \cdot \pi \cdot [\tau d - \beta\tau_r Y + s\tau(Y - d)]^\gamma - \lambda \cdot (1 - \pi)[\tau d - \beta\tau_r Y]^\gamma$ , when  $0 > Y_{na} \geq Y_a$ ;
3.  $V^+(d) = \pi \cdot [-\tau d + \beta\tau_r Y - s\tau(Y - d)]^\gamma + (1 - \pi)[- \tau d + \beta\tau_r Y]^\gamma$ , when  $Y_{na} \geq Y_a \geq 0$ .

a)  $\tau \geq \beta\tau_r$ .

In this case,  $Y_a - r = -\tau d + \beta\tau_r Y - s\tau(Y - d) < 0$  for all  $d \in [0, Y]$ , which implies that, when audited, the taxpayer is always in the loss domain. We remark that this case also applies for the stationary context in which  $\tau = \tau_r$  (given in particular that  $\beta \in [0, 1]$ ). In this case, provided that  $d < \frac{\beta\tau_r}{\tau} Y$  (see discussion below for  $d > \frac{\beta\tau_r}{\tau} Y$ ), the objective function of the maximization problem is  $V(d) = -\lambda \cdot \pi \cdot [\tau d - \beta\tau_r Y + s\tau(Y - d)]^\gamma + (1 - \pi)[- \tau d + \beta\tau_r Y]^\gamma$ .

Computing its first derivative and solving for  $\partial V / \partial d = 0$  implies:

$$d^* = Y \frac{\frac{\beta\tau_r}{\tau}(K + 1) - s}{K + 1 - s} \quad (11)$$

where  $K = \left[ \frac{1 - \pi}{\pi\lambda(s - 1)} \right]^{\frac{1}{\gamma - 1}}$ . Some algebra implies that:

1. if  $\frac{1 - \pi}{\pi\lambda(s - 1)} > \left( \frac{\beta\tau_r}{s\tau - \beta\tau_r} \right)^{1 - \gamma}$ , then the optimal reported income is  $d = 0$ ;

2. if  $\frac{1-\pi}{\pi\lambda(s-1)} < \left(\frac{\beta\tau_r}{s\tau-\beta\tau_r}\right)^{1-\gamma}$  and  $V(d^*) > V^-(Y)$ , then the optimal reported income is  $d = d^*\epsilon(0, Y)$ ;
3. if  $\frac{1-\pi}{\pi\lambda(s-1)} < \left(\frac{\beta\tau_r}{s\tau-\beta\tau_r}\right)^{1-\gamma}$  and  $V(d^*) < V^-(Y)$ , then the optimal reported income is  $d = Y$ .

Thus, the condition for the reported income to be strictly positive is  $\frac{1-\pi}{\pi\lambda(s-1)} < \left(\frac{\beta\tau_r}{s\tau-\beta\tau_r}\right)^{1-\gamma}$ . There is instead no straightforward condition to distinguish between  $d = d^*\epsilon(0, Y)$  and  $d = Y$ . The problem is that when the reported income is greater than the threshold  $\frac{\beta\tau_r Y}{\tau}$ , then  $Y_{na} - r = -\tau d + \beta\tau_r Y < 0$ , so that the taxpayer is in the loss domain even if not audited. In that case, the objective function becomes:  $V^-(d) = -\lambda \cdot \pi \cdot [+ \tau d - \beta\tau_r Y + s\tau(Y - d)]^\gamma - \lambda \cdot (1 - \pi) \cdot [+ \tau d - \beta\tau_r Y]^\gamma$ . This function is convex everywhere and therefore the optimal  $d$  can only be at the upper extreme of the interval  $d \in \left(\frac{\beta\tau_r Y}{\tau}, Y\right]$ . Since it is possible to show that, at  $d = \frac{\beta\tau_r Y}{\tau}$ ,  $V(d)$  is decreasing in  $d$ , it follows that when  $\frac{1-\pi}{\pi\lambda(s-1)} < \left(\frac{\beta\tau_r}{s\tau-\beta\tau_r}\right)^{1-\gamma}$ , the optimal reported income is either at  $V(d^*)$  or at  $V^-(Y)$ .

By simple algebra,  $\partial d^*/\partial \tau < 0$ . Thus, if  $d^*\epsilon(0, Y)$ , then an increase of the current tax rate,  $\tau$ , relatively to the reference tax rate,  $\tau_r$ , decreases the optimal reported income. Moreover, since  $\left(\frac{\beta\tau_r}{s\tau-\beta\tau_r}\right)^{1-\gamma}$  is decreasing in  $\tau$  and  $\partial V^-(Y)/\partial \tau < 0$ , it follows that as  $\tau$  raises, the optimal solution  $d = 0$  becomes more likely to occur than an internal solution  $d^*\epsilon(0, Y)$ , which in turn becomes more likely to occur than  $d = Y$ . These comparative static predictions give the results stated in Proposition 2.

When  $\tau = \tau_r$ , then  $d^* = Y \frac{\beta(K+1)-s}{K+1-s}$  which is independent of the tax burden. Moreover, simple algebra shows that when  $\tau = \tau_r$ , both the term  $\left(\frac{\beta\tau_r}{s\tau-\beta\tau_r}\right)^{1-\gamma}$  and the sign of  $[V(d^*) - V^-(Y)]$  are also independent of the tax rate. Thus, when  $\tau = \tau_r$  (the stationary context), the optimal reported income is unaffected by the tax rate (as stated in Proposition 1).

Finally, it is worthwhile noticing that in case of the piecewise linear utility function (with  $\gamma = 1$ ) used for the simulations presented in the text, the term  $K$  in equation (11) tends to  $+\infty$ . Therefore,  $d^* \rightarrow \frac{\beta\tau_r}{\tau} Y$  and the conditions for the corner and internal solutions simplify in: *i.*  $\frac{1-\pi}{\pi\lambda(s-1)} > 0$  for  $d = 0$ ; *ii.*  $\frac{1-\pi}{\pi\lambda(s-1)} < 0$  and  $\pi s < 1$  for  $d = d^*$ , and *iii.*  $\frac{1-\pi}{\pi\lambda(s-1)} < 0$  and  $\pi s > 1$  for  $d = Y$ .

b) Case  $\tau < \beta\tau_r$ . We distinguish between two sub-cases: b1)  $\tau < \beta\tau_r \leq s\tau$  and b2)  $\tau < s\tau < \beta\tau_r$ .

b1)  $\tau < \beta\tau_r \leq s\tau$ . In this case,  $Y_{na} - r = -\tau d + \beta\tau_r Y > 0$  for all values of  $d \in [0, Y]$ . Thus, the taxpayer is always in the gain domain if not audited. If audited, the taxpayer may end up in the loss domain with  $Y_a - r = -\tau d + \beta\tau_r Y - s\tau(Y - d) < 0$ , when she chooses  $d$  in the interval  $d \in [0, \frac{s\tau - \beta\tau_r}{\tau} Y)$ . It is however easy to show that the only possible optimum in this interval is  $d = 0$  (with  $V(0) = -\lambda\pi[-\beta\tau_r Y + s\tau Y]^\gamma + (1 - \pi)[\beta\tau_r Y]^\gamma$ ). When instead the taxpayer chooses  $d \in [\frac{s\tau - \beta\tau_r}{\tau} Y, Y]$ , it is easy to show that the optimum can only be internal or at  $d = Y$ . To find the internal solution, we first write the objective function  $V^+(d)$  when  $d \in [\frac{s\tau - \beta\tau_r}{\tau} Y, Y]$  which is given by:  $V^+(d) = \pi \cdot [-\tau d + \beta\tau_r Y - s\tau(Y - d)]^\gamma + (1 - \pi) \cdot [-\tau d + \beta\tau_r Y]^\gamma$

Taking the first derivative and solving for  $\partial V^+/\partial d = 0$ , it follows:

$$d^{**} = Y \cdot \frac{\frac{\beta\tau_r}{\tau}(1-F) + sF}{(s-1)F + 1} \quad (12)$$

where  $F = \left[ \frac{1-\pi}{\pi(s-1)} \right]^{\frac{1}{1-\gamma}}$ . Some algebra implies that:

1. if  $\pi s < 1$  and  $V(0) > V^+(d^{**})$ , the optimal reported income is  $d = 0$ ;
2. if  $\pi s < 1$  and  $V(0) < V^+(d^{**})$ , the optimal reported income is  $d = d^{**}$ ;
3. if  $\pi s > 1$ , the optimal reported income is  $d = Y$ .

b2) Sub-case  $\tau < s\tau < \beta\tau_r$ . In this case,  $Y_a - r = -\tau d + \beta\tau_r Y - s\tau(Y - d) > 0$  for all values of  $d \in [0, Y]$ . Thus, the taxpayer is in the gain domain even if audited. The internal optimum is given by  $d^{**}$  in equation (12). Some algebra implies that:

1. if  $\frac{1-\pi}{\pi(s-1)} > \left( \frac{\beta\tau_r}{s\tau - \beta\tau_r} \right)^{1-\gamma}$ , then the optimal reported income is  $d = 0$ ;
2. if  $\frac{1-\pi}{\pi(s-1)} < \left( \frac{\beta\tau_r}{s\tau - \beta\tau_r} \right)^{1-\gamma}$  and  $\pi s < 1$ , the optimal reported income is  $d = d^{**}$ ;
3. if  $\pi s > 1$ , the optimal reported income is  $d = Y$ .

Simple algebra shows that (since  $F > 1$  for  $\pi s < 1$ )  $\partial d^{**}/\partial \tau > 0$ . Thus, if  $d^* \in (0, Y)$ , then an increase of the current tax rate,  $\tau$ , relatively to the reference tax rate,  $\tau_r$ , increases the optimal reported income. Moreover, since both  $\partial V(0)/\partial \tau < 0$  and  $\frac{\partial \left( \frac{\beta\tau_r}{s\tau - \beta\tau_r} \right)^{1-\gamma}}{\partial \tau} < 0$ , it also follows that as  $\tau$  raises, the corner solution  $d = 0$  under both sub-case b1) and b2) becomes less likely to occur than the internal optimum  $d^{**}$ . These comparative static predictions deliver the second part of Proposition 3.

Finally, in case of the piecewise linear utility function (when  $\gamma = 1$ ), then the term  $F$  in equation (12) tends to  $+\infty$ . Thus,  $d^{**} \rightarrow \frac{s - \beta\tau_r}{s-1} Y$  and the conditions for the solution simplify in: *i.*  $\pi s < 1$  and  $[1 - \pi(1 + \lambda(s-1))] > 0$  for  $d = 0$ ; *ii.*  $\pi s < 1$  and  $[1 - \pi(1 + \lambda(s-1))] < 0$  for  $d = d^{**}$ ; <sup>24</sup> *iii.*  $\pi s > 1$  for  $d = Y$ .

## B Instructions

*[Instructions were originally written in Italian. Between treatments, instructions only differed in the tax rates used in the first and in the second phase.]*

### Instructions

Welcome. Thanks for participating in this experiment. If you follow the instructions carefully you can earn an amount of money that will be paid to you in cash at the end of the experiment. In this experiment, there are 20 participants. Of the other participants you will know neither the identity nor the earnings. During

<sup>24</sup>Obviously, the previous solution does not apply in sub-case b2 when  $s\tau < \beta\tau_r$ .

the experiment you are not allowed to talk or communicate in any way with other participants. If you have any questions raise your hand and one of the assistants will come to you to answer it. The rules that you are reading are the same for all participants.

#### General Rules

In this experiment you will participate to two consecutive phases. At the end of the experiment, one of the two phases will be randomly selected by tossing a coin and used to determine participants' final earnings. The instructions for the second phase will be distributed at the end of the first phase. During the experiment, your earnings will be expressed in tokens. At the end of the experiment, your final earnings will be converted into euro at the rate 10 tokens = 1 euro.

#### First Phase

The first phase consists of 12 consecutive periods in each of which you will make only one choice. At the end of the experiment, if the first phase will be used to determine participants' payments, your final earnings will depend on the results of one period only. In particular, the period used to determine participants' final earnings will be randomly selected by drawing one of 12 cards, numbered from 1 to 12.

#### Your task in each period of the first phase

In each of the 12 periods of the first phase, you have to choose which share of income to report in order to pay taxes. In particular, in each of the 12 periods of the first phase, the computer will randomly and anonymously assign an amount of tokens included between 120 and 180 tokens. For simplicity, let us refer to this amount of tokens as the gross income. Given your gross income, you have to choose how many tokens to report. On the reported amount of tokens, you will pay taxes according to a flat rate of XX%. You can report any number of tokens included between 0 and your gross income.

In each of the 12 periods of the first phase, the amount of tokens you have chosen to report can be randomly selected for auditing to verify the correspondence of your choice with respect to your gross income. In the case your choice is not selected for auditing, then your earnings in the period is given by your gross income minus the taxes computed on the amount of tokens you have reported. In the case your choice is selected for auditing and the amount of tokens you have reported is lower than your gross income, then your earnings in the period is given by your gross income minus the taxes computed on your gross income minus a fine that is equal to the taxes you have not paid. Of course, if the amount of tokens you have reported is equal to your gross income, then the auditing procedure does not imply any fine.

#### The auditing procedure

At the end of each period, after all the choices have been made, each subject is randomly and anonymously assigned one of 20 cards, numbered from 1 to 20, by the computer. Then, the computer randomly selects two of the 20 cards. The choices made by the owners of the two cards will be audited. The auditing procedure is anonymous. Therefore, participants whose choices have been audited are privately

informed about the results of the auditing procedure. Finally, notice that the probability to be audited in a given period does not depend on the results of the auditing procedures conducted in previous periods.

#### Second phase

The instructions for the second phase are the same of those used in the first phase. In particular, the second phase consists of 12 consecutive periods in each of which you will make only one choice. At the end of the experiment, if the second phase will be used to determine participants' payments, your final earnings will depend on the results of one period only. In particular, the period used to determine participants' final earnings will be randomly selected by drawing one of 12 cards, numbered from 1 to 12.

#### Your task in each period of the second phase

As in the previous phase, in each of the 12 periods of the second phase, you have to choose which share of income to report in order to pay taxes. In particular, in each of the 12 periods of the second phase, the computer will randomly and anonymously assign a gross income in tokens included between 120 and 180 tokens. Given your gross income, you have to choose how many tokens to report. On the reported amount of tokens, you will pay taxes according to a flat rate of XX%. You can report any number of tokens included between 0 and your gross income.

In each of the 12 periods of the second phase, the amount of tokens you have chosen to report can be randomly selected for auditing to verify the correspondence of your choice with respect to your gross income. In the case your choice is not selected for auditing, then your earnings in the period is given by your gross income minus the taxes computed on the amount of tokens you have reported. In the case your choice is selected for auditing and the amount of tokens you have reported is lower than your gross income, then your earnings in the period is given by your gross income minus the taxes computed on your gross income minus a fine that is equal to the taxes you have not paid. Of course, if the amount of tokens you have reported is equal to your gross income, then the auditing procedure does not imply any fine.

#### The auditing procedure

At the end of each period, after all the choices have been made, each subject is randomly and anonymously assigned one of 20 cards, numbered from 1 to 20, by the computer. Then, the computer randomly selects two of the 20 cards. The choices made by the owners of the two cards will be audited. The auditing procedure is anonymous. Therefore, participants whose choices have been audited are privately informed about the results of the auditing procedure. Finally, notice that the probability to be audited in a given period does not depend on the results of the auditing procedures conducted in previous periods.