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Do nudging letters play a role in contrasting tax evasion?

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Corresponding Author:	Roy Cerqueti Sapienza University of Rome: Universita degli Studi di Roma La Sapienza ITALY
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	Sapienza University of Rome: Universita degli Studi di Roma La Sapienza
Corresponding Author's Secondary Institution:	
First Author:	Amedeo Argentiero
First Author Secondary Information:	
Order of Authors:	Amedeo Argentiero
	Roy Cerqueti
	Raffaella Coppier
Order of Authors Secondary Information:	
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Response to Reviewers:	Dear Editor, I’m happy to submit the revised version of the manuscript “Do nudging letters play a role in contrasting tax evasion?”, co-authored with Amedeo Argentiero and Raffaella Coppier, and conditionally accepted in Quality and Quantity. We have revised the abstract in accordance with the Editor-in-Chief's requirements. Great thanks for your attention! Best regards,Roy Cerqueti

Do nudging letters play a role in contrasting tax evasion?

Amedeo Argentiero* Roy Cerqueti† Raffaella Coppier ‡

*University of International Studies, Faculty of Economics. Via Cristoforo Colombo 200, I-00147 Rome, Italy.
Email: amedeo.argentiero@unint.eu

†Corresponding author. Sapienza University of Rome, Department of Social and Economic Sciences. Piazzale Aldo Moro, 5, I-00185 Rome, Italy and University of Angers, GRANEM, SFR CONFLUENCES, F-49000 Angers, France. Email: roy.cerqueti@uniroma1.it

‡University of Macerata, Department of Economics and Law. Via Crescimbeni, 14, I-62100 Macerata, Italy. Email: raffaella.coppier@unimc.it

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Abstract

This study presents a theoretical sequential game for exploring a two-stage audit strategy implemented by the State to combat tax evasion. The players are the entrepreneurs and the tax inspectors who act on behalf of the State. Specifically, the model introduces the so-called "nudging letters", which represent a preliminary step in the audit process for "gently" pushing entrepreneurs to pay taxes before a formal inspection. It is shown that the nudging activity interacts with business cycle, taxation, bargaining power of the entrepreneurs, and audit policy. In detail, the results suggest that nudging letters strengthen the deterrence effect of monitoring activity through an increase in perceived reputational costs of evading. Moreover, monitoring activity is more effective in the presence of low tax rates.

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1 Introduction

Tax evasion represents the share of fiscal revenues deriving from the underground economy[1] and concealed to the Government. Much of this behavior is attributable to entrepreneurs and self-employed workers, because they are not subject to withholding tax, thus declaring an income lower than the actual one[2]. Since the seminal paper of Allingham and Sandmo (1972), economic literature has investigated the determinants of tax evasion with regard to the effectiveness of deterrence policies linked to the probability of detection and the fine raised to the discovered evaders (see, e.g., Alm et al., 1993; Andreoni et al., 1998; Orsi et al., 2014; Argentiero and Cerqueti, 2021). Despite this extensive research, a persistent discrepancy remains between the theoretical predictions of deterrence models and the limited real-world success of audit-based enforcement. In most countries, the probability of being audited is extremely low, yet compliance is far from negligible. This paradox suggests that tax behavior cannot be explained solely by expected utility maximization; it is also shaped by behavioral, social, and institutional dimensions that affect how individuals perceive the risks and fairness of taxation (Myles and Naylor, 1996; Alm, 2019; Dimant et al., 2020; Löfgren and Nordblom, 2020).

Recent behavioral and experimental studies have therefore emphasized that the decision to evade taxes is influenced by trust in institutions, social norms, fairness perceptions, and reputational concerns (Pickhardt and Prinz, 2014; Adriaenssens and Hendrickx, 2015; Weaver, 2014). Following Thaler and Sunstein (2008), these mechanisms can be affected through nudges low-cost, easily avoidable interventions that modify the choice architecture without changing monetary incentives. Among these tools, nudging letters have attracted growing attention as a practical instrument to gently

[1] Following OECD (2002): "Underground production consists of activities that are productive in an economic sense and quite legal (provided certain standards or regulations are complied with), but that are deliberately concealed from public authorities for the following kinds of reasons: a) to avoid the payment of income, value added or other taxes; b) to avoid payment of social security contributions; c) to avoid having to meet certain legal standards such as minimum wages, maximum hours, safety or health standards, etc.; d) to avoid complying with certain administrative procedures, such as completing statistical questionnaires or other administrative forms".

[2] In Italy, a country where tax evasion amounted to almost 90 billion euros per year from 2010 to 2014, in 2014 the share of taxpayers declaring an income above 200,000 euros was 0.25% of the total (source: Italian Ministry of Economy).

push taxpayers toward compliance by increasing the salience of audit risk and the social visibility of tax behavior.

Several governments have successfully implemented such policies, including the UK's Behavioral Insights Team, the US Internal Revenue Service, and, more recently, Italy's Cambioverso program. Empirical evidence from large-scale field experiments (Hallsworth et al., 2017; Kleven et al., 2011; Hasseldine et al., 2007; Ortega and Sanguinetti, 2013; European Commission, 2016; Santoro, 2019) confirms that nudging letters can significantly raise reported income and tax payments. More recent meta-analyses (Antinyan and Asatryan, 2024) and field collaborations with tax administrations (Pomeranz and Vila-Belda, 2019) show that deterrence-type nudges -those reinforcing perceived audit probabilities- tend to outperform moral or reminder nudges in boosting compliance. However, these findings remain largely empirical and fragmented.

Theoretical models that integrate nudging into the broader framework of tax enforcement are still scarce (Alm and Torgler, 2022). In particular, we lack a unified explanation of how deterrence nudges interact with audit probability, taxation, firm heterogeneity, and macroeconomic conditions. This absence of analytical modeling limits our understanding of the mechanisms through which soft behavioral instruments can complement traditional deterrence strategies.

This paper addresses this gap by developing a theoretical sequential game between entrepreneurs and tax inspectors, in which a two-stage auditing process is introduced. In the first stage, the State sends a nudging letter that prompts entrepreneurs to reconsider their declaration decisions before a formal audit takes place. This setup allows to study how the perceived probability of audit is endogenously shaped by entrepreneurs' moral sensitivity and reputational costs, and how these behavioral factors interact with taxation, bargaining power, and the business cycle. The results show that nudging letters raise the perceived audit probability heterogeneously across entrepreneurs, amplifying reputational costs and thereby strengthening the deterrence effect of monitoring activity. Moreover, the model highlights that tax evasion becomes more costly during positive phases of the business cycle, that nudging reinforces compliance particularly when tax rates are moderate, and that monitoring activity is most effective when coupled with behavioral interventions. Hence, this contribution is both theoretical and

policy-oriented: we integrate behavioral insights into the deterrence framework, providing a formal rationale for the inclusion of nudging instruments in tax enforcement strategies. By linking micro-level behavioral reactions to macro-policy implications, the paper bridges the gap between the empirical evidence on nudging and the analytical models of tax compliance.

The paper proceeds as follows. Section 2 discusses the relevant literature and policy background. Section 3 presents the theoretical model and derives the equilibrium outcomes. Section 4 develops the policy implications, and Section 5 concludes.

2 The background

Following Thaler and Sunstein (2008), a recent strand of the behavioral economics literature focuses on identifying economic interventions that can "push" agents to make better decisions without limiting their choices. Behavioral interventions aimed at strengthening tax compliance without, at the same time, changing the real economic incentives that guide the decisions of agents, are increasingly implemented by different countries as they are, at the same time, inexpensive and highly effective tools in increasing tax revenues. Regarding individual taxpayer behavior, different articles highlight the important role of "audit threat letters" sent to taxpayers: Slemrod et al. (2001) for Minnesota taxpayers and Kleven et al. (2011) for Denmark provide evidence in favor of the deterrence model of compliance, showing that "audit threat letters" increase reported income. Regarding business taxpayers, Hasseldine et al.(2007) for the UK, Ortega and Sanguinetti (2013) for Venezuela, also find evidence that an increased threat of audit increases reported income. At the public sector level, the nudge principle is used by some States: the first to undertake its use were the USA and the United Kingdom, which created real "Nudge Units" within their governments, precisely for the study and implementation of "kind pushes" towards taxpayers. The British "Nudge Unit" was established in 2010 by the then British Prime Minister David Cameron, who decided to call Richard Thaler to drive the Behavioral Insights Team (BIT). This team is made up of experts in the field of economics, psychology, statistics, and public policy. A very interesting BIT report is "Applying behavioral insights to reduce fraud, error and debt", which contains experiments carried out by the "Nudge Unit".

This report, published in M. Hallsworth et al. (2017), show the results highlighted by two experiments carried out on a sample of more than 200,000 individuals in the UK. These two experiments demonstrated the effectiveness of the "Letters of compliance" as a useful tool to combat tax evasion, producing in both cases an extra revenue for the State. These letters sent to the taxpayers are real nudges, given that they are at almost zero cost for the financial administration, both at no cost to taxpayers, who will be able, however, to decide to continue not to pay taxes, however due. Following the excellent results of the Behavioral Insights Team, many other States have begun to consider adopting behavioral policies, with the use of nudges, and many national cases are reported in the report of the European Commission (2016). States like France, Norway, and the United Kingdom have opted for a tool like the "Compliance letter" to try to prod taxpayers to one greater tax compliance. In Norway, the Norwegian Tax Administration (NTA) has sent letters to around 18,000 citizens. Half were informed about how to report their income and their wealth in tax models, the other half was informed of how the NTA was aware of their irregular income and wealth statements produced abroad. In 2015, Italy also introduced a regulatory change known as "Cambioverso" which aims to increase tax revenues, not by strengthening enforcement activity but with a gentle push (nudging). As reported by Santoro (2019), in the last three years, the agency has identified a growing number of taxpayers (700 thousand in 2016, 1.4 million in 2017, and 1.9 million in 2018) whose declarations presented inconsistencies and anomalies with respect to other data (of the same or other taxpayers) with which the declarations themselves were crossed. The tax agency then invited them, through specific letters, to pay the taxes due through the supplementary declarations, and thus obtained an additional revenue of 1.8 billion.

Recent research has continued to expand the empirical evidence on the effectiveness of nudging strategies in tax compliance across diverse contexts. For instance, Yang, Zhao and Zhou (2024) show that informational reminder nudges improve personal income tax reporting in China, while Saulitis and Chapkovski (2024) and that normative and deterrence-based messages increase wage declaration compliance among Latvian firms. Similar results emerge from developing economies, where Kalembe et al. (2025) demonstrate that simplified reminder and social-norm nudges enhance SME compliance in Uganda, and Abdelnabi et al. (2025) provide evidence from Pak-

istan that text-message nudges emphasizing loss aversion or active choice significantly raise tax filing rates. These recent studies confirm the growing global interest in behavioral approaches to tax enforcement and reinforce the need for theoretical models capable of explaining the underlying mechanisms of such interventions.

As highlighted by Antinyan and Asatryan (2024), there are several types of nudges: "deterrence nudges", "reminder nudges" and "tax morale nudges". In the first nudges, i.e. "deterrence nudges", *tax compliance may be driven by a cost-benefit calculation reflecting on the trade-off between higher retained income due to evasion and costs potentially incurred if caught evading. This is the essence of the so-called deterrence approach to tax compliance.*[3] Therefore, the fine rate and the probability of audit are the two key policy instruments for enforcing tax compliance (Alm, 2019). "Deterrence nudges" leverage these factors to promote compliance without altering the actual probability of audit or the fine rate. Substantial evidence from both field and laboratory studies confirms the importance of audit and penalty rates in compliance decisions (e.g., Slemrod, 2019)." Deterrence nudges" can enhance compliance by increasing the salience of audit and penalty rates for taxpayers or by updating their perceptions of these factors' magnitudes.

In "reminder nudges", tax compliance behavior can be influenced by the behavioral fallacy of limited attention. When individuals overlook tax payment deadlines, timely reminders can effectively address this issue and improve compliance.

Finally, "tax morale nudges" rely on the fact that various moral factors, including intrinsic motivation, social norms, altruism, reciprocity, and perceptions of fairness, can significantly influence tax compliance decisions.

Antinyan and Asatryan (2024) show that *deterrence nudges, that is, interventions that inform taxpayers about potential audit probabilities and fine rates when caught cheating, increase compliance by an additional 3.2 percentage points on top of reminders.*"

The nudging letters here considered are "deterrence nudges" because,

[3]The first three categories of letters identified by Slemrod (2019) can fall into this type of letter: 1) letters that contain information about the enforcement generally, such as the probability of audit or detection and the fines for detected and reported evasion; 2) letters that contain "explicit audit threats" and in this case, the consequent response to receiving such letters has the potential to shed light on the impact of changing the probability of audit because this type of letters can modify the perception of probability of audit for a tax payer; 3) letters that "convey that the tax authority possesses personalized information."

as it is stressed by Antinyan and Asatryan (2024): *it is also plausible that nudges implemented by tax authorities are simply more effective at updating perceptions of audit probabilities than perceptions of the various morale tax elements.*

In addition, as stressed by Pomeranz and Vila-Belda (2019) and Slemrod (2019), nudges that increase the perception of audit probabilities because this type of nudging letters are more effective in reducing tax evasion than the perception of a social norm. For this reason, the model considers that individual financial motives, rather than elements of tax morale, remain the most important factor behind compliant behavior.

3 Theoretical model

3.1 The model description

As already mentioned, the economy is made up of two players: the tax inspectors and the entrepreneurs.

At the outset of the game, the random variable Nature decides in which state entrepreneurs find themselves with their consequent level of production. In fact, it is assumed that the level of production depends on the state of Nature - good or bad - that may occur. Indeed, with probability $1-p$, an entrepreneur produces an amount y (good state of Nature), while with probability p, a bad state of Nature will occur and the entrepreneur's production will be equal to $y-e$ where $e \in [0, y]$ is the lost production of the adverse state of Nature. The entrepreneurs must pay taxes on declared production at a rate $t > 0$.

When a bad state of Nature occurs, the entrepreneur reports the real-low production $(y-e)$, while, in a good state of Nature, the production is y, and then the entrepreneur may find it worthwhile to partially evade taxes by reporting that a bad state of Nature has occurred. Therefore, quantity e plays a double role: it represents the lower level of production in a bad state of Nature, while in a good state of Nature it can represent the evaded production.

Evasion can be discovered only if the entrepreneur is checked by a tax inspector: in fact, the tax inspector, before the audit process, only knows the reported production by the entrepreneur, but he does not know the specific state of Nature that has occurred for the entrepreneur itself. Thus, he does

not check the entrepreneur if an amount y is reported, while he checks the entrepreneur's production when an amount $y - e$ is reported. Indeed, in this latter case, the tax inspector does not know whether the lower level of production derives from the adverse state of Nature or from the evasion. At this point, a two-stage auditing process begins: in the first stage of auditing activity the entrepreneur receives a "nudging letter" that warns him that the income he declared is low and that if he does not adhere to an agreement, he will undergo an audit procedure. The tax inspector, before the audit, only knows the declared income of the entrepreneur, but he does not know the specific state of Nature that has occurred for the entrepreneur itself. The evasion can be discovered only if the entrepreneur is audited by a tax inspector: in fact, the tax inspector can, only on the basis of an audit, find out whether the low income declared by the entrepreneur is due to a bad state of Nature or rather, is due to a false declaration by the entrepreneur, i.e., evasion. As a consequence of the "nudging letter", the entrepreneur can decide to avoid an audit and pay taxes on the declared production plus a fine, whose amount depends on the bargaining strength of the tax inspector and taxpayer. If an agreement between the tax inspector and the entrepreneur is not reached, the latter is subject to an audit and, in the case in which he is an evader, he must pay a fine on evaded taxes plus a reputation/moral cost, measuring the social image damage suffered by an evading enterprise (see e.g. Cerqueti and Coppier, 2009). Furthermore, the model assumes that entrepreneurs are not homogeneous agents regarding the social stigma (Casal and Mittone, 2016) they suffer in the case of discovered and reported evasion.

The underlying idea of the model is that the effect of nudging letters on the perception of audit probability is not the same for all entrepreneurs. Thus, the perception of the audit probability depends on the entrepreneur perceiving it.

In detail: in the first phase, the inspector send a nudging letter to all the entrepreneurs who declare a production $y-e$, and he proposes an agreement to the taxpayer on the amount – fine and taxes – to be paid to the State in order to avoid a lengthy and costly audit process. If the agreement is achieved, then the entrepreneur pays the taxes on the declared production $y-e$ plus a fine b, which is the Nash solution of a bargaining game between the entrepreneur and the tax inspector. In this case the control ends. The

bargaining strength of the entrepreneur is denoted by $\alpha \in (0,1)$ and, consequently, that of the tax inspector as $(1-\alpha)$.
In the case in which the agreement is not achieved (second phase), then a real audit, which allows the inspector to discover the eventual evasion, is made by the inspector at a cost for the entrepreneur and for the State. The $j-th$ entrepreneur, consequently receiving the nudging letter, estimates an audit probability that is linked to his "morality": the greater the reputational/ moral costs for the $j-th$ entrepreneur, the greater the upward bias of the estimated audit probability. It is assumed that entrepreneurs are not homogeneous agents and suffer different "reputation costs".
More specifically, the audit probability $\beta \in [0,1]$ is an objective value comes from the available public information about the audit activity of the State. In the case of a bad State of Nature, there will be no evasion, and therefore the entrepreneur will not change the perceived likelihood of being caught, which depends on the social stigma of being caught in evasion. In this situation, the entrepreneur's perception of the probability of being caught will coincide with the real probability β.
The introduction of nudging letters for all entrepreneurs has the effect of increasing the objectively perceived probability β. This effect is heterogeneous over the considered population; it is an increasing function of the specific moral "sensitivity" of entrepreneurs, i.e., to their heterogeneous reputation/moral costs. Thus, the probability of undergoing an audit perceived by the j-th entrepreneur is given by

$$\beta_j = \beta + \delta_j, \tag{1}$$

where $\delta_j \in [0, 1-\beta]$ takes larger values as the moral cost of the j-th entrepreneur are larger.
Now, assume that γ_j is the moral cost of the j-th entrepreneur. Without loss of generality, one can imagine that γ_j ranges in a bounded interval $[0, \Gamma]$, where 0 and $\Gamma > 0$ represent the corner cases of absence of moral cost (unethicity) and maximum level of moral cost, respectively. Then, one can assume that $\delta_j = \rho\gamma_j$, where $\rho \in \left[0, \frac{1-\beta}{\Gamma}\right]$. Thus, the parameter ρ serves as a universal translator of the moral cost in (over)perception of the audit probability. If $\rho = 0$, then the nudging letters have no effect on the entrepreneurs. As the value of ρ increases, then the nudging letters have a

greater effect on the population on the basis on the moral costs.
Without loss of generality, it is assumed that $\Gamma = 1$ and the distribution of entrepreneurs' costs[4] γ_j for the social stigma is uniform in $[0, 1]$.
The cost for the State of the audit activity is assumed to be proportional to evasion, and it is equal to $a \cdot e$. In the presence of an audit, the game proceeds according to the state of Nature.
If an adverse state of Nature has occurred, then there has been no evasion from the entrepreneur, and the audit of the tax inspector implies only a cost for the State.
If a good State of Nature has occurred, the tax inspector, through the audit, discovers the evasion. Then he reports it and the entrepreneur has to pay the taxes on the real production y plus a fine (k) proportional to evasion e.

3.2 The game: equilibria and solution

Given the framework described above, one can formalize the economic problem as a game with incomplete information. The payoff vector will be indicated with a couple of payoffs:

$$\underline{\pi} = (\pi^E, \pi^S) \tag{2}$$

where π^E and π^S represent the payoffs of the j-th entrepreneur and the State, respectively. The game works as follows (see Figure 1).

In the first stage, Nature decides in which state the entrepreneurs find themselves with their consequent level of production: y with probability $(1 - p)$ and $(y - e)$ with probability p.

- If the adverse State of Nature occurs, then the entrepreneur declares the real production $(y - e)$. The tax inspector, seeing a low level of declared income, sends a nudging letter in which he proposes to the taxpayer an agreement to pay a fine on the (eventual) evasion.

  - If the j-th entrepreneur accepts the proposed agreement, then he must pay taxes on the declared production $(y - e)$ plus a fine b, which is the result of a bargaining game between him and the tax

[4]It is assumed perfect knowledge of the term γ_j by all the players in this game, in the sense that there is an objective measure of the entrepreneurs' reputational damage.

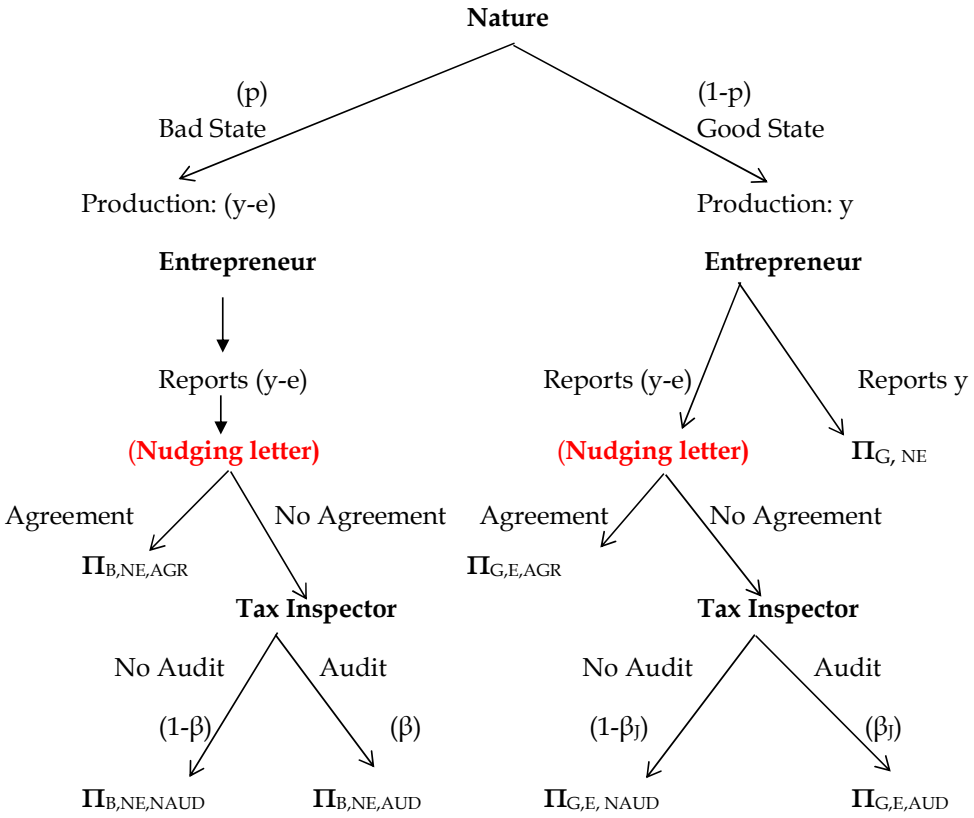

Figure 1: The game tree.

inspector. The State obtains the taxes paid by the entrepreneur plus b. The game ends with the payoff vector:

$$\underline{\pi}_{B,NE,AGR} = ((1-t)(y-e)-b, t(y-e)+b). \tag{3}$$

– If the agreement between the j-th entrepreneur and the tax inspector is not achieved, the tax inspector, with a probability β, makes an audit through which he discovers eventual evasion.

∗ If – with probability $(1-\beta)$ – the tax inspector does not check the entrepreneur's production, the j-th entrepreneur pays taxes only on the declared real production $(y-e)$ and the State obtains taxes equal to $t(y-e)$. The game ends with the payoff vector:

$$\underline{\pi}_{B,NE,NAUD} = ((1-t)(y-e), t(y-e)). \tag{4}$$

∗ If – with probability β – the tax inspector checks the entrepreneur's production, but, since evasion did not occur, the j-th entrepreneur must pay the taxes on the real production $y-e$ while the State must suffer the cost of audit ae. The game ends with the payoff vector given by:

$$\underline{\pi}_{B,NE,AU} = ((1-t)(y-e), t(y-e)-ae). \tag{5}$$

.

- If the good state of Nature occurs, the entrepreneur produces y, then two cases appear:

– If the entrepreneur decides to be honest and declare y, then the tax inspector does not check the entrepreneur's production, and the game ends with the following payoff vector:

$$\underline{\pi}_{G,NE} = ((1-t)y, ty). \tag{6}$$

– If the entrepreneur decides to evade, and thus he declares $y-e$, the tax inspector, seeing a low level of declared income, sends a nudging letter in which he proposes to the taxpayer an agreement

to pay a fine on the (eventual) evasion.

* If the j-th entrepreneur accepts the proposed agreement, then he must pay taxes on the declared production $(y - e)$ plus a fine b, which is the result of a bargaining game between him and the tax inspector. The State obtains the taxes paid by the entrepreneur plus b. The game ends with the payoff vector:

$$\underline{\pi}_{G,E,AGR} = ((1 - t)y + et - b, t(y - e) + b). \tag{7}$$

* If the agreement between the j-th entrepreneur and the tax inspector is not achieved, the tax inspector makes an audit through which he discovers the evasion. As already said, the effect of the nudging letters on the perception of audit probability is not the same for all the entrepreneurs: the nudging letters have the effect of raising the objectively perceived probability β and such an effect is an increasing function of the specific moral "sensitivity" of the entrepreneurs, i.e. to their heterogeneous reputation/moral costs. Thus, the probability of undergoing an audit perceived by the j-th entrepreneur is given by $\beta_j = \beta + \rho\gamma_j$. Therefore, there is an information asymmetry: the inspector performs an audit with a probability β equal for all entrepreneurs, but the j-th entrepreneur believes that it will be checked with a probability β_j.
  - If the tax inspector does not check the entrepreneur's production, the j-th entrepreneur pays taxes only on the declared production $(y - e)$ and the State obtains taxes equal to $t(y - e)$. The game ends with the payoff vector:

$$\underline{\pi}_{G,E,NAUD} = ((1 - t)y + et, t(y - e)). \tag{8}$$

  - If the tax inspector checks the entrepreneur's production, in this case, because evasion occurred, the j-th entrepreneur must pay the taxes on the real production y plus a fine ke. The game ends with the payoff vector

given by:

$$\underline{\pi}_{G,E,AUD} = ((1-t)y - ke, ty + ke - ae). \tag{9}$$

In order to proceed to the solution of the game, an explicit expression of the fiscal fine b_j^{NB} is provided. As already said above, such an expression is the result of the bargaining process between the j-th entrepreneur and the tax inspector. The solution of the game is different depending on the state of Nature. It is here presented and resolved only the non-trivial case, i.e., the case of the good State of Nature. Indeed, it is the only State in which evasion can occur.

Proposition 3.1. *There is a unique agreement amount b_j^{NB}, as the Nash solution to the bargaining game, given by:*

$$b_{j,good}^{NB} = e\{(t+k)[\beta(1-\alpha p) + (1-\alpha)\rho\gamma_j] - \alpha\beta a\}. \tag{10}$$

where $\alpha \in [0,1]$ measures the bargaining strength of the entrepreneur.

Proof. In this case, there is important asymmetric information between the entrepreneur – who knows which state of Nature occurs – and the tax inspector – who does not own this information. Therefore, when the tax inspector bargains for $b_{j,good}$, he knows that with probability p, the adverse state of Nature occurred (the entrepreneur is not an evader) while with a probability $(1-p)$ the good state of Nature occurred (the entrepreneur is an evader).

The entrepreneur has a surplus represented by the difference in payoff between the case in which they accept the agreement ($\pi_{G,E,AGR}^E$) and the case in which no agreement is reached ($\pi_{G,E,NAGR}^E$). In the latter case, the j-th entrepreneur (the evader) believes that they will be monitored and discovered with probability β_j. The random payoff is:

$$\pi_{G,E,NAGR}^E = \begin{cases} \pi_{G,E,AUD}^E = (1-t)y - ke, & \text{with probability } \beta_j; \\ \\ \pi_{G,E,NAUD}^E = (1-t)y + et, & \text{with probability } 1-\beta_j. \end{cases} \tag{11}$$

Therefore, the expected payoff for the j-th entrepreneur in the case of evasion without an agreement will be given by:

$$\mathbb{E}\left[\pi^{E}_{G,E,NAGR}\right] = y(1-t) - \beta_j ek + (1-\beta_j)et, \tag{12}$$

where $\mathbb{E}$ is the expected value operator. In the case where the agreement is reached, the expected payoff for the j-th entrepreneur will be given by:

$$\mathbb{E}\left[\pi^{E}_{G,E,AGR}\right] = y(1-t) + et - b \tag{13}$$

By (12) and (13), one has

$$\left\{\mathbb{E}\left[\pi^{E}_{G,E,AGR}\right] - \mathbb{E}\left[\pi^{E}_{G,E,NAGR}\right]\right\}^{\alpha} =$$

$$= [(1-t)y + et - b - (1-t)y + \beta_j ek - (1-\beta_j)et]^{\alpha} = [et\beta_j + \beta_j ke - b]^{\alpha},$$

which represents the surplus for the j-th entrepreneur resulting from whether or not, having evaded, he accepts the deal with the tax inspector, "weighted" for his bargaining strength α.

Regarding the surplus for the tax inspector, it is given by the difference between the payoff obtained in the case of an agreement (π^{S}_{AGR}) with the entrepreneur and the payoff obtained in the case where the agreement is not reached (π^{S}_{NAGR}). Regarding the payoff obtained by the inspector in the case where the agreement is reached, it is important to remember that the inspector does not know which state of Nature has occurred: he only sees a low-income declaration (y–e) and proposes an agreement to the entrepreneur. Since the payoff is the same in both states of nature, the random payoff is:

$$\pi^{S}_{AGR} = \begin{cases} t(y-e) + b, & \text{with probability } p; \\ \\ t(y-e) + b, & \text{with probability } 1-p. \end{cases} \tag{14}$$

Thus, the expected payoff for the tax inspector in case of agreement will be given by:

$$\mathbb{E}\left[\pi^{S}_{AGR}\right] = t(y-e) + b. \tag{15}$$

Conversely, in the case where the agreement is not reached and the inspector proceeds to carry out an audit, the payoff differs depending on whether a good state of Nature, with probability $(1-p)$, has occurred

($\pi^S_{G,E,AGR}$) or, with probability p, a bad state of Nature has occurred ($\pi^S_{B,NE,AGR}$).

In the case where a bad state of Nature has occurred, the random payoff for the inspector is given by:

$$\pi^S_{B,NE,NAGR} = \begin{cases} \pi^S_{B,NE,AUD} = t(y-e) - ae, & \text{with probability } \beta; \\ \\ \pi^S_{B,NE,NAUD} = t(y-e), & \text{with probability } 1-\beta. \end{cases} \tag{16}$$

Therefore, the expected payoff for the tax inspector in case of no agreement and a bad state of Nature will be given by:

$$\mathbb{E}\left[\pi^S_{B,NE,NAGR}\right] = t(y-e) - \beta ae. \tag{17}$$

In the case where a good state of Nature, with probability $(1-p)$, has occurred, the random payoff for the tax inspector is given by:

$$\pi^S_{G,E,NAGR} = \begin{cases} \pi^S_{G,E,AUD} = ty + ke - ae, & \text{with probability } \beta; \\ \\ \pi^S_{G,E,NAUD} = t(y-e), & \text{with probability } 1-\beta. \end{cases} \tag{18}$$

By (27), the expected payoff for the tax inspector in case of no agreement and a good state of Nature, will be given by:

$$\mathbb{E}\left[\pi^S_{G,E,NAGR}\right] = ty - et(1-\beta) + \beta ke - \beta ae. \tag{19}$$

The random payoff for the tax inspector in case of no agreement will be given by:

$$\pi^S_{NAGR} = \begin{cases} \pi^S_{B,NE,NAGR} = t(y-e) - \beta ae, & \text{with probability } p; \\ \\ \mathbb{E}\left[\pi^S_{G,E,NAGR}\right] = ty - et(1-\beta) + \beta e(k-a), & \text{with probability } 1-p. \end{cases} \tag{20}$$

By (20), the expected payoff for the tax inspector in case of no agreement will be given by:

$$\mathbb{E}\left[\pi^S_{NAGR}\right] = [t(y-e) - \beta ae]p + (1-p)[ty - et(1-\beta) + \beta e(k-a)] =$$

$$= ty - et(1-\beta) - pet\beta + (1-p)\beta ek - \beta ea.$$

Therefore, the surplus for the tax inspector is given by:

$$\left\{\mathbb{E}\left[\pi^S_{AGR}\right] - \mathbb{E}\left[\pi^S_{NAGR}\right]\right\}^{1-\alpha} = [t(y-e)+b-ty+et(1-\beta)+pet\beta-(1-p)\beta ek+\beta ea]^{1-\alpha} =$$

$$= [(b - \beta et(1-p) - \beta ke(1-p) + \beta ae]^{1-\alpha}$$

Then, following the generalized Nash bargaining theory, the agreement amount is the solution of the optimization problem

$$\max_{b\in[0,+\infty)} \vartheta(b), \tag{21}$$

where

$$\vartheta(b) := \left\{\mathbb{E}\left[\pi^E_{G,E,AGR}\right] - \mathbb{E}\left[\pi^E_{G,E,NAGR}\right]\right\}^{\alpha} \cdot \left\{\mathbb{E}\left[\pi^S_{AGR}\right] - \mathbb{E}\left[\pi^S_{NAGR}\right]\right\}^{1-\alpha} =$$

$$= [et\beta_j + \beta_j ke - b]^{\alpha} \cdot [b - \beta et(1-p) - \beta ke(1-p) + \beta ae]^{1-\alpha}. \tag{22}$$

Problem (21) has solution given by b_j^{NB} as in (10).

Indeed, by imposing the first order conditions on function ϑ in (22) with respect to b, one has

$$\vartheta'(b) = -\alpha\,[et\beta_j + \beta_j ke - b]^{\alpha-1}\,[b - \beta et(1-p) - \beta ke(1-p) + \beta ae]^{1-\alpha} +$$

$$+ [et\beta_j + \beta_j ke - b]^{\alpha}\,(1-\alpha)\,[b - \beta et(1-p) - \beta ke(1-p) + \beta ae]^{1-\alpha-1} = 0,$$

which is verified when

$$-\alpha\,[b - \beta et(1-p) - \beta ke(1-p) + \beta ae] + (1-\alpha)\,[et\beta_j + \beta_j ke - b] = 0. \tag{23}$$

Condition (23) is true when

$$b = \alpha\beta et(1-p) - \alpha\beta ea + \alpha(1-p)\beta ek + (1-\alpha)et\beta_j + (1-\alpha)ek\beta_j. \tag{24}$$

Some simple algebra assures that (24) is equivalent to say $b = b_j^{NB}$, where b_j^{NB} is as in (10).

□

The solution of the game is now presented.

Proposition 3.2. *Define*

$$\gamma^{\star} = \frac{t[(1-\beta)+\beta p\alpha] - \beta(1-p\alpha)k + \beta\alpha a}{(t+k)\rho(1-\alpha)}. \tag{25}$$

One has:

(a) if the reputation cost of the j-th entrepreneur is $\gamma_j > \gamma^{\star}$, then the game ends with the payoff $\underline{\pi}_{G,NE}$;

(b) if the reputation cost of the j-th entrepreneur is $\gamma_j \leq \gamma^{\star}$, then the game ends with the payoff vector $\underline{\pi}_{G,E,AGR}$

Proof. The game is solved by using the backward induction technique. We present only the non-trivial case, i.e. production y.
At the last stage of the game, the j-th entrepreneur believes that with a subjective probability β_j will be checked by the inspector, while with a probability equal to $(1-\beta_j)$ it will not be audited. In this stage of the game, the j-th entrepreneur must decide whether to agree with the conciliation proposed by the tax inspector or not. Substituting the value of b_j^{NB} in the payoff of the entrepreneur given in (13) (case of agreement with the bribe), his expected payoff is obtained as follows:

$$\mathbb{E}\left[\pi^{E}_{G,E,AGR}\right] = (1-t)y + et - e(t+k)\beta(1-p\alpha) - e(t+k)(1-\alpha)\rho\gamma_j + \alpha\beta ae. \tag{26}$$

The j-th entrepreneur finds it worthwhile to accept the conciliation and then the agreement is achieved if and only if:

$$\mathbb{E}\left[\pi^{E}_{G,E,AGR}\right] > \mathbb{E}\left[\pi^{E}_{G,E,NAGR}\right]. \tag{27}$$

Condition (27) can be rewritten as follows:

$$(1-t)y + et - e(t+k)\beta(1-p\alpha) - e(t+k)(1-\alpha)\rho\gamma_j + \alpha\beta ae >$$

$$> (1-t)y - (\beta+\rho\gamma_j)ke + et(1-(\beta+\rho\gamma_j)),$$

which leads to

$$\gamma_j > -\frac{\beta p}{\rho} - \frac{\beta a}{\rho(t+k)}. \tag{28}$$

Since, by definition, $\gamma_j \in [0, \Gamma]$, then the inequality in (28) is always verified.

At the second stage of the game, the j-th entrepreneur must decide whether to report y or $y - e$.

The entrepreneur reports production y if and only if he has, in reporting the real production, a payoff higher than the expected one when evading, i.e. if and only if $\pi^E_{G,NE} > \pi^E_{G,E,AGR}$, so that

$$(1-t)y > (1-t)y + et - e(t+k)\beta(1-p\alpha) - e(t+k)(1-\alpha)\rho\gamma_j + \alpha\beta ae, \quad (29)$$

which is verified when $\gamma_j > \gamma^\star$ of (25). □

It is assumed that entrepreneurs are uniformly distributed with respect to their reputation costs γ_j. Therefore, $\gamma^\star$ – if not greater than one – represents the fraction of evader entrepreneurs who decide to declare non-real production $(y-e)$. Clearly, if $\gamma^\star \geq 1$, then, all entrepreneurs are evaders, while the case $\gamma^\star \leq 0$ means that all entrepreneurs do not evade taxes.

The payoff vectors describe two different situations:

- $\underline{\pi}_{G,NE}$ is the equilibrium without evasion. It describes the situation in which the j-th entrepreneur will find it worthwhile to declare the entire production.
- $\underline{\pi}_{G,E,AGR}$ is the equilibrium with evasion.

4 Policy implications

Coherently with the analytical framework presented in Section 3, the policy implications discussed below originate directly from the model's equilibrium condition and comparative statics. In particular, the threshold value of the reputational cost γ^*, derived in equation (25), provides the structural foundation for interpreting the results of the simulations. Since γ^* is a function of the perceived audit probability ($\beta_j = \beta + \rho\gamma_j$), the tax rate (t), the entrepreneur's bargaining power (α), and the business cycle state (p), the following numerical exercises are not merely descriptive but represent graphical extensions of the theoretical mechanisms previously discussed. They allow to translate the analytical relationships into policy-relevant scenarios, thereby clarifying how changes in fiscal parameters or behavioral sensitivity affect the compliance equilibrium within the two-stage auditing framework. In fact, the results obtained via the solution of the sequential game presented

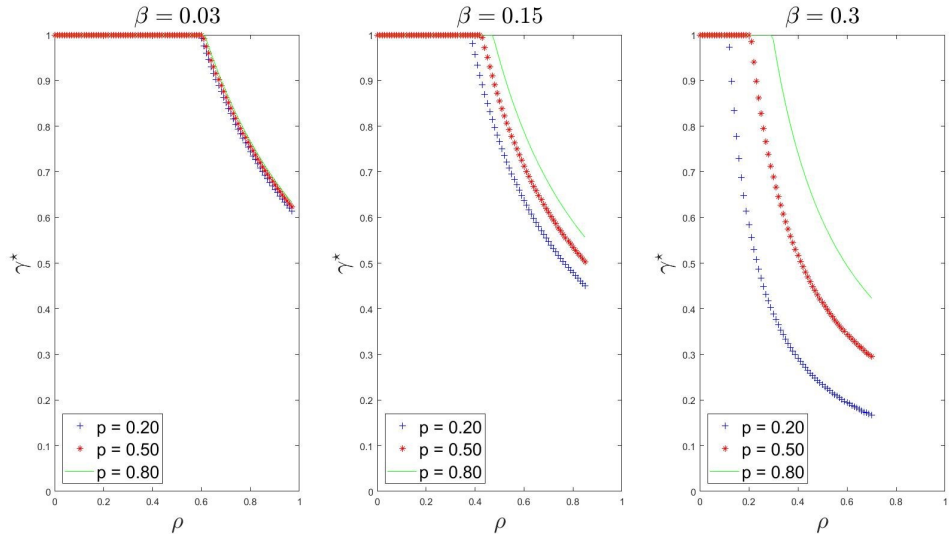

Figure 2: Simulation 1: different phases of the business cycle.

in the previous section allow to derive some important considerations for the policy-makers. To achieve this, three comparative statics simulations of the function $\gamma^* = f(\rho)$ in spaces of dimensions $\rho * \gamma^*$ are carried out. The parameter ρ is the subjective weight of the control probability cost, induced by the nudging letters, while γ^* represents the threshold value of the reputational cost of evading.

Without loss of generalization, the parametrization of the model for Italy is presented. Specifically, in each of these simulations, three values for the probability of being audited by the tax authorities are considered: $\beta = 0.03$, $\beta = 0.15$, $\beta = 0.30$. These values are in line with the stylized facts of Italy for the probability of being inspected by firm size: in fact, as amply documented by Corte dei Conti (Relazione Annuale sulla Finanza Pubblica, 2020), Italian firms have a different probability of being audited based on size class.

The first simulation (Figure 2) shows how different phases of the business cycle, measured by the parameter p, influence the function $\gamma^* = f(\rho)$ as β varies, considering the other parameters fixed based on what is indicated in table 1:

The value of the tax rate t corresponds to the legal rate of profit tax in

Table 1: Policy Simulation 1 - parametrization

Parameters	*Values*
t	0.24
α	0.02
a	0.02
k	0.50

Italy for capital companies (IRES), whereas the unit cost of the audit activity, indicated by parameter a, is equal to the ratio between the total cost of the inspections, measured by the cost of personnel of the Italian Revenue Agency, and the evasion recovered for the year 2019 (Agenzia delle Entrate, Relazione Annuale sulla performance).

The bargaining power, α, has been assumed equal to 0.50, to construct a "neutral" scenario in which the entrepreneur and the government have the same bargaining power. The fine, k, has been supposed equal to half the value of the tax evaded: generally speaking, this parameter varies according to a multiplicity of factors, such as the type of tax, the amount of the tax evaded and any amnesties provided for by the tax authorities.

In the first panel of Figure 2, with a low probability of being audited[5] it can be seen that there is a substantial coincidence of the three functions that link the subjective incidence of the probability of an audit with the threshold value of the reputational cost of evading. In particular, the maximum value of the latter is obtained at $\rho = 0.6$, showing indeed that with a low probability of inspection the subjective cost of the evader does not substantially depend on the phases of the business cycle. Differently, with increasing control probabilities (second and third panel of Figure 2), the maximum value of the reputational cost of evading is obtained with lower values of the perceived cost of the control probability: specifically, as the probability of positive phases of the economic cycle increases, a circumstance where the entrepreneur may find it convenient to hide part of its income from taxation, the values of the perceived cost of the probability of control associated with high reputational costs of tax evasion are reduced. Therefore, the attitude to evade in positive phases of the economic cycle, *ceteris paribus*, is more

[5]This value is in line with that found for Italy for SMEs and self-employed workers (see e.g. Orsi et al. 2014).

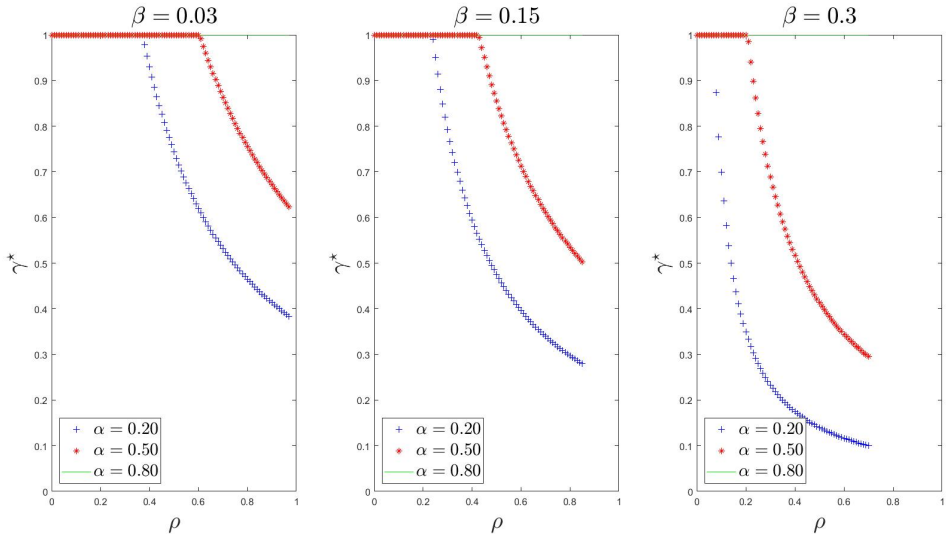

Figure 3: Simulation 2: different values of the entrepreneur bargaining power.

expensive in the presence of a more intense control activity.

The second simulation (Figure 3) shows how different values of the bargaining power, α, have an effect on the function $\gamma^* = f(\rho)$ as β varies, considering the other parameters fixed on the basis of what is indicated in the table 2.

Table 2: Policy Simulation 2 - parametrization

Parameters	*Values*
t	0.24
p	0.50
a	0.02
k	0.50

In this context, it is assumed a neutrality of the business cycle, on the basis of which $p = 0.5$.

The function $\gamma^* = f(\rho)$ is now influenced by the bargaining power of the entrepreneur: in particular, as it decreases, the values of the perceived cost of the control probability associated with high moral costs of evasion tend to decrease, but this effect is more marked in the transition from low to high probabilities of inspection (first, second, and third panel of Figure 2). The policy implication of this result is straightforward: the deterrence

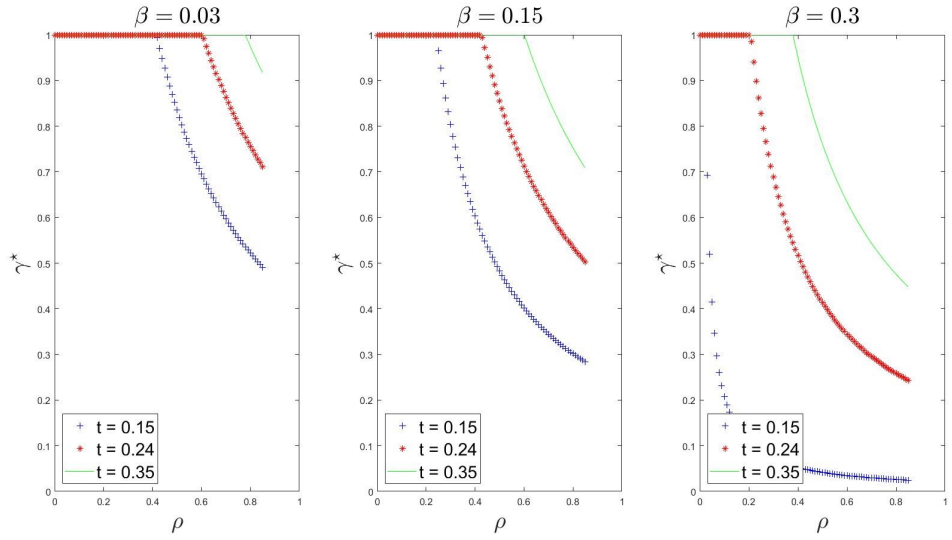

Figure 4: Simulation 3: different values of tax rate.

of anti-evasion controls through nudging letters weaken the effects of the entrepreneur's bargaining power on the reputational costs of tax evasion and on those perceived by the controls themselves. Even with low values of the latter, the maximum threshold of moral costs tends to be high.

Finally, the third simulation (Figure 4) shows how different values of the tax rate, t, have an effect on the function $\gamma^* = f(\rho)$ as β varies, considering the other parameters fixed on the basis of what is indicated in table 3.

Table 3: Policy Simulation 3 - parametrization

Parameters	*Values*
a	0.50
p	0.50
a	0.02
k	0.50

In particular, for each probability of being inspected, the function $\gamma^* = f(\rho)$ assumes three trends on the basis of three values of the tax rate: $t = 0.15, t = 0.24$ and $t = 0.35$. The first two values represent, respectively, the flat tax rate on profits for companies operating as partnerships and for self-employed workers with a turnover of less than €85,000, and the flat tax rate on profits for capital companies (IRES). The third value refers to a

hypothetical restrictive fiscal policy scenario.
In this case, in order for the high reputational costs linked to evasion to correspond to low values of the perceived cost of the associated control probability, the deterrence effect of the increased audits (first, second and third panel of figure 4) must necessarily be accompanied by a tax rate cut. On the contrary, in the presence of high values of the tax rate, individuals associate high moral costs linked to evasion with high costs perceived by the controller, thus weakening the latter's compliance function and nullifying the nudging letter tool. This suggests that monitoring activity is more effective in the presence of low tax rates. This result is in line with the results of Orsi et al. (2014), where a reduction in the tax burden accompanied by a greater effort in controls, leads to a reduction in the underground economy, and by Argentiero and Cerqueti (2021), who show how the level of taxation and monitoring activity are closely interconnected factors in a strategy aimed at reducing the debt/GDP ratio. In addition, the obtained contribution stresses the crucial role of the business cycle: when the economy faces a positive phase, tax evasion is more likely and hence, tax audits should be more intense. Yet, to assure a better effectiveness of the inspections, these latter must be associated with tax rate cut. The outcomes of the simulations are fully consistent with the mechanisms embedded in the theoretical model. As shown in equation (25), the equilibrium level of γ^* decreases with the perceived probability of audit and with higher moral sensitivity (ρ), while it increases with the tax rate and the entrepreneur's bargaining power. These relationships, analytically derived, explain the numerical patterns observed in Figures 2–4: during expansionary phases of the business cycle, evasion becomes more attractive unless the rise in perceived monitoring—reinforced by nudging letters—offsets it; when bargaining power shifts towards the tax authority, reputational concerns amplify compliance incentives; and finally, lower tax rates strengthen the effectiveness of monitoring policies by reducing the relative gain from evasion. Hence, the simulated results should be viewed as direct numerical implications of the equilibrium condition established in Section 3. This coherence confirms that the behavioral mechanisms introduced through nudging letters are not exogenous to the model but are formally integrated into the strategic interaction between entrepreneurs and the State, reinforcing the theoretical and policy relevance of the two-stage audit design.

5 Concluding remarks

In this paper, a theoretical model based on a sequential game with incomplete information is presented, to shed light on the determinants of the choice of tax evasion, also incorporating a two-stage auditing scheme based on "nudging letters" sent from the tax agency to the entrepreneur. In particular, it is shown that in a peak scenario of the business cycle, the entrepreneurs may choose to under report their production to reduce their fiscal obligations. The deterrence devices available to the State are based on: 1) tax audits, built in two stages: the former is a "nudging letter", with the aim of encouraging tax compliance spontaneously, the latter is a traditional inspection taking place in the case in which the "nudging letter" has no effects; 2) the State bargaining strength against the tax evader, when the agreement is achieved; 3) the magnitude of tax rate.

The nudging letters for all the entrepreneurs are shown to have the effect of raising the perceived probability of an audit. This effect is heterogeneous over the considered population of entrepreneurs; it is an increasing function of the specific moral "sensitivity" of the entrepreneurs, i.e. to their heterogeneous reputational costs.

The policy implications derived from a comparative statics simulation of our model are threefold: 1) in a positive phase of the business cycle, tax evasion can be made more expensive by a more severe audit policy; 2) nudging letters strengthen the deterrence effect of tax audit through an increase in perceived reputational costs of evading; 3) monitoring activity cannot be uncoupled from a tax rate cut, which, in turn, makes it more effective.
Possible and exciting developments of this work would be to consider different distributions of the reputational costs. In doing so, one can describe and explore countries in which moral costs are concentrated on the low values (economies in which there is low "inner honesty") and countries where, conversely, entrepreneurs have high moral costs (high "inner honesty"). Such challenging themes are already in our research agenda.

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