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Abstract

Purpose – The purpose of this paper is to use the instrumental game theory to understand the behavior of the front agents tax evasion and tax authority in Brazil.
Design/methodology/approach – In order to analyze the taxpayer's behavior before the Brazilian tax system and tax actions aimed at reducing tax evasion, the authors developed a theoretical model based on the payoffs of Graetz *et al.* (1986) and increased with situations proposed by Siqueira (2004), Lipatov (2006) and Oliveira (2011).
Findings – Considering the cases with and without specialists, the main results show that in high dropout situation, penalize taxpayers with high fines or deprivations of liberty may not be as effective. Another result of the analysis is that the audit and inspection costs played an important role in driving the equilibrium system.
Research limitations/implications – One limitation of this study is to consider how the exogenous tax authorities earnings (Federal Revenue of Brazil and Federal Police) and not as a function of the goals and certain enforcement policies for each public body.
Practical implications – The authors suggest the following policy: investing in tax inspectors and unbureaucratic the authorities of the cost structure become a more effective tool to combat non-compliance with tax obligations that the intensity of the penalties imposed by the act of evading.
Originality/value – This paper contributes to the literature insofar as it models for the first time, using game theory, the behavior of the evading agent and the tax authority in Brazil.

Keywords Specialists, Tax evasion, Game theory, Tax evasion in Brazil

Paper type Research paper

Introduction

Surveys usually draw a line between legal under-reporting of tax obligations, known as tax avoidance, and illegal undervaluation, or tax evasion. In the field of economics, however, it is impossible to distinguish between the two (Lipatov, 2005). In this situation, it makes sense to split these understatements into simple and sophisticated, rather than into evasion and avoidance. Simple tax evasion means not using either specialized accounting or financial specialists. Fiscal responsibility of sub-statements that require special knowledge will be called sophisticated tax evasion (sophisticated tax evasion: Lipatov (2005)).

It is noteworthy that there is no measurement of any type of tax evasion available. Schneider (2006), for example, used the informal sector as a proxy to tax evasion. Sophisticated evasion prevents such attempts because arrangements that are more complex are being considered. Therefore, we observed large cases of inspection and audit in the proportion of tax revenue from taxpayers in total tax revenue. In the USA, as noted by Slemrod (2004), the latter US fell from 6.4 percent of GDP in 1951 to less than 1.5 percent of GDP in recent years. Indirect evidence for the maintenance of sophisticated evasion is provided by the fact that the largest taxpayers in the USA have paid less tax in the last three years, even when they increased yields, as shown by Browning (2004). To solve this problem, many countries have made tax reforms and introduced revenue mobilization (Bekoe *et al.*, 2016).

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However, academic papers in this area are scarce. Tax evasion with specialists has increased in all sectors, because they need to submit their reports to audits by tax authorities regularly (every three years in most countries). Thus, they use a specialist to guarantee a tax evasion successful (Lipatov, 2005).

This does not mean that taxpayers are fully protected against the actions of the tax authorities, as has been highlighted by several scandals over the years. Dibra (2016) has prepared a wide collection of material on such scandals, which include the cases of Enron and Parmalat: probably the most famous cases. In addition, conventional tax havens represent sophisticated evasion. Johnston (2003) and Blackburn *et al.* (2010) showed that sophisticated tax evasion causes corruption and presents problems for economic development.

Recently, the use of sophisticated tax evasion has gone beyond corporate boundaries to include individuals with high net worth and high taxable income. These individuals use sophisticated evasion that is difficult to detect because it requires consideration of many legal entities, some of which either may be in another tax jurisdiction (another city, state, or country) or have been settled at the time of the audit (Klepper *et al.*, 1991; Erard, 1993).

The economic literature to date contains several contributions to analyze tax evasion and specialists. Reinganun and Wilde (1993) showed the potential of specialists to reduce cost statements. Using a game theory approach, they conclude that tax audit reports prepared by specialists are more effective than other tax audits.

In the most recent research, Crocker and Slemrod (2005) suggested that the effects of repressive policies depend on whether the agent is penalized. Lipatov (2005) analyzed the problem of tax evasion and showed that tax authorities must conduct more intense auditing of those taxpayers who do not coordinate their evasion decisions jointly.

In Brazil, Arbex and Mattos (2012) studied an ideal tax audit policy in an economy where consumers are encouraged to require tax reports of Brazilian companies through. The results of their study showed that these discounts are positive and more effective than is the probability of audit by the state. Del Vecchio Júnior (2012) showed that game theory is an important addition to the existing management practices in Organization of the Military Police of São Paulo, Brazil. Through these methods of investigation, we seek to mitigate tax evasion and increase tax authority inspection.

Brazilian system to tax control has two main public authorities that fight simple and sophisticated evasion: The Federal Revenue of Brazil (RFB) and the Federal Police (PF). RFB is the tax authority and is responsible for analyzing taxpayers' statements and checking for irregularities (SINPROFAZ, 2013).

When the RFB detects fraud, they notify the taxpayer to present evidence within a given period, to demonstrate the non-withholding of taxes required by the tax authorities. If taxpayer does not then submit the required papers, he is charged with tax evasion, and the PF initiate an inspection. PF then opens an inquiry and investigates bank accounts and equilibrium sheets, etc. If PF needs a more specific investigation, they ask the Financial Specialists sector to prepare a specialist report indicating where fraud and tax evasion can be seen to have occurred. However, if the taxpayer pays off the fine that is due and present new documents during the investigation, the criminal investigation is canceled and the company is cleared of any criminal activity (SINPROFAZ, 2013).

Nevertheless, how can the Brazilian tax authorities detect sophisticated evasion? First, they have to certify the tax reports to government agencies. This means that auditors play an essential role in sophisticated tax avoidance schemes. We use game theory approach to understand tax evasion behavior and tax authority control in Brazil. Brazilian laws dealing with the problem of tax evasion are general and do not consider the forms of tax evasion as sophisticated tax evasion with specialists.

Thus, this paper has four sections. We present the theoretical framework in the second section. In the third section, we show the configuration of the models and their interpretation. In the fourth section, we conclude by summarizing our results and suggesting the policy implications.

Theoretical framework

Allingham and Sandmo (1972) were the first to use economic tools to analyze tax compliance through modern risk theory developed by von Neumann and Morgenstern. Since then, the literature on the economic analysis of tax evasion has evolved and, most likely, few aspects of compliance with the tax law have escaped a preliminary economic review.

According to Siqueira and Ramos (2005), the main argument used in economic studies is that taxpayer's behavior is due to rational calculation and careful assessment of the costs and benefits of tax evasion. Even in the simplest systems of taxation, where the incentives for reliable compliance with tax obligations are not obvious, this economic perspective offers valuable findings that we use to derive appropriate measures of public policy.

In this context, the authors of existing literature highlight several methods that economists have used to measure tax evasion across countries.

Alm (1998) used statistical analysis via a sample survey to show how each factor influences the decision of the taxpayer to declare their tax obligations.

Allingham and Sandmo (1972) used behavioral modeling to develop the first model of taxpayers' tax evasion decisions. In this model, tax evasion is a portfolio allocation problem because the taxpayer must decide what portion of their income to invest in this risky activity. If the taxpayer does not want to take any chances, he fully declares his income; otherwise, he declares only a fraction of his income and accepts the risk of being caught and fined. Thus, one can write the expected utility of the taxpayer as:

$$UE(e) = (1–p).U(INA)+p.U(IA) = (1–p).U[y–t(y–e)] + p.U(y–ty–\beta te), \quad (1)$$

where e denotes the amount of evaded income ($e = y–x$), where x is declared income, t is the fixed rate to which the reported income is taxed, and evasion is fined in a β rate proportional to the evaded tax. *INA* is the net income when the evader is not audited, and *IA* is the net income when the evader is audited. The likelihood of an audit is fixed and exogenous and is given by p. The taxpayer decides to evade a portion of his tax to maximize the expected utility of his net income. This basic model gives a good idea of tax evasion decisions of taxpayers in a very simple structure: taxes and penalties are proportionate, the probability of audit is constant, and only one form of tax evasion is available.

Following this line of reasoning, Siqueira (2004) analyzed the main theoretical aspects of tax evasion and presented two main pieces of evidence about the problem of income tax evasion by individuals in Brazil, using an extension of the Allingham and Sandmo model. First approach is to increase the strength of the enforcement system by increasing the penalties for either infringement or the avoidance of detection. Second is to improve the efficiency of audits of tax statements. The results of Smith's study indicate that increases in audit probabilities, penalties, the marginal tax rate and efficiency of fine reduce individuals' income tax evasion.

Graetz *et al.* (1986) [1] contributed significantly to the literature and began interactive studies between agents and tax authorities.

They consider taxpayers as "compliers" and, usually, taxpayers report their income truly, given their pecuniary interests. Taxpayers act strategically, examining their incentives carefully, and act to maximize expected utility, given the likelihood of supervision associated with the income that they choose to report.

Graetz *et al.* (1986) assumed two classes of income – high and low, denoted by H and L, respectively, where $L < H$ and $L > 0$; $H > 0$. The incomes of taxpayers are not directly observable, so they can report either high or low income. H is the actual income and L represents the reported income; thus, H-L is the unreported income, t denotes the tax that the individual must pay to the tax authorities. They assumed that $t \leqslant L$ and $t \leqslant H$ and $t \geqslant 0$. Taxpayers found under-reporting their income will be fined by an amount equal to the amount withheld, designated s, ($s \geqslant 0$). The parameters t and s are shown to be values that are fixed by tax authorities.

They denoted c as a monitoring cost, where $c \geqslant 0$. For the model, it is assumed that $H - L + s > c$, i.e., the revenue associated with tax evasion and fines exceed the audit cost. They also assumed that $t + s \leqslant L$ and $t + s \leqslant H$, which is the sum of taxes plus fines, could not exceed the income of the taxpayer and that taxpayers who report truthfully will never pay fines and will not suffer from other audit costs.

Finally, q is the probability of choice by the taxpayer to evade, where $0 < q < 1$. Similarly, p is the probability of audit by the regulatory agencies, with $0 < p < 1$.

From this information, it is possible to obtain a taxpayer's utility function $U(p,q)$ and the expected revenue from the tax authorities $\pi(p,q)$:

$$U(p,q) = pq\,(H - st(H - L) - t(H - L) - 1) + qtH + (1 - t)H \tag{2}$$

$$\pi(p,q) = pqt(H - L)(1 + s) - qt(H - L) + tH - pc \tag{3}$$

This information is available in the form of a simultaneous game in Table I.

In this game, taxpayer decides either to evade or not to evade taxes, while the tax authority chooses either to audit or not. The evasion and audit probabilities are q and p, respectively.

A comparative static analysis shows that the probability of an audit decreases with the fine and that likelihood of evasion increases with audit costs and decreases with fine, tax rate and differential income.

With respect to corporate tax evasion, Lipatov (2005) demonstrated the problem of tax evasion and considered the interaction between firms and transaction costs as elements influencing the tax return to the tax authorities. He noted that, when the transaction cost is low, there is a single stable equilibrium and they audited firms and tax reports. However, when the cost is high, there are multiple equilibria, and the result is that either all or no taxpayers withhold taxes.

The games presented by Lipatov (2005) shows some interesting results. First, tax authorities must conduct more intense audits of firms that do not coordinate their evasion decisions jointly. Second, transaction costs firms can affect the evaded amount in the opposite direction. If there are many tax evaders, it is more likely that transaction costs increase evasion, and vice versa. Third, the effect of fines on the equilibrium value depends, crucially, on the existence of standard accounting reports. When firms have a high accounting standard, increased fines and audits may have an adverse effect on the tax commitment of companies.

Table I. Simultaneous game between taxpayer and tax authorities

	Audit (p)	Not audit ($1-p$)
Evade (q)	$(1-t)H - st(H - L)$; $tH + st(H - L) - c$	$H - tL$; tL
Not evade ($1-q$)	$(1-t)H$; $tH - c$	$(1-t)H$; tH

Source: Adapted from Lipatov (2005) based on Graetz *et al.* (1986)

In another study, Lipatov (2006) considered firms that do not know how to evade taxes and, therefore, hire a specialist professional. Considering the price charged for this professional, the author found three types of equilibrium in scrimmages: pooling equilibrium to zero returns; separating equilibrium, with true statements of earnings; and hybrid equilibrium, with low types submitting zero returns and high types revealing their profits.

Crocker and Slemrod (2005) begin the task of developing an economic theory for reduction of corporate tax evasion, addressing the behavior of either companies or agents toward the policies of tax authorities, which provide explicit contracts to minimize taxes. The results suggest that the effect of these policies depends on whether tax authorities penalize the company and how contracts with the tax agents can help this type of sanction. From the point of view of the tax agency, penalties are more effective anti-tax evasion tools than are contracts, because, although they sharpen the conflict between the shareholders and the state, penalties further reduce corporate evasion.

Through these papers, both national and international, economic science has sought to study and understand the problem of tax evasion and to propose sanction measures and promote compliance with tax obligations.

Theoretical proposed model

To analyze both taxpayer behavior in the Brazilian tax system and tax actions aimed at reducing tax evasion, we developed a theoretical model based on the payoffs of Graetz *et al.* (1986) and expanded upon it using situations proposed by Siqueira (2004), Lipatov (2006) and Oliveira (2011).

Initially, this section presents the basic assumptions considered in the models. First, we divide the population into two groups: taxpayers and tax authorities. All taxpayers and tax authorities are identical, but taxpayers may have different skills in tax evasion, such as hiring a specialist in tax evasion.

The set of possible strategies for taxpayers consists: choosing not to cheat ($-S$); choosing to cheat with specialist services (SE); and choosing to cheat without specialist services (S). The set of possible strategies for the tax authorities consists of: the RFB can either inspect (F) or not inspect ($-F$) the taxpayer; after step I, the PF can supervise (P) or not supervise ($-P$) the taxpayer.

Dynamic models with imperfect information and equilibrium in pure strategies

Tax authorities can select taxpayers to investigate and choose the best time to start inspection. Therefore, determining whether the actions are either sequential or simultaneous is relevant to determining the outcome of the operation (Oliveira, 2011).

In this section, two possibilities regarding information are considered. With imperfect information, actions are sequential and the game is dynamic. Therefore, the sequence of the game is as follows: the taxpayer decides whether to commit to tax evasion – if he chooses the escape option, he must decide whether to use a specialist. The tax authorities, in turn, participate in the next stage – they do not know the previous history of the game – and have the option of whether to inspect such a taxpayer. With perfect information, the game would involve only one stage and, a priori, would not be advantageous for the players.

The payoffs are shown in Figure 1. In this game, we assume that taxpayers do not use specialists to evade taxes in this way; the payoffs are similar to Graetz *et al.* (1986).

At the case, that taxpayer decides to evade tax: if there is either no supervision by the Internal Revenue Service and not by the Police, he pays only the underreported tax (tL). If the PF enforce payment, then the taxpayer must pay the total amount of taxes plus a parameter (z), which signifies the "penalty" imposed by the police on the evader. This parameter is included in the PF payoff with cost of monitoring (c_2). If RFB audits, the taxpayer pays the full amount of taxes plus fine (s). This parameter includes the RFB

payoff and the audit cost (c_1). If there is either supervision by the Internal Revenue Service and by the Police, both fines (z and s) and cost (c_1 and c_2) are included in payoffs.

In Figure 1, c_1 is the cost of RFB audit, c_2 the cost of supervision of the PF, and z is the individual cost of earned punishment [2] by the PF.

We solve this game with three stages and imperfect information by backward induction. However, its equilibrium depends on some assumptions about the financial allocation of the tax authorities and the audit and inspection costs (c_1 and c_2).

In regards to the PF, if $tH + z > c_2$ then PF always choose to proceed with-surveillance (P). In regards to the RFB, if $tH + st(H-L) > c_1$, RFB always choose to audit (F). Given this trend, the taxpayer chooses not to evade tax and the subgame perfect equilibrium (ENPS) outcome is ($-S$).

However, the inspection costs are greater than the financial allocations of the tax authorities, $tH + z < c_2$ and $tH + st\ (H-L) < c_1$, that is high enough so that the "recipe" obtained even with tax evasion. Then, the taxpayer chooses to evade taxes, without audit or inspection by tax authorities, and (($-P$), ($-F$), (S)) is the ENPS outcome.

These results have some implications. First, the effect of audit and inspection costs is not linear. Tax evasion crimes occur when the cost of auditing the taxpayer is $c > tH + st\ (H-L) + z$, and $c = c_1 + c_2$. This occurs in audits of either small businesses or taxpayers with low incomes. As the cost of supervision and audit is fixed and independent of the investigating agent, auditing taxpayers with low incomes is economically disadvantageous. In the same way, Gupta and Ziramba (2009) showed that a higher degree of tax evasion within a country, resulting from a higher level of corruption, results in higher degrees of financial repression.

The main limitation of this model is that it not assumes a taxpayer's ability to tax evasion. Even when only one regulatory body acts to combat tax evasion, the taxpayer does not commit the crime of tax evasion. This contradicts the evidence that the taxpayer is only practicing evasion either when safe or when supported by a professional, thus increasing the probability of non-detection by the tax authorities (see Slemrod, 2004; Lipatov, 2006).

The second model presented in this essay assumes that taxpayers hire a tax evasion specialist, thereby requiring a greater effort from the tax authorities to detect tax evasion. This assumption is from Lipatov (2006), who, in one of his models, extends the case where taxpayers hire a specialist in tax evasion. In this model, he considered simple tax evasion, which does not require special knowledge, and complex evasion, which requires sophisticated tax evasion. The tax rate is given by t, tax evasion's fine by s_1 and specialists fine by s. Once the income has been observed, each agent decides how much tax he wants to evade. For this, he consults a specialist to forge some invoices. This model contains the probability, r, that the authority will detect sophisticated tax evasion. This probability can be modified, but there is a cost involved.

Specialists move first, charging the price, pr, per unit of unreported income. The taxpayer then moves, deciding how much of the income will be reported. The tax authority plays last,

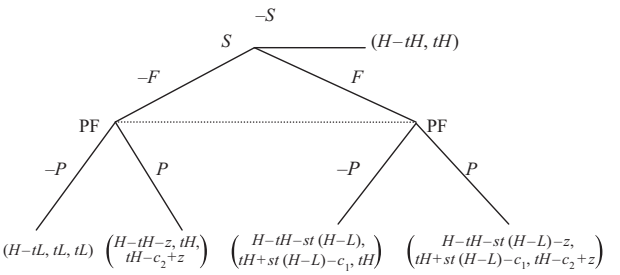


Figure 1.
Sequential game with imperfect information and without specialists

deciding the probability of auditing r after observing the statements. This is followed by the payoffs of the specialists, the agents, and the fiscal authority. The parameters t, s_1 and s are exogenous and are common knowledge.

The following payoffs are:

(1) Specialists: we have the price set $p_r \in (0,1)$ that depends on tax evasion amount $(H-L)$. The income of the specialist is:

$$\Pi = p_r(H-L) - c_s - st(H-L) \tag{4}$$

where $(H-L)$ is the total of the evaded income and c_s is the cost of the specialist.

(2) Contributors: after hiring the specialist, there is the following taxpayer utility function, similar to that proposed by Graetz *et al.* (1986), but now including the cost for the sophisticated tax evasion. This is represented as:

$$U(p,q) = pq\left(H - s_1 t(H-L) - t(H-L) - 1\right) + qtH + (1-t)H - p_r(H-L) \tag{5}$$

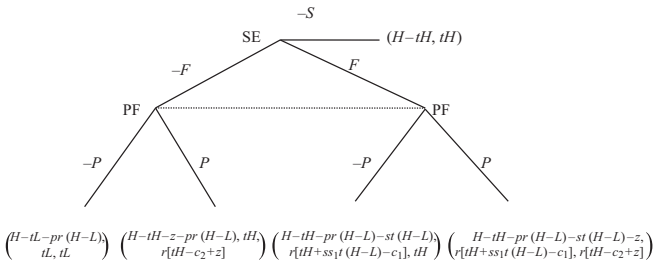
(3) Tax authority: the tax revenue is obtained in the same way as in the previous model, now with the probability, r, of detecting the sophisticated tax evasion. This is represented as:

$$\Pi(p,q) = r[pqt(H-L)(1+s+s_1) - qt(H-L) + tH - pc] \tag{6}$$

Thus, in this new version of the game, taxpayers evade payment in collusion with a specialist, making it difficult for the Federal Revenue Service and the PF to investigate. We modify the payoffs from the previous game to include these new assumptions. The extensive form of this modified game is given in Figure 2.

Some assumptions about the costs of auditing and fiscalization of the tax authorities and the likelihood of detection of sophisticated tax evasion are necessary. For the PF, if $tH+z > c_2$ and the probability of detection of the sophisticated tax evasion is close to 1 ($r = 1$), then PF always chooses inspection (P). In this model, the parameter r is the key parameter for the change in the PF choice of whether to inspect. It should be noted that, with a mean value for r (i.e. $r = 0.5$), the PF decides, on the branch ((F), (PF)), not to oversee (since $tH > r(tH - c_2 + z)$. On the other hand, if (($-F$), (PF)), the PF supervises the taxpayer (since $r(tH - c_2 + z) > tL$]. However, if the PF does not have sufficient tools to detect sophisticated tax evasion, the probability r will be very low (i.e. $r = 0.25$). In this case, it is rational for the PF not to oversee.

Assuming an average value for the probability of detection of the sophisticated tax evasion ($r = 0.50$), the Internal Revenue Service has the following options: audit (F), since the PF does not audit ($-P$); or not audit ($-F$), since the PF supervises (P). In this situation,



Source: Prepared by the authors

Figure 2.
Sequential game with imperfect information and with the specialist's performance

the fine increases the financial endowment of the RFB for the specialist, being rational to audit (F). Knowing the actions of PF and RFB, the taxpayer rationally decides not to evade taxes. Thus, the ENPS, for these assumptions, would be $((-S), (F), (-P))$.

With respect to audit and inspection costs: assuming that these are always higher than are those collected by the tax authorities ($tH + ss_1t(H-L) < c_1$ for the RFB and $tH+z < c_1$ for the PF) the value of probability r is irrelevant, and the ENPS will always be $((S), (-F), (-P))$.

In general, we conclude that, for the two models analyzed, the behavior of the taxpayer is directly related to the auditing and fiscalization capacity of the fiscal authorities. Thus, decreases in the procedural costs of investigation and increases in technologies for detecting complex forms of tax evasion are essential for the taxpayer not to evade.

Dynamic model with imperfect and equilibrium information in mixed strategies

An alternative analysis arises when one considers the probability of the fiscal authority overseeing a particular taxpayer. In this case, the equilibrium occurs in mixed strategies, and we consider the probability α, of the Internal Revenue Service, and the probability β, of the PF, to supervise. Thus, following the same strategy adopted by Oliveira (2011), we have the following probabilities:

$$\alpha = \frac{tH + st\,(H-L) - c_1}{tH} \tag{7}$$

$$\beta = \frac{tH + z - c_2}{tH} \tag{8}$$

It can be seen that the probabilities are directly related to the revenue obtained from the actions of the tax authorities and inversely related to the costs of auditing and inspection.

To find the equilibrium in mixed strategies, we considered the first model, in which there is no specialist. The extensive form of this modified game and its payoffs is given in Figure 3.

After the new calculation of the payoffs, we solve the game with retroactive induction, that is, back to front. The PF is the first to choose whether to inspect the taxpayer. Assuming that the financial allocation is greater than the cost of supervision, the PF always choose to audit (P). From then on, the RFB decides whether it is wise to audit the agent. If the gain from the fine is greater than the audit cost, the RFB always chooses to audit (F). Thus, for the taxpayer, given the choices of the tax authorities, it is best not to evade taxes; thus, mixed strategy Nash equilibrium (ENMS) is given by $((-S), (F), (P))$.

It should be noted, again, that the costs of the fiscal authorities play a fundamental role in the decision whether to inspect the taxpayer. Therefore, public policies aimed at reformulating the state apparatus that is part of the national tax system may be more effective in mitigation of tax evasion than increases in fines or private penalties.

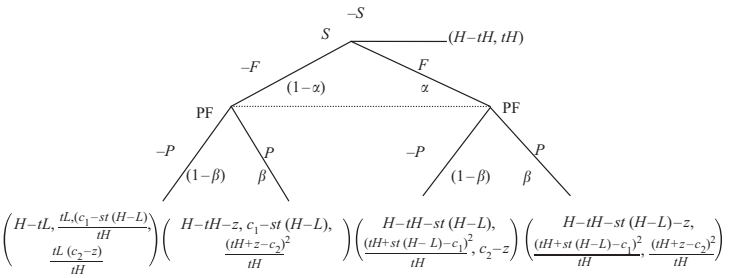


Figure 3.
Sequential game with imperfect information and without the specialist's performance – mixed strategies

Source: Prepared by the authors

Conclusion

As games between the tax authorities, taxpayers and the performance of a specialist characterize a reality that involves scandals perpetrated by large corporations and people with large fortunes, we analyzed the sophisticated evasion. Thus, it was possible to identify two types of equilibrium in a perfect subset: the agent does not withhold taxes, and the agent evades taxes and both tax authorities do not supervise.

For the equilibrium in mixed strategies, the results were the same: either not evade or withhold in the absence of full supervision.

The main results of the study show that, in a high dropout situation, penalizing taxpayers either with high fines or deprivations of liberty may not be very effective. The analysis also shows that audit and inspection costs play an important role in driving the equilibrium system. This enables us to suggest the following policy: when there is a situation with tax evasion, as in the case of Brazil, investing in tax inspectors becomes a more effective tool to combat non-compliance with tax obligations than does the intensity of the penalties imposed on evaders.

The analysis has several limitations, and we propose, as a first attempt, to simulate games in sequential actions of taxpayers and tax authorities in Brazil. In this sense, the study can be extended in many ways. First, it could consider a performance of specialist and the amount of tax evasion. Specialists can also hinder fraud detection and rearrange the accounts of taxpayers so that the final amount evaded is greater. Second, the study could consider the career plans of public servants who work in the fight against tax evasion in Brazil in the simulations and check whether this changes the equilibrium. Finally, to analyze the robustness of the equilibrium, it would be interesting to consider the dynamics of evasion in a repetitive game context.

Notes

1. See Graetz *et al.* (1986), section 3 "A simple interactive model."
2. In most cases, the punishment by the PF comes to deprivation of liberty.

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