# Tax Evasion and Unaccounted Incomes:
# A theoretical approach

No. 289
30 December 2019

Amey Sapre

National Institute of Public Finance and Policy
New Delhi

# Tax evasion and unaccounted incomes: A theoretical approach

**18 December 2019**

**Amey Sapre**
amey.sapre@nipfp.org.in*

This paper analyzes the problem of tax evasion by incorporating a simple game theoretic framework wherein an individual is confronted with the decision of declaring income for taxation. The model is a re-formulation of Allingham & Sandmo (1972) and Srinivasan (1973) original single period decision making problem and extends it to to a repeated game involving a tax payer and a tax authority. The game theoretic results shows that probability of audit and penalty rate are inversely related and that beyond a threshold penalty rate, the tax payer has no incentive to evade. In an infinitely repeated game setting, first, the threat of audit in all future periods acts as a deterrent to evasion and second, the result provides some intuitive understanding of the role of patience and equilibrium strategies in a long repetitive engagement that supports cooperation and prevents deviations.

JEL: C73, E06, H26

Keywords: Tax evasion, Repeated game, Public Finance

*Assistant Professor, National Institute of Public Finance and Policy, New Delhi. This paper is based on my doctoral work in Economics at Indian Institute of Technology (IIT) Kanpur. I'm thankful to Praveen Kulshreshta and Pronab Sen for useful comments for improving the paper and to Subhamoy Chakraborty and Moumita Das for helpful discussions.

# 1 Introduction

In this paper I develop a theoretical analysis of the problem of tax evasion. The paper takes a renewed approach to analyze the decision making problem of an individual confronted with the choice of either declaring the entire income or a part thereof for paying taxes. The work primarily builds on existing theoretical approaches that have modeled a variety of problems ranging from decision under uncertainty to experimental approaches to understand compliance, predictive audits and network effects. Tax evasion, as has been commonly understood, is about the illegal methods of escaping from paying taxes. The act of evasion also implies that individuals (or firms) deliberately misreport their incomes, expenditure, or other gains so as to pay less taxes. In the context of behavioral attributes or studies, such deliberate acts of tax evasion are seen as forms of *non-compliance* and open a new and separate line of research.

The formal approach to analyze tax evasion at an individual level began with the seminal works of Allingham & Sandmo (1972) and Srinivasan (1973). Other notable ideas in this area were also introduced by Mossin (1968), Stiglitz (1969) and Mirrlees (1971) and Yilthzaki (1974) that eventually led to the formalization of the decision under uncertainty model. Later formulations included works of Gordon (1987), Graetz et. al (1986) Liu (1986) and Mittone (2006) that brought several social interactions into consideration. The framework was built on the proposition that tax payers abide by the axioms of utility theory and maximize expected utility and that audits (or detection of evasion) conducted by tax authorities were random in nature. Hence, gains could be made by under-reporting incomes and thus engaging in tax evasion. The key limitation of this approach is that such a simplified model over predicts the extent of evasion when evaluated with objective probabilities of audits, rather than subjective beliefs of tax payers. Recent research in areas of behavioral economics has shown that a large number of audits are 'risk based' and only a small proportion are done on a random basis. This line of approach has motivated several applications in predictive audits, agent based modeling and other experimental settings. (See Hashimzade et. al. (2013) for a survey)

From the tax authorities side, the costs of tax administration play a significant role in determining the number or extent of scrutiny, audits or even prosecutions of offenders. In the conventional setup, such direct costs of administering a tax system has received little attention as the analysis is largely summarized in either the tax effort or the efficiency of the tax system as a whole (See for instance Chattopadhyay (2002)). Similarly, there are no established feedback mechanisms on how tax payers perceive the administration's cost of audits which in turn can influence their decision to engage in evasion. These are primarily summarized in the subjective beliefs of tax payers about the probability of being audited and efforts made by the administration.

The key underlying aspect of the engagement of tax payers and the authority is that the tax authority does not necessarily commit to an audit rule, before tax payers report their incomes (or file tax returns). However, given optimal audits, the authority may well follow procedures to audit reported incomes below (above) a certain threshold and selectively audit the others. In case no such committed rule exists, the interaction between a tax payer and the authority becomes complicated and is more of strategic in nature.

The paper builds on this premise as it allows to formulate the interactions in a game theoretic setting with each agent, namely the tax payer and the authority devise their best response.

### 1.1 Motivation and extensions

Theoretical research in the domain of tax evasion has touched upon several dimensions. However, a common theme of all foundational papers was to model a one period decision. Within this framework, findings of the seminal papers highlighted that the level of tax evasion primarily depends on two factors, namely (i) penalty or punishment for tax evasion and (ii) the probability of detection. Similarly, extensions in the existing framework explain the factors or variables that affect *non-compliance*, as opposed to *compliance* in paying taxes. However, even within a static framework, the results in most of the cases have been conflicting. In order to broaden the existing framework, it is useful to ask whether further modifications provide more useful insights?

The first question in extending the framework is whether the decision of under-reporting of income (hence tax evasion) can be considered over repeated interactions? This question is clearly plausible as given an income stream, an individual faces the decision of reporting the true income in every single time period. The analysis of a series of decisions also allows us to characterize the accumulation of unreported income. In the static framework, the unreported income is only in a single period, which in principle, does not allow us to infer the size of unreported income over time. Once we conceptualize that over time, underreporting of true income generates a flow of unaccounted incomes and saved tax thereof, we have an extended problem as compared to the existing static one period problem.

The extensions also have a qualitative nature. In Allingham & Sandmo (1972) and Srinivasan (1973) the role of the tax authority was not modeled explicitly. The tax authority plays a passive role as there is no strategic engagement of the authority in the tax payers' decision of whether or not to evade taxes. Another important aspect not emphasized in the literature is the tax authority's cost of audit. As the tax authority is primarily concerned with collection of tax revenue and penalties in cases of evasion, the net outcome of conducting an audit can be conceptualized as gains from collecting tax and penalties, vis-a-vis, incurring the cost of audit. We can now ask the question: do the results of the static model change if we incorporate these two aspects in the static model? Second, do the results change if we consider the decision in a repeated scenario? In what follows, the extensions are build into a simple game theoretic framework.

## 2 Basic structure: A short review

Studies in the past have provided several insights into the factors contributing to tax evasion. Broadly, three types of model based approaches have been used, namely; models with exogenous income, endogenous income and in recent times, behavioral and predictive models on audit strategies have been studied. Theoretical models with exogenous income provided the foundation in the area of tax evasion. The initial contributions of Sharon (1967), Allingham & Sandmo (A-S) (1972), Srinivasan

(1973) and Anderson (1977) provided the basic setup to analyze the individual's decision of reporting income for taxation. The general setup of the model specifies how an individual maximizes expected utility from reporting part of income for taxation with the uncertainty of being caught of evasion. The decision problem of the individual is set as under;

$$\max_{R} E(u) = (1-p)u[y-tR] + pu[y-tR-\pi(y-R)] \tag{1}$$

where $E(u)$ is the expected utility and the other variables are defined as above. The expression summarizes the expected utility of the individual in the two possible states, viz. let-off or undetected with probability $(1-p)$ and caught, with probability (p). The decision variable for the individual is $R$, i.e. the reporting fraction of the actual or true income. In general, to draw inferences, one would require specific forms of the utility function and risk preferences of the tax payer. Nevertheless, we can consider the major implications of the basic model. First, the predictions about the effect of different parameters such as tax rate, penalty, and the probability of detection depend largely on the choice of utility functions. Allingham & Sandmo (1972) made use of the Arrow-Pratt measure of risk aversion and assumed decreasing absolute risk aversion. Also, with regard to marginal tax rate, the model predicts that a rise in tax rate has an ambiguous effect on tax evasion. The prediction is due to the ambiguity in magnitudes of income and substitution effects. With higher taxes, the income effect is negative as the individual is left poorer, but the substitution effect works in favor of tax evasion.

Further, changes in the probability of detection and the penalty structure change the results considerably. Yitzhaki (1974) modified the setup to change the way the penalty was imposed. Yitzhaki argued that if the penalty were imposed on the evaded tax, i.e. $(\pi t(y-R))$, instead of the unreported income $(y-R)$, then the model does not have any substitution effect. With this change, only the income effect remains, which establishes a negative relation between tax rate and amount of evasion.

Srinivasan (1973) presented a similar model of tax evasion, but with modifications in the objective of the individual. In his model, individuals chose to maximize expected income instead of utility, which implied that individuals were treated as risk-neutral. Another assumption made was that individuals chose to report a proportion of their true income in order to maximize expected income. An important conclusion of this model was that with a constant marginal tax rate and with probability of detection as an increasing function of the *actual* income, individuals will report a larger fraction of income for taxation as their actual incomes rise.

Christiansen (1980) was among the early studies to modify the A-S framework by introducing an association between the penalty and the probability of audit (or detection). The analysis shows that, given the nature of the functions, in some cases, increase in penalty might lead to increase in tax evasion. Another modification was done by Witte & Woodbury (1985), wherein two separate probabilities were introduced, viz. civil and criminal, instead of a single probability of audit. The approach was to introduce additional parameters to explain non-compliance, rather than a singular instance of audit. Cross and Shaw (1981, 1982) extend the framework further to consider a case of tax evasion and avoidance. They argue that evasion-avoidance are joint decisions and can act as substitutes or complimentary options under different scenarios.

The second line of approach to understanding tax evasion was build on endogenous nature of income; Andersen (1977), Baldry (1979), Pencavel (1979), Isaehen and Strom (1980) and Sandmo (1981)) The premise of such models is that earning of income and tax evasion are joint decisions and since income accrues from the working for wage, tax evasion and labor-leisure decisions are linked. The earlier models failed to provide this linkage as they considered income as exogenously given. Incorporating the labor supply decision in the framework makes true and reported income endogenous and also brings out the interaction of income and substitution effect with tax and labor-supply.

Isachsen & Storm (1980) and Cowell (1985a, 1985b) argued that such models presented an unrealistic set of choices to the individual and introduced the premise that in trying to evade taxes, the individual must make choices to switch jobs or participate in an unofficial or black economy. The argument implied that instead of a limited choice of under-reporting income and evading taxes, the individual must explore other choices with available labor hours and engage into other activities. They bridge the gap by introducing separate working hours in the irregular or black economy and make the assumption that none of the income earned from the black economy is declared, while entire income from the official work hours is declared. Thus, they conceive two separate labor supply function, one for official work and the other for engaging in the irregular or black economy. The results in most cases depend almost entirely on the formulation used. Among other assumptions made in such models, a particular assumption is of an individual making his decision in isolation and is unconnected with decisions of other tax payers. This argument promoted an alternate line of approach to model the behavior of the tax payer by considering interactions among tax payers. Benjamini & Maital (1985), Schlicht (1985) and Gordon (1987) constructed models with interactions among tax payers. They introduced concepts such as social interactions, stigma and the cost of acting dishonestly. They argue that a social cost like stigma can be avoided only when the entire income is disclosed. Thus, if such social costs are significant, individuals would tend to deter from engaging in evading activities. However, the results of such models crucially depend on the proportion of honest and dishonest tax payers and since cost of stigma may vary across individuals, the predictions of the model vary considerably.

Sproule (1985) introduced the premise of information uncertainty. The model improves upon the work of Isachsen & Storm (1980) by introducing a stochastic tax variable to capture the element of lack of complete information on part of the tax payer. Tirole (1996) further expanded on the idea of social stigma by considering collective reputation and its application in ares of corruption and firm quality. In more recent literature, the analysis of tax evasion has received a varied attention. Bernasconi (1998) analyzes the effect of different orders of risk aversion in the standard A-S (1972) model. Manski (2000) develops an endogenous model of social interactions among tax payers. Brock and Durlauf (2001), Moffitt (2001) and Cohen-Cole (2004) extend this framework by considering alternative frameworks to allow for randomized group composition, exclusion restrictions and non-linear effects of variables on tax payers' behavior.

Fortin et. al (2007) build on the behavioral aspect to analyze the effect of social interaction on tax evasion. In a series of papers, Hashimzade & Myles (2010, 2017), Hashimzade, et. al (2012, 2014, 2015, 2016) explore a variety of behavioral economics aspects on audits, predictive analysis on audits, agent based approach to model tax compliance and effect of social networks on tax compliance.

The third strand of literature looks at some of the factors that contribute to tax evasion. In this approach, several insights are drawn from social experiments in public finance, game theory and behavioral economics. Studies that deal with behavioral and empirical applications have considered some of these factors. On a related issue, Pestieau *et.al* (1994) analyzed the effects of tax audit and compliance on occupational choices the tax payer. They argue that individuals have different risk preferences and risk averse individuals would choose safe occupations, while less averse people would prefer entrepreneurship. Also, differential tax treatment for individuals might serve a better purpose for deterring tax evasion, than having conflicts in audit policies. Similarly, level of information with tax payers, levels of scrutiny and risk preferences have been common among applications. For instance, Das-gupta *et.al* (2004) analyzed the effect of tax reform on compliance. Using data on tax audits of different assessment units, they find evidence consistent with the predictions of the A-S (1972) model. A similar line of research is available in Mookherjee & Png (1989) and Mookherjee (1990, 2004) and Mookherjee (2008).

More recently, Rao & Tandon (2016) use prospect theory to model the revisit the compliance problem. Their starting point of the analysis is the decision to file a tax return, instead of the conventional approach of modeling reporting of income. They conduct a simulation exercise of different policy parameters of the model and find a threshold beyond which individuals choose to file their tax returns. Their work introduces a new dimension to the existing set of problems by considering an additional step of filing a tax return. An important finding is that not all individuals find it optimum to file a tax return and that at low incomes, individuals may not prefer to file a tax return.

Given the vast literature on the problem of tax evasion, it is useful to summarize the main findings before attempting to develop a renewed approach to the problem. Broadly, the general theme that emerges from the literature is that variables such as; tax structure or rates, effectiveness of tax administration, penalty structure, audit probability, among others qualitatively explain the individual's decision of *non-compliance* or involving in tax evasion. The first lesson is that the foundation of tax evasion models is based on the theory of risk and uncertainty. Second, individuals are perceived as maximizing expected incomes or expected utility, which is based on two possible states, i.e. one of successful evasion and the other in which evasion is detected. The Allingham & Sandmo (1972) and Srinivasan (1973) model argues that;

- The decision to optimally report income (or evade taxes) simultaneously depends on; (i) tax rate, (ii) penalty function, (iii) probability of audit, (iv) efficiency of tax administration
- Choice of risk preferences of the individual are crucial for obtaining predictions over signs and thus direction of effect of variables on tax evasion
- If the probability of detection is an increasing function of unreported income, then for a constant marginal tax rate, the optimal evasion declines with increase in income.
- Penalty structure and efforts of tax administration can act as substitutes of each other as both serve to deter tax evasion. In this setup, the decision variables are functions of income and have no other qualitative aspect such as; pleasure or remorse.
- Extensions on qualitative aspects have considered social stigma, collective reputation, etc. as part of the decision making process.

However, one important aspect often missed is that causes of tax evasion may operate *simultaneously* and not in isolation. For instance, if tax authorities have weak administrative powers, it may result into lower chances of audits, imposition of penalties and an overall inefficient tax system. Individuals with information and knowledge about tax administration are more likely to consider such factors together while deciding to evade taxes. In general, it is possible to argue that individuals are more likely to consider the effect of all factors while making decisions, and not limit it only to monetary gains. In what follows, this paper builds on this extension and outline a simple game theoretic approach to analyze the problem of tax evasion.

# 3 Tax evasion: A game theoretic approach

## 3.1 Formulation

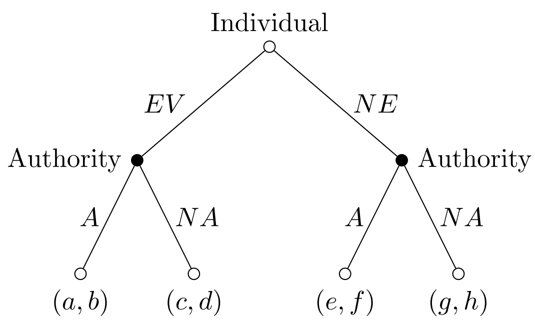
The basic framework is similar in spirit to Allingham & Sandmo (1972) and Srinivasan (1973), but differs in formulation. In this setup, an individual has an exogenously given income and has to make the decision of whether or not to engage in tax evasion by under reporting income. The renewed approach extends the basic framework with two key departures. To begin with, the variables used to formulate the model are as follows.

| | |
|---|---|
| $y$ | denotes the income of the individual in a given time period |
| $\alpha$, $(0 \leq \alpha \leq 1)$ | denotes the fraction of income reported to tax authorities |
| $\tau$, $(0 < \tau < 1)$ | denotes the tax rate on income |
| $p$, $(0 < p < 1)$ | denotes the probability of audit & detecting the instance of tax evasion |
| $c$, $(c > 0)$ | denotes the cost of conducting an audit of the individual |
| $d$, $(0 < d < 1)$ | denotes the probability of engaging in tax evasion for in the individual |
| $N$ | Time periods |

The first distinction from the conventional setup is to explicitly incorporate role of tax authority in conducting an audit. In the earlier models, the role of the tax authority was taken as passive, and cost of audit was also not included in the model. A second departure is by introducing a repeated interaction between a representative tax payer and the tax authority. In earlier formulations, the model of decision under uncertainty provides a limited characterization of the decision and the strategies available to the stakeholders involved. The game theoretic formulation also allows us to extend the problem to a multi-period setup, thereby changing the decision making process from a static to a dynamic scenario. However, some basic features of the earlier models continue to used as building blocks. Following Yilthzaki (1974), the penalty in case of begin caught of tax evasion is levied on evaded tax.

To formulate the problem, consider first a single period decision making situation. The individual earns an income ($y$) and decides whether or not to evade taxes by under reporting income. Given an income, the individual engages in tax evasion by choosing to report a fraction $(0 < \alpha < 1)$ of the income to tax authorities. The remaining fraction $(1-\alpha)$ remains unreported and escapes tax liability. Thus, in a single period, the individual has a tax liability only on reported income, i.e. $(\tau\alpha y)$.

In the second case, the individual does not engage in tax evasion and thus chooses to report the entire income for taxation. From the tax authority's side, the purpose of conducting audits is primarily to ensure tax compliance and to uncover tax evasion in case of willful tax defaulters. Also, in case of tax evasion, the authorities are empowered to levy penalties that contribute to additional tax revenues. However, conducting tax audits involve significant monetary and human resource costs, and given a resource constrained tax authority, it can be safely assumed that not all tax payers are audited. This subjective, yet practical view allows tax payers' the possibility of a successful evasion in any given time period. If we consider that a tax payer faces an audit with probability $(p)$, a penalty of $(\pi > 1)$ is levied on the amount of evaded tax in case the tax payer is found engaging in tax evasion. Thus, if we conceptualize the choices available to the individual and the tax authority in a strategic setting, the outcomes of a single time period can be explained using a game tree structure.




The individual's has two available choices $\{EV, NE\}$, i.e. to evade or not to evade taxes. For each choice, the individual can be audited by the tax authority with probability $(p)$ or can be let off with probability $(1-p)$. These two outcomes are denoted by $\{A, NA\}$ on each node. With four possible outcomes, the payoffs for each can be summarized under different scenarios for both the tax payer and authority.

### 3.2 Case - I: Basic game

The simplest case is the original problem in the literature where the individual compares the expected value of income from evasion and no evasion. Let $(d)$ denote the probability that the individual evades taxes by under reporting income. The payoffs (or the income remaining with the individual) for each strategy can be given by;

$$\{EV, A\} = y - (\tau\alpha y) - \pi[\tau(1-\alpha)y] \quad \Big| \quad \{EV, NA\} = y - \tau(\alpha y)$$
$$\{NE, A\} = y - \tau y \quad \Big| \quad \{NE, NA\} = y - \tau y$$

$\{EV, A\}$ denotes the outcome where the individual decides to under report income and is audited. The payoff in this situation is the income left after paying the tax on the reported income and the penalty on evaded tax. For the outcome $\{EV, NA\}$, the individual evades taxes by under reporting income, but escapes the audit (with probability $(1-p)$). Tax is paid only on the reported income and the tax payer successfully evades taxes on unreported income. In the other two outcomes, $\{NE, A\}$ and $\{NE, NA\}$, the tax payer reports her full income, and thus does not evade taxes, irrespective of being audited or not. From the side of the tax authorities, each strategy leads to different payoffs in terms of tax collections. For each choice, the tax collections can be summarized as;

$$\{EV, A\} = (\tau\alpha y) + \pi[\tau(1-\alpha)y] - c \quad \Big| \quad \{EV, NA\} = \tau(\alpha y)$$
$$\{NE, A\} = (\tau y) - c \quad \Big| \quad \{NE, NA\} = \tau y$$

In the first case, the tax authorities collect the tax paid on reported income and the penalty on evaded tax. The authority also incurs a monetary cost of audit and in the net payoff, the cost of audit is deducted from the total tax collection. For ease of exposition, it is assumed that the (tax and) penalty exceed the cost of audit. In the second case, tax collection is only on the reported income as the tax payer is not audited and successfully evades taxes by under reporting income. In the last two cases, tax collection is on actual or full income as the tax payer does not under report income. However, in case of an audit, the tax authority incurs a cost and that is deducted from the tax collection. The payoffs can be summarized and tabulated in a $2 \times 2$ game matrix with the strategies for the tax payer and authorities.

| | $(p)$ Audited | $(1-p)$ Not audited |
|---|---|---|
| $(d)$ Evade | $y - (\tau\alpha y) - \pi[\tau(1-\alpha)y]$, $(\tau\alpha y) + \pi[\tau(1-\alpha)y] - c$ | $(1-\tau\alpha)y$, $\tau(\alpha y)$ |
| $(1-d)$ Do not evade | $(1-\tau)y$, $(\tau y) - c$ | $(1-\tau)y$, $\tau y$ |

## Nash Equilibrium: One period stage game

The payoff structure has the following implications. First, rational and selfish individuals will evade taxes if not audited, and will comply in case they are audited. Second, tax authorities will conduct audits if tax payers evade taxes, and do not conduct audits in cases where tax payers comply. The consequence of such a payoff structure is that neither the tax payer nor the authority has a best or a fixed strategy, i.e. there is no best action for either parties, regardless of the decision of the other. Thus, in this setting, the game does not have a 'pure' strategy equilibrium. Therefore, to choose their best decision, each party has to decide on a mix of strategies. In order to find the best set of choices for both players, we need to find the mix strategy Nash equilibria of the game. We first derive the best response function of the tax payer and the authority. Consider the argument for each player as follows.

*Tax payer's best response*: The tax payer faces two possibilities, namely audited and not being audited, with probabilities $(p)$ and $(1-p)$. If $p = 0$, i.e. the tax payer is not audited, the best choice in this situation is to evade taxes, since the payoff $(1-\tau\alpha)y > (1-\tau)y$. If $p = 1$, i.e. the tax payer is audited, then the best choice is not to evade taxes since the payoff $(1-\tau)y > y - (\tau\alpha y) - \pi[\tau(1-\alpha)y$. We can now ask the question: for what probability of audit the tax payer is indifferent between evading and not evading taxes?

To compute, for a given value of $p$, the expected payoff of evasion is; $p[y - (\tau\alpha y) - \pi[\tau(1-\alpha)y]] + (1-p)[(1-\tau\alpha)y]$, while the expected payoff of not evading taxes is; $p[(1-\tau)y] + (1-p)[(1-\tau)y]$. The individual is indifferent between the two choices when the value of both outcomes is equal. This implies;

$$p[y - (\tau\alpha y) - \pi[\tau(1-\alpha)y]] + (1-p)[(1-\tau)\alpha y] = p[(1-\tau)y] + (1-p)[(1-\tau)y] \tag{2}$$

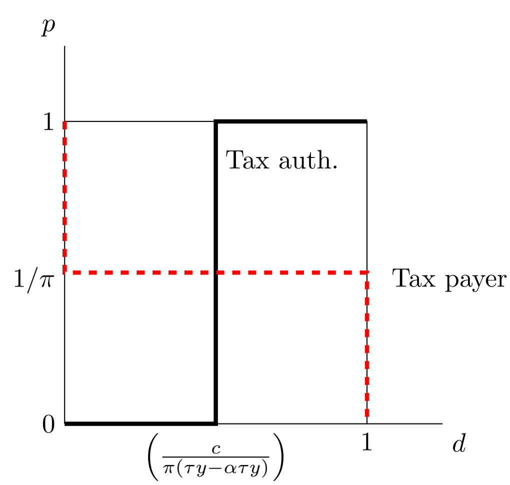
Simplifying and rewriting the expression in terms of $p$, we have; $p^* = 1/\pi$.

*Tax authority's best response*: The tax authority has to decide whether or not to audit the tax payer. If the tax payer evades, i.e ($d = 1$), the best choice for the authority is to audit, since the payoff in terms of tax collection is higher ($\tau y(\alpha + \pi - \pi\alpha) - c > \tau(\alpha y)$). However if ($d = 0$), then the best choice is not to audit the tax payer as the payoff $(\tau y) > (\tau y) - c$. Similar to the tax payer's expected income, the expected tax collection for the authority in case of auditing is; $d[\tau y(\pi + \alpha(1-\pi)) - c] + (1-d)[\tau(y) - c]$, while for not auditing, the payoff is $d[(\tau\alpha y)] + (1-d)[\tau y]$. The authority is indifferent in conducting an audit if;

$$d[(\tau\alpha y) + \pi[\tau(1-\alpha)y] - c] + (1-d)[(\tau y) - c] = d[(\tau\alpha y)] + (1-d)[(\tau y)] \tag{3}$$

Simplifying the expression, the value of $(d)$ is; $d^* = c/\pi(\tau y - \alpha\tau y)$. Combining the best responses of each player, we can graph the responses in the $(d, p)$ space. In Figure 1 the dashed line plots the best response of the tax payer. The solid line represents the response of the tax authority. The

Figure 1: Best response function of tax payer and tax authority




equilibrium point is at the intersection of the two best response functions in the $(p, d)$ space, i.e. $(p^*, d^*) = (1/\pi,\ c/(\pi(\tau y - \alpha\tau y))$, thus giving us the following proposition;

**Proposition 1** *Given the set of actions and payoffs for the individual and the tax authority, the strategy profile* $(p^*, d^*) = (1/\pi, c/\pi(\tau y - \alpha\tau y)$ *is a unique mixed strategy Nash Equilibrium of the game*

The equilibrium values $p^*$ and $d^*$ can be obtained after equating equations 2 and 3, i.e. the best response functions of the tax payer and the tax authority. The equilibrium value are depicted in Figure 1. In this mixed strategy equilibrium, the tax payer is honest on some occasions and is dishonest on other occasions. This fact is also clear from the payoffs as the best response in case of being audited is not to evade taxes, but in case of no audit, the payoff of evading taxes is higher, i.e. $(1-\tau\alpha)y > (1-\tau)y$. Alternatively, from the expression that gives the value of $(d)$, we can note that the value of $(\alpha)$ is positive. Rearranging the expression in terms of $(\alpha)$ gives; $\alpha = \left(\frac{d\tau y\pi - c}{d\tau y\pi}\right)$, which is positive based on the condition that tax revenue $(\tau y)$ times penalty is higher than the cost of audit for the authority.

From the equilibrium values of $(p, d)$, we can determine that if the probability of audit were to fall below $(1/\pi)$, the individual can improve her payoff by evading taxes, since the best response that case is $d = 1$. Conversely, for audit probability values higher than $(1/\pi)$, the individual's best response is to not evade taxes, i.e $(d = 0)$. In a specific case, if we consider the penalty on tax evasion to be 100%, implying that the tax payer has to pay an equal amount of evaded tax by way of penalty, then the threshold value of $p$, equals 1/2 $((\pi = 2)$ in case of 100% penalty on evaded tax). Qualitatively, the result gives new insights into the tax evasion problem. The mix strategy equilibrium has a counter intuitive implication that higher penalties may not lead to decrease in evasion. The reason is that the mix strategy equilibrium is optimal only when both parties make each other indifferent between their respective two actions. In case both parties are not indifferent between the two decisions, the player can take advantage by exploiting the other, and thus giving incentive to change the decision. The result of the mix strategy equilibrium is consistent with the earlier formulations of Allingham & Sandmo (1972), Srinivasan (1973) and Sandmo (2004). The result also provide a range of values of the probability of evasion, which in the earlier models was not explicitly available. Also, the result is achieved under much simpler and general conditions, since in the earlier formulations, the choice of utility functions clearly limit the scope of signing the derivatives to obtain a clear prediction. In addition, an important aspect of the game theoretic model is that it actively models the role of tax administration.

The key variables that operate through the probability of audit are the penalty rate and cost of audit. In earlier models, the cost of audit was not included, thereby leaving a wide scope for interpretation of the results. Once we incorporate the role of cost of audit, it clearly influences the decision making on the part of the tax payer. Also, qualitative understanding of the penalty rate, which is taken to act as a deterrent on tax evasion, is equally important. Since the probability of audit is inversely related to the penalty rate, it provides a logical answer to the question of evasion. If penalty rates are high, they are expected to lead to lower number of audits and tax assessments. Conversely, if penalty rates are lower, tax payers may perceive a lower burden of penalty on being caught of tax evasion, and thus, lower penalty rates may not act as a deterrent. It follows that to compensate for the low deterrence, the frequency of audits must increase.

In the literature, the interactions between the tax payer and the administration have also been explored. On this account, the result provides an insight. Given the subjective nature of probability, evasion may actually increase if tax payers believe that audit costs are significantly high. Intuitively, a similar logic applies for deciding on the extent of under reporting. If audit costs are high and in-turn lead to fewer audits, tax payers are more likely to under report their income by a greater extent. Thus, given the set of actions and payoffs for the individual and the tax authority, higher penalty rates leads to a lower probability of audit.

As earlier, the penalty structure and the cost of audit are the key variables that influence the decision of the tax payer on evasion. The penalty structure also operates as an incentive to the tax authority as they can recover additional revenue apart from tax collections on declared incomes. If recoveries from penalties are assumed to be higher than the cost of audit, i.e. $\pi[\tau(1-\alpha)y] > c$, then there are clear incentives in conducting audits in cases where tax payers choose to evade. What other insights can be obtained from the tax evasion game?. We can now extend the basic model to consider if the tax payer can successfully accumulate undisclosed income and evade taxes over repeated interactions.

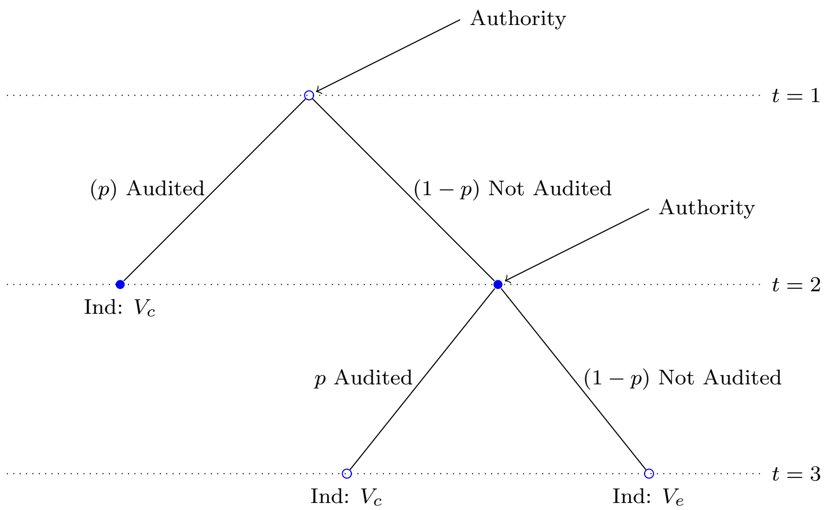
### 3.3 Case - II: Repetition and no disclosure

To build on the existing result, consider a repeated version of the one period game. Since tax evasion decisions are not limited to a one-time decision, a tax payer has to decide on disclosing income in every period. In this setting, the tax payer compares the gains from evading against not evading over many periods. As there are incentives in evading taxes, it is presumptions on the part of the tax payer that unless audited, it is gainful to evade taxes as long as possible. The mechanism at work is that a tax payer can successfully under report income in any period and not disclose it in any future time period. Thus, in every period, the tax payer discloses only the current period income, and escapes tax liability on any previously undisclosed income. On the other side, the tax authorities have the same choice as earlier, i.e. whether or not to audit the tax payer.

However, in a repeated interaction, we assume that if the tax payer is caught of evasion, the tax authorities will audit the individual in every subsequent period. The underlying logic is that once an evader is found, tax authorities are more likely to audit to prevent further evasion. The principle is similar to a one-step-deviation, wherein players choose a pair of strategies and continue with them up until one of the player defects and post defection, continue to defect *thereafter*. To formulate the situation, consider that a tax payer can be caught evading in any period. Once caught, the tax payer will be in audited every period, thus will not evade henceforth. For successful evasion throughout, the tax payer must not be caught in any period. Therefore, the individual has to consider the payoffs of evading and being caught at least once, vis-a-vis not evading at all. The setup is as follows;

Let $V_c$ denote the payoffs from the strategy where the tax payer evades and is caught, i.e. $[EV, A]$. Let $V_e$ denote the payoffs when the tax payer successfully evades, i.e. the strategy $[EV, NA]$ and $V_{ne}$ the payoff when the tax payer does not evade. To begin with, consider a setup in $N$ periods. The situation unfolds in each period, particularly when the tax payer is not audited and thus successfully evades in the period. In other words, the tax payer can either successfully evade in period 1, or get caught. Similarly, the tax payer can successfully evade in the first 2 period, and not get caught, and so on. Continuing to $N$ periods, Figure 2 shows the sequence of the tax payer moving over each time period depending on whether the individual was audited (and caught) in the previous period.

Figure 2: Timing and sequence




The payoffs are derived as under;

> For $t = 1$, the payoff of the taxpayer is $p[V_c + (N-1)V_{ne}] + (1-p)V_e$. The expression captures the expected value under the scenario that either the taxpayer is caught in the first period with probability $(p)$ thus giving the payoff of $V_c$ and $V_{ne}$ for all future time periods, or is not audited in the first period and thus successfully evading with probability $(1-p)$ and the payoff $V_e$.
>
> For $t = 2$, the situation is dependent on whether the taxpayer successfully evaded in the previous period. The payoff is; $(1-p)[p(V_c + (N-2)V_{ne})]$, i.e. the probability of not being caught in the previous period times the payoff of the second period. The sequence $(N-i)\, i = 1, 2, \ldots N$ captures the payoff the taxpayer will get for the rest of the periods in the event of being caught.
>
> For $t = N$, the general expression is; $(1-p)^{N-1}[p(V_c + (N-N)V_{ne}) + (1-p)V_e]$.

where, $(p)$ and $(1-p)$ are respectively the probabilities of being caught and let-off, i.e. not audited. As earlier, the payoff after being caught in any period is the payoff of non-evasion, i.e. $V_{ne}$ as the tax payer does not engage in evasion thereafter. For evasion to be gainful, the tax payer must compare this sum of this stream with the other alternative of not evading in any period, i.e. $V_ne$. Expanding it to $N$ periods, we get;

$$pV_e \left[\frac{1-(1-p)^N}{1-(1-p)}\right] + (1-p)V_e \left[\frac{1-(1-p)^N}{1-(1-p)}\right] + \\ pV_{ne}\left[(N-1) + (1-p)(N-2) + (1-p)^2(N-3) + \cdots + (1-p)^{N-1}(N-N)\right] \tag{4}$$

Solving the expression requires simplifying the RHS in two parts. First, reducing the second part (equation 4) of the sequence, we have;

$$pV_{ne}\left[(N-1) + (1-p)(N-2) + (1-p)^2(N-3) + \cdots + (1-p)^{N-1}(N-N)\right] \tag{5}$$

Rearranging by excluding the last term and shifting backwards, we obtain;

$$pV_{ne}\left[(N-1)+(1-p)(N-2)+(1-p)^2(N-3)+\cdots+(1-p)^{N-2}(N-(N-1))\right] \tag{6}$$

Rearranging the sequence further in reverse order of terms, we have;

$$pV_{ne}\left[1.(1-p)^{N-2}+2(1-p)^{N-3}+\cdots+(1-p)^2(N-3)+(1-p)(N-2)+(N-1)\right] \tag{7}$$

Writing the series as a sum of the components;

$$pV_{ne}\left[\sum_{i=1}^{N-1} i(1-p)^{N-1-i}\right] \tag{8}$$

Solving the expression ($\forall i \in 1...N-1$) and denoting the sum within the parenthesis by $S$, we have

$$S = 1.(1-p)^{N-2}+2(1-p)^{N-3}+\cdots+(N-2)(1-p)+(N-1) \tag{9}$$

Multiplying both sides by $(1-p)$, we have;

$$(1-p)S = 2(1-p)^{N-2}+3(1-p)^{N-3}+\cdots+(N-1)(1-p)+(1-p)^{N-1} \tag{10}$$

Subtracting the above expression from the previous expression, we obtain;

$$pS = -(1-p)^{N-2}-(1-p)^{N-3}-\cdots-(1-p)^{N-1}+(N-1) \tag{11}$$

Rearranging,

$$-pS = 1+(1-p)+(1-p)^2+\cdots+(1-p)^{N-2}+(1-p)^{N-1}-N \tag{12}$$

which reduces to

$$-pS = \left[\frac{1-(1-p)^N}{1-(1-p)}\right]-N \text{ or } S = \left[\frac{N}{p}-\frac{1-(1-p)^N}{p^2}\right] \tag{13}$$

Combining the reduced form of the second part with the earlier expression (equation 4) gives us the comparison;

$$pV_e\left[\frac{1-(1-p)^N}{1-(1-p)}\right]+(1-p)V_e\left[\frac{1-(1-p)^N}{1-(1-p)}\right]+pV_{ne}\left[\frac{N}{p}-\frac{1-(1-p)^N}{p^2}\right] \geq NV_{ne} \tag{14}$$

The expression captures the payoff of the entire sequence of the repeated game, dependent on the period in which the individual is caught and henceforth does not evade, versus the payoff of not evading in any period. Rearranging this inequality, we can write by canceling out $p$ from the last square term;

$$[pV_c+(1-p)V_e]\left[\frac{1-(1-p)^N}{p}\right] \geq NV_{ne}-V_{ne}\left[N-\left(\frac{1-(1-p)^N}{p}\right)\right] \tag{15}$$

Solving by canceling out the term $\left[\frac{1-(1-p)^N}{p}\right]$ from both sides, we obtain;

$$(pV_c + (1-p)V_e) \geq V_{ne} \tag{16}$$

Substituting the values of the payoffs from the earlier payoff matrix, we have;
$V_c = (y - \tau\alpha y - \pi[\tau(1-\alpha)y])$, $V_e = (y - \tau\alpha y)$ and $V_{ne} = (y - \tau y)$. Simplifying, the expression becomes;

$$p(y - \tau\alpha y - \pi(\tau(1-\alpha)y)) + (1-p)(y - \tau\alpha y) \geq y - \tau y \tag{17}$$

Rearranging, we obtain, $(1-\tau\alpha) - \pi p\tau(1-\alpha) \geq 1 - \tau$ and reducing it further, we get $(\tau - \tau\alpha) \geq \pi p\tau(1-\alpha)$, leading us to the condition;

$$p \leq \frac{1}{\pi} \tag{18}$$

**Proposition 2** *In the N period repeated game, the condition for no evasion in any period is given by* $p^* > 1/\pi$

The condition provides us a new result as compared to the earlier game. In a repeated version, if $p > 1/\pi$ the tax payer has no incentive to evade. The results also establishes the original mixed strategy equilibrium strategy $(p^*, q^*)$ where the best strategy for the taxpayer for $p < 1/\pi$ is not to engage in evasion. However, the result is qualified on two counts, namely (i) penalties are not levied on past accumulated undisclosed income and (ii) risk preferences of the tax payer. In specific cases, the result on level of penalty is consistent with the provisions on tax penalties. For instance, under the Indian Income Tax Law the maximum penalty in most cases is up to the amount of evaded tax. In some cases, penalty exceeds 100%, but is at the discretion of the authorities. Thus, in most cases, tax authorities can only recover maximum penalties equal to the amount of evaded tax. If we assume that audits are conducted to revel only current period evasion, the result provides some intuitive understanding of tax evasion over time. The threat of a regular or an every period audit is a key deterrent to enforce compliance on part of the tax payer.

### 3.4 Rationality, patience and future payoffs

In the previous model, which is also called a super game, the future payoffs were not discounted. The formulation assumes that the players are patient throughout such that they do not differentiate between payoffs in different time periods. Therefore, their payoffs in the repeated game can be represented by the sum of utilities in the basic games. In this particular case, consider the discounting factor as; $\beta = \left(\frac{1}{1+r}\right)$, where $r$ is a representative interest rate. Applying the discounting to the payoff series would imply discounting the evasion and non-evasion payoffs leading up the inequality where the taxpayer compares the two payoffs.

The solution is dealt in two parts, first using the payoff stream (see figure 2) for period $t = 1$ the discounted payoff can be written as; $p[v_e + \beta V_{ne} + \beta^2 V_{ne} + \cdots + \beta^{N-1} V_{ne}] + (1-p)V_e$, which sums and simplifies to;

$$p\left[V_e + \beta V_{ne}\left(\frac{1-\beta^{N-1}}{1-\beta}\right)\right] + (1-p)V_e$$

Using the same sequence, for $t = N$ periods, the general expression is;

$$(1-p)^{N-1}\left[p\left(\beta^{N-1}V_e + \beta^N V_{ne}\left(\frac{1-\beta^{N-N}}{1-\beta}\right)\right) + (1-p)\beta^{N-1}V_e\right] \tag{19}$$

Second, in case of no evasion for all periods, which is the RHS of inequality (16), the future payoffs would be discounted as; $V_{ne} + \beta V_{ne} + \cdots + \beta^{N-1}V_{ne}$, which can be written as;

$$V_{ne}(1 + \beta + \cdots + \beta^{N-1}) \text{ or } V_{ne}\left(\frac{1-\beta^N}{1-\beta}\right) \tag{20}$$

Combining the two parts gives the comparison that the taxpayer makes between evading and being caught in any period, versus not evading in any period. Reducing both expressions and rearranging the inequality gives the comparison;

$$\left[\frac{1-(1-p)\beta^N}{1-(1-p)\beta^N}\right](pV_c + (1-p)V_e) \geq \frac{V_{ne}}{1-\beta}(1-\beta)\left[\frac{1-(1-p)\beta^N}{1-(1-p)\beta^N}\right] \tag{21}$$

Canceling out the common terms on both sides leads us back to the original inequality (16) and after substituting the values of the payoffs we obtain the same condition as in (19), i.e. $(pV_c+(1-p)V_e) \geq V_{ne}$ and $p > 1/\pi$. There are however few alternatives in case of infinitely repeated games. First, we may not assume that agents discount future payoffs and instead believe that repeated interactions would continue in the future, i.e. from one round to another with some constant probability, say $q$. Thus, if the probability of moving from one round to another is independent of the previous round, the probability that the game is still being played $N$ rounds from the current round is $q^N$. Therefore, the present value of a future payoff $V$ of every round is simply; $V[q + q^2 + \dots]$ or $V[q/(1-q)]$, which is similar to the discounting stream, if $q = \beta$. The intuition in this case explains the role of patience and the value that agents put on the future. For instance, if the tax payer puts a sufficiently higher weight on the future, then a reward and punishment mechanism works towards cooperation or non-defection. The trade-off in a one-step-deviation setup is an immediate gain versus future payoffs, wherein the loss from defection will eventually more than offset the immediate gains. Thus, patience in a repeated setting leads to agents continuing on their equilibrium path and not deviating.

The second alternative is to consider the *limit of means* of payoffs which leads to the proposition that $U_i = \liminf_{N\to\infty} \frac{1}{N}\sum_{n=0}^{N} u_i(v_n)$, where $U$ is the utility associated with the payoff. However, the concept is considered unrealistic and also does not guarantee a Subgame Perfect Nash Equilibrium (SPNE). (See for instance Radner et. al (1986), Aumann (1997) for a discussion). Equilibrium strategies in such games and particularly in the one shot stage game also depend critically on the assumption of rationality of individual agents. The assumption implies that agents act in their best interest, choose the best actions to achieve their objective, have perfect foresight and act after using all available information. The difficulty arises particularly in case of repeated games as assumptions of perfect foresight imply that agents can contemplate outcomes from the beginning of the interaction. Extensions in areas of evolutionary mechanisms solve such difficulties by taking away the element of foresight, but only mechanically. (See Guth et. al. (1982), Binnmore (1985) and Aumann (1997)). The results from the infinite game can now be summarized in few key takeaways;

- Equilibrium strategies in an infinite setting can be taken as 'rules of thumb', i.e. such strategies tell the player what to do in a long-repetitive engagement.
- As players would continue to have repetitive interactions, the engagement can extent to a long period, without specifying *how* long.
- The limit of means or the average payoff in the repeated game tell the player *how much* to expect gains, whereas the un-discounted version tells the player *how to* play in a long term engagement.

### 3.4.1 Beyond payoffs and role of social preferences

One important lesson from the literature has been that penalty structure and efforts of the tax administration can act as substitutes to each other. This finding is intuitive as both serve to act as deterrent to tax evasion, in the sense that higher penalty rates may lead to lower frequency of audits and vice-versa. It also suggests that while the probability of audit may be dependent on the subjective beliefs of tax authorities on levels of evasion, higher penalty rates do act as deterrent to tax evasion. Two perspectives emerge from the association between audits and penalty rates. First is the cost of audit. Tax payers may perceive that tax audits are costless. However, tax audits can prove to be expensive and may entail several other costs, even when the tax payer has reported the true income. From the tax authorities perspective, audit costs play a significant role as authorities choose whether or not to conduct audit based on their subjective beliefs of tax evasion. Unless expected benefits of audits are considerably higher (in cases where the reported fraction of income is lower), tax authorities do not have sufficient incentives to increase number of audit of tax payers. The belief structure also translates into the fact that tax payers may perceive fewer audits if they believe that cost of audit are significantly high for the tax authorities. Second, the objectives of conducting tax audits by authorities are generally unknown. One can broaden the scope of audits to consider that authorities may be interested in unearthing larger undisclosed incomes, instead of collecting taxes or penalties. This situation is clearly plausible as given the limits of imposing penalties, it is in the interest of tax authorities to detect more undisclosed incomes.

The analysis on tax evasion in general limits the tax payer's decision only to maximize gains from evasion. However, the scope of analysis can be extended in several areas such as; social interactions and network effects, reputation or other dimensions such as predictive auditing strategies. Broadly, going beyond payoffs requires understanding and integrating the role of social preferences, which among others can be narrowed down to at least three dimensions;

- Fairness or Fair play: people receive utility from being fair to others.
- Altruistic: people receive utility from being nice to others.
- Vindictive: people like to punish those deviating from accepted norms of behavior.

Social preferences also convey means to understanding compliance behavior. For instance, works of Hashimzade et. al (2016) has shown the use of networks with heterogeneous in risk preferences, beliefs, attitude towards compliance, and self-selection into different occupational groups can effectively lead to predictive audit strategies. Such preferences can allow tax authorities have more decision making variables other than maximizing revenue collections or choosing income thresholds for audits.

# 4 Conclusion

This paper takes a renewed approach to analyze the problem of tax evasion by incorporating a simple game theoretic framework wherein an individual is confronted with the choice of declaring income for taxation. The model is a re-formulation of Allingham & Sandmo (1972) and Srinivasan (1973) original single period decision making problem of an individual deciding whether or not to under-report income for taxation. However, once we conceptualize that the individual has to decide on reporting incomes in more than one period, the problem of tax evasion in its simplest form can be extended to a repeated problem with strategic interactions of a tax payer and a tax authority. To begin with, a basic one stage game is formulated in which a tax payer has two choices; whether or not to engage in evasion and the tax authority has choices over auditing or not auditing the tax payer.

The game version modifies the single period problem first by incorporating the cost of audits for the tax authority. The game provides a mix-strategy Nash equilibrium in which a tax payer's best response is not to evade as long as the probability of audit is higher than $1/\pi$, where $\pi$ is the penalty rate on evaded tax. In the literature, penalty rate on tax evasion and the probability of audit are considered as substitutes for deterrence. The mixed strategy equilibrium result shows that the probability of audit is inversely related to the penalty rate.

An infinitely repeated version of the game extends the decision making problem to multi-periods. In this setting if a tax payer is caught evading, the authorities audit the individual in every subsequent period. The underlying logic is that once an evader is found, tax authorities are more likely to audit to prevent further evasion. The principle is similar to a one-step-deviation rule, wherein agents choose a pair of strategies and continue with them up until the other agent defects and post defection, continue to defect *thereafter*.

The repeated version reestablishes the result of the mix-strategy equilibrium and the un-discounted version provides the insight that (i) agents would continue to have repetitive interactions, hence the engagement can extent to a long period, without specifying *how* long, (ii) the role of patience and the value that agents put on the future is critical as short gains from a one time deviation can be can be more than offset by a low continued payoff in the future. For instance, if the tax payer puts a sufficiently higher weight on the future, then a reward and punishment mechanism works towards cooperation or non-defection, (iii) equilibrium strategies in an infinite setting can be taken as 'rules of thumb', i.e. such strategies tell the player *what to do* in a long-repetitive engagement, whereas payoffs tell *what to expect* in the long engagement.

Factors such as audit costs of the tax authority clearly influence the decision of the tax payer and evasion might increase in case individuals perceive that audit costs for the tax authorities are significantly high. A related aspect to audit is that the objectives of the tax authorities are generally unknown. Given that there maybe limits to imposing penalties, one can broaden the scope of audits to consider that authorities may be interested in unearthing larger undisclosed incomes, instead of collecting taxes or penalties.

---

## References


**Allingham, Michael G. & Sandmo, Agnar** (1972) Income Tax evasion: A theoretical analysis, *Journal of Public Economics*, Vol. 1, pp. 323-338

**Aumann, Robert J.** (1997) Rationality and Bounded Rationality, *Games and Economic Behavior*, Vol. 21, pp. 2-14

**Benjamini, Y. & Maital, S.** (1985) Optimal tax evasion and optimal tax evasion policy: Behavioural aspects, in: Gaertner and Wenig (Eds.) *The economics of the shadow economy*, Berlin: Springer-Verlag

**Bernasconi, Michele** (1998) Tax evasion and orders of risk aversion, *Journal of Public Economics*, Vol. 67, Issue 1, pp. 123-134

**Binmore, K., Shaked, A. and Sutton, J.** (1985) Testing non-cooperative bargaining theory: A preliminary study, *American Economic Review*, Vol. 75, pp .1178-1180

**Brock, W.A., Durlauf, S.N** (2001) Discrete choice with social interactions, *Review of Economic Studies*, Vol. 68, pp. 235-260

**Chattopadhyay, Saumen & Das-Gupta, Arindam** (2002) *The compliance cost of the personal Income Tax and its determinants*, Planning Commission - NIPFP Study, Published by National Institute of Public Finance and Policy (NIPFP): New Delhi

**Christiansen, V.** (1980) Two comments on tax evasion, *Journal of Public Economics*, Vol. 13, pp. 363-373

**Cowell, Frank** (1985a) Tax evasion with labour income, *Journal of Public Economics*, Vol. 26, pp. 19-34

**Cowell, Frank** (1985b) The economic analysis of tax evasion', *Bulletin of Economics Research*, Vol. 37, pp. 163-193

**Cross, R.B & Shaw, G. K.** (1981) The tax evasion - avoidance choice: A suggested approach, *National Tax Journal*, Vol. 34, pp. 489-491

**Cross, R.B. & Shaw, G. K.** (1982) The economics of tax aversion, *Public Finance*, Vol. 37, pp. 36-47

**Das-Gupta, Arindam** (2004) Tax compliance costs and non filing behavior, *NIPFP Working Paper*, WP No. 05, Feb 2004, National Institute of Public Finance and Policy, New Delhi

**Das-Gupta, Arindam, Ghosh, S. & Mookherjee, Dilip** (2004) Tax administration reform and taxpayer compliance in India, *International Tax and Public Finance*, Vol. 11, Issue 5, September, pp. 575-600

**Elffers, Henk, Robben, Henry S.J. & Hessing, Dick J.** (1992) On measuring tax evasion, *Journal of Economic Psychology*, Vol. 13 (1992), pp. 545-567

**Fortin, Bernard, Lacroix, Guy & Villeval, Marie-Claire** (2007) Tax evasion and social interactions, *Journal of Public Economics*, Vol. 91, pp. 2089-2112

**Gordon, J.** (1987) Modelling Tax Evasion where honesty may be the best policy, ESRC programme on taxation, incentives and the distribution of income, *Discussion Paper* No. 102/1987

**Graetz, Michael J., Jennifer F. Reinganum & Louis L. Wilde** (1986) The Tax compliance game: Toward an interactive theory of law enforcement, *Journal of Law, Economics, & Organization*, Vol. 2, No. 1 (Spring, 1986), pp. 1-32

**Guth, W., Schmittberger, R. and Schwarze, B.** (1982) An experimental analysis of ultimatum bargaining, *Journal of Economic Behavior and Organization*, Vol. (3), pp. 367-388

**Hashimzade, N., Khodavaisi, H. & Myles, G.D.** (2011) Country characteristics and preferences over tax principles, *International Tax and Public Finance*, Vol. 18(2), pp. 214-232

**Hashimzade, N., Myles, G.D. & Tran-Nam, B.** (2012) Applications of behavioral economics to tax evasion, *Journal of Economic Surveys*, Vol. 27, No. 5, pp. 941-977

**Hashimzade, N., Myles, G.D., Page, F. & Rablen, M.** (2014) Social networks and occupational choice: The endogenous formation of attitudes and beliefs about tax compliance, *Journal of Economic Psychology*, Vol. 40, pp. 134146

**Hashimzade, N., Myles, G. D., Page, F. & Rablen, M. D.** (2015) The use of agent-based modeling to investigate tax compliance, *Economics of Governance*, Vol. 16(2), pp. 143-164

**Hashimzade, N., Myles, G. D. & Rablen, M. D.** (2016) Predictive analytics and the targeting of audits. *Journal of Economic Behavior and Organization*, Vol. 124, pp. 130-145

**Hashimzade, N. & Myles, G.** (2017) Risk-based audits in a behavioral model, *Public Finance Review*, Vol. 45(1), pp. 140-165

**Lui, Francis T** (1986) A dynamic model of corruption deterrence, *Journal of Public Economics*, Vol. 31, Issue 2, November, pp. 215-236

**Manski, Charles F.** (2000) Economic analysis of social interactions, *Journal of Economic Perspectives*, Vol. 14 (3), pp. 115-136

**Mirrlees, James A.** (1971) *Notes on some special cases of the taxation of risk-taking*, mimeographed, Unpublished

**Mittone, Luigi** (2006) Dynamic behaviour in tax evasion: An experimental approach, *The Journal of Socio-Economics*, Vol. 35 (2006), pp. 813-835

**Moffitt, R.A.** (2001) Policy interventions, low-level equilibria and social interactions. In: Durlauf, Steven N., Peyton Young, H. (Eds.), *Social Dynamics*, Brookings Institution

**Mookherjee, Dilip & Png, Ivan** (1989) Optimal auditing, insurance, and redistribution, *The Quarterly Journal of Economics*, Vol. 104, Issue 2, pp. 399-415

**Mookherjee, Dilip** (1990) Enforcement costs and the optimal progressivity of income taxes, *Journal of Law, Economics and Organization*, No. 6 (2), pp. 410-31

**Mookherjee, Dilip** (2004) Tax administration reform and taxpayer compliance in India, *International Tax and Public Finance*, No. 11, (5), pp. 575-600

**Mookherjee, Dilip** (2008) Income tax compliance in India: An empirical analysis, *World Development*, 1995, No. 23 (12), pp. 2051-2064

**Mookherjee, Dilip** (2008) *Market Institutions, Governance, and Development: Collected essays*, Oxford University Press: New Delhi

**Mossin, J.** (1968) Taxation and risk-taking: an expected utility approach, *Economica* Vol. 35, pp. 74-82

**Pencavel, J. H.** (1979) A note on income tax evasion, labor supply and non-linear tax schedules, *Journal of Public Economics*, Vol. 12, pp. 115-124

**Pestieau, Pierre, Possen, Uri & Slutsky, Steve** (1994) Optimal differential taxes and penalties, *Public Finance*, Vol. 49, (supplement), pp. 15-27

**Radner, R.** (1980) Collusive Behavior in Non-cooperative Epsilon-Equilibria of Oligopolies with Long but Finite Lives, *Journal of Economic Theory*, Vol. 22, pp. 136-154

**Rao, Kavita R. & Tandon, Suranjali** (2016) Revisiting the tax compliance problem using prospect theory, *NIPFP Working Paper No. 169, April/2016*, National Institute of Public Finance and Policy, New Delhi

**Sharon, Emanuel** (1967) Income tax evasion as rational behavior under risk, *Working Paper No. 217*, Center for Research in Management Science, Univ. of California, Berkeley

**Srinivasan, T. N** (1973) Tax evasion: A model, *Journal of Public Economics*, Vol. 2, Issue No. 4, pp. 339-346

**Sproule, Robert A.** (1985) Tax evasion and labour supply under imperfect information about individual parameters of the tax system', *Public Finance*, Vol. 40, pp. 441-455

**Stiglitz, Joseph E.** (1969) The effects of income, wealth and capital gains taxation on risk-taking, *Quarterly Journal of Economics*, Vol. 83, pp. 263-283

**Tirole, Jean** (1996) A theory of collective reputations (with applications to the persistence of corruption and to firm quality), *Review of Economic Studies*, Vol. 63, No. 1, pp. 1-22

* * * * * * *

## MORE IN THE SERIES

- Ghosh Anindita, Lekha Chakraborty, (2019). Analysis Telangana State Finances: Elongation of Term of Maturity of Debt to Sustain Economic Growth, WP No. 288 (December).
- Bhanumurthy, N.R., Sukanya Bose, Sakshi Satija, (2019). Fiscal Policy, Devolution and Indian Economy, WP No. 287 (December).
- Chakraborty, L., Kaur, A., Shrestha, R., Jain, K., Jacob, J. F., Ghosh, A., (2019). Nutrition Public Expenditure Review: Evidence from Gujarat, WP No. 286 (December).

Amey Sapre is Assistant Professor, NIPFP
Email: amey.sapre@nipfp.org.in

National Institute of Public Finance and Policy,
18/2, Satsang Vihar Marg,
Special Institutional Area (Near JNU),
New Delhi 110067
Tel. No. 26569303, 26569780, 26569784
Fax: 91-11-26852548
www.nipfp.org.in