Tax Enforcement with Somewhat Honest Taxpayers

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Abstract

Standard compliance theory assumes that individuals evade to the extent it benefits them monetarily. However, a growing empirical literature suggests that many underlying cognitive considerations, including lying aversion, may play a non-trivial role when individuals make decisions. This study aims to analyze whether optimal audit rules that are the result of standard models survive a model with agents that are lying averse. I show the canonical cut-off audit rule where above a certain threshold no reported income is audited (introduced by Reinganum and Wilde (1986a) and further developed by Sanchez and Sobel (1993)) is not optimal in this setting. Moreover, a Bayesian incentive compatible audit probability does not need to be monotone in reported income, i.e. a higher report might be subject to a higher probability than a lower report.

JEL Codes: H26, D91, D82

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1 Introduction

1.1 Motivation

Many of the canonical models in the tax evasion literature assume that taxpayers will under-report their income as long as they have material gains, and their preference for risk allows it. However, a growing empirical literature on honesty suggests that some individuals might be influenced by non-monetary incentives when they make their compliance decisions. This literature also suggests that this type of behavior might be attributed to individuals potentially incurring a psychological cost when they lie. Current models of optimal enforcement and auditing rely on the standard models where all individuals are prone to dishonesty. However, if taxpayers are averse to lying, previous results from the literature might not apply anymore. Even though the previous literature acknowledges that some taxpayers might be inherently honest, the effect of such taxpayers on enforcement strategies, namely the audit rule, is not further analyzed.

This paper analyzes whether the optimal cutoff audit rule that is introduced by Sanchez and Sobel (1993) and Scotchmer (1987) survives a setting where taxpayers are lying averse, and show that the optimal cutoff audit rule is not robust to a simple addition of a lying aversion parameter. Specifically, this paper shows that when taxpayers are homogeneously lying averse, a random audit rule with constant probability of audit across the income distribution might perform better than the cutoff audit rule.

A cutoff audit rule is such that, given an audit threshold income, only taxpayers who report below that threshold are audited. In a standard model, the audit probability for the reported incomes below the threshold is chosen so that no taxpayer with true income below the threshold evades, whereas, all the taxpayers with true incomes above the threshold evade and report the threshold. Furthermore, the threshold is chosen such that the tax agency audits as many low reports as its budget allows. The technical intuition is that in an audit class, in which individuals' all observable characteristics but the reported income are the same, high-income individuals can lower their tax liability by imitating low-income individuals. Therefore, to disincentivize evasion the tax authority audits low-income reports with a higher probability than high-income reports.

Even though they are widely used in the literature, cutoff audit rules still seem counter-intuitive as, ultimately, only lower-income individuals, who report honestly, get audited. However, a simple alteration to the standard model where taxpayers incur an intrinsic cost that increases in the size of the lie, i.e. evasion, changes the characteristics of the cutoff rule.

Interestingly, one of the results suggest that contrary to what standard enforcement theory suggests, the audit probability does not have to be non-increasing in reported income to ensure incentive compatibility. In other words, a higher report can be associated with a higher probability than a lower report. To see this, first consider the standard setting where all agents are prone to evading as long as it benefits them monetarily, then, if higher reported incomes were audited more frequently, by reporting less taxpayers can decrease their tax liability without increasing expected penalty too much. In a cutoff rule setting this implies that once the tax agency defines a threshold where the audit probability is zero, the audit probability should be zero for all reported income above that threshold. However, introducing lying costs into the utility function of the taxpayer gives more freedom in choosing the audit probability. A lying averse taxpayer not only trade-offs decreasing tax liability and decreasing expected tax payments but also by reporting less, he risks incurring a higher lying cost. For example, in an extreme case, given a level of lying aversion, there exists an real income threshold such that a taxpayer will not report zero income even if she knows for sure she would not be audited. Therefore, it is sufficient but not necessary to have a non-increasing audit probability in reported income to deter taxpayers from mimicking each other. To further illustrate this idea, consider the taxpayer who has the top income. Given a cutoff audit rule, this taxpayer will report the cutoff and will not get penalized for cheating. However, in the presence of a high degree of lying aversion, this taxpayer might not report the cutoff. Applying the same logic to other taxpayers with high levels of true income implies that not all taxpayers with true income above the cutoff will end up bunching at the cutoff. This lack of significant bunching at the threshold suggests that the tax authority can now audit some individuals above the threshold and collect revenue.

An important aspect of the model is that I assume the tax agency chooses its optimal audit rule in order to maximize government revenue. In the standard model where all taxpayers are prone to evading and therefore they only aim to minimize their expected tax payments, maximizing revenue and a social welfare function usually leads to similar results. However, in this case, assuming the tax agency only maximizes revenue implies that the agency ignores a part of individuals' utility function- lying costs. Maximizing revenue instead of a social welfare function suggests that the approach taken here is more positive rather than normative, however, this approach is consistent with the "yield" criteria used by the tax agency for selection of returns for audit (Graetz et al. (1986)). This approach is also not too distinct from the approach taken by Sanchez and Sobel (1993) where they assume a hierarchical setting between a revenue-maximizing tax agency and a social welfare maximizing government. In Sanchez and Sobel (1993), the tax agency chooses the optimal audit rule subject to a budget constraint, whereas the government chooses the tax agency's budget and the tax rate. Therefore, the analysis conducted in this study can be considered as the first step of a sequential maximization problem. It is important to note that defining a social welfare function in this setting can be a tricky task. Firstly, the fact that lying costs depend on evaded income implies that the government needs to directly include the utility costs due to lying in its objective function; it has to know exactly how much each taxpayer evades. This is an unrealistic assumption that will render the existing models obsolete because if the government already knows how much each person evades there is no asymmetric information and the decision of whom to evade is no longer interesting.

An important caveat is that even though in this model it is assumed that all taxpayers are lying averse, this might not be true in the real world. There is evidence that suggests compliance rates are a lot higher than we expect, yet, it is important to distinguish the compliance rates based on income type. According to Bankman et al. (2015) compliance for individuals who earn wage income is 99%, however, for business income, it is around 40%. They suggest that the intrinsic desire not to evade plays a smaller role in the observed compliance and attribute the high compliance levels to third-party reporting. Although, the effect of third-party reporting is quite large without dispute, it still does not imply that the intrinsic costs have a small role. One of the implications that can still be drawn from the Bankman et al. (2015) study is that even though all taxpayers evade, given the opportunity, they might still shy away from evading to the extreme extent.

The rest of the paper is structured as follows. In the next subsection 1.2, I review the relevant existing public finance and behavioral/experimental economics literature and Section 2 introduces the model and analyzes the taxpayer's problem (subsection 2.1) as well as the tax agency's problem (subsection 2.2). Finally, section 3 delivers concluding remarks.

1.2 Context and Literature Review

This section has three parts: the first part explains why lying aversion matters by providing evidence from select works from the behavioral and experimental economics literature, the second part looks at how previous literature incorporated different levels of lying aversion into models, and finally the last part briefly discusses the literature on optimal cutoff audit rules.

The majority of lying aversion literature consists of experimental studies. Even though the external validity of laboratory experiments are a concern when it comes to real-world reporting behavior, they do provide information about the extent of the effect of non-rational aspects of individuals' behavior. One of the most comprehensive works that study lying costs is by Abeler et al. (2016). They combine data from 72 studies in different fields, including economics, psychology, and sociology and confirm that people do in fact lie very little compared to what has been widely assumed in economic theory. They present several possible explanations for the behavior in the data and conclude that only a combining preference for being honest and a preference for being seen honest can explain the data. Even though they focus on a setting where there are no strategic interactions, including audits, they do briefly discuss an "audit model" where they find evidence of intrinsic lying aversion on top of possible reputational concerns to be found out as a liar. Abeler et al. (2016) only consider a binary choice set- lying and not lying-, however, an individuals' choice set for reported income is likely to have more than two alternatives. On the other hand, Gneezy et al. (2018) design a framework where individuals have more than one choice; therefore they do not only answer the question "do people lie?" but also focus on the question "how much do people lie?". Their results suggest that when individuals make the decision to lie, they lie to the extreme, however, partial lies do occur if there are reputational concerns and/or individuals care whether they are seen as honest or not, which is relevant to the tax audit case. Even though they do not formally address the question, Fischbacher and Föllmi-Heusi (2013) imply that individuals are more likely to partially lie because the marginal cost of lying is likely to increase with regards to the size of the lie. Mazar et al. (2008) predict the same result, however, they theorize that the underlying reason for partial lying is due to the fact that individuals trade-off maintaining a positive self-concept as honest vs. gaining a monetary benefit from dishonesty. In summary, although it is agreed upon that individuals are averse to lying, the lying aversion literature does not have a consensus on whether individuals lie partially or to the extreme. It is important to note that in order to isolate pure lying aversion from monetary considerations, the models in the aforementioned papers assume cheating always increases monetary payoff and the only disutility incurred is from a variant of a lying cost. However, in the context of tax evasion, cheating, i.e. evading, does not unambiguously increase the monetary payoff because of the penalty incurred in case of an audit. This implies that individuals might not lie to the extreme extent (report 0 income) even if there is no lying aversion.

As stated by Erard and Feinstein (1994), there are some works in the public finance literature that recognize the fact that some taxpayers can be inherently honest (Graetz et al. (1986), Alm et al. (1992), Erard and Feinstein (1994)), however, not enough attention has been given to how these type of taxpayers can change our analysis of optimal enforcement tools.

Graetz et al. (1986) is one of the first works to consider an honest type of taxpayers- "habitual compliers"- individuals who always report their tax liability correctly. Habitual compliers comprise both taxpayers who do not have an opportunity to cheat on their taxes, i.e. wage earners, people subject to third-party reporting, etc., and taxpayers who disregard the potential monetary benefits of non-compliance. They develop "an interactive model" which is a signaling game played between the tax agency and the taxpayers. The most relevant result of their model is that as the proportion of habitual compliers increases, the probability that "strategic non-compliers" cheat decreases, leaving the optimal audit strategy and all other aspects of the model unchanged. This result heavily depends on the assumption that there are only two income classes, high and low, therefore, the IRS will never audit a taxpayer who reports high income. In contrast, the model presented here will assume a continuum of incomes, therefore, the optimal audit policy changes when there are individuals who are averse to lying.

To show that honest taxpayers do have a significant effect on tax agency policies, Erard and Feinstein (1994) extend the game theoretic compliance model developed by Reinganum and Wilde (1986a,b) by adding an explicit budget constraint for the tax agency. In a model where there is a continuum of agents who have different income levels and two possible behavioral types- honest and dishonest-, they reach a separating equilibrium among dishonest taxpayers where each report is associated with a specific income level. Because each report can be attributed to both dishonest and honest taxpayers, the tax agency cannot infer the ex-post true income. Finally, in contrast with previous similar models, the underlying true income distribution plays a role in their model. Because they find it not possible to analytically solve the model, they pursue conducting computer simulations and show that incorporating honest taxpayers alter the equilibrium calculation results, and these results fit with empirical facts. Their most relevant result from the simulations is that if the true income range is sufficiently wide, as the portion of the honest taxpayers increases, the audit function gains a convex upper tail. In other words, even the wealthiest taxpayers face a positive audit probability.

Lastly, because this paper deals with cutoff audit rules, it is important to have a brief summary of the existing literature. Reinganum and Wilde (1985) first introduced this class of audit rules, in which every taxpayer with a reported income below a certain threshold is audited with a fixed probability. They also show that cutoff rules weakly dominate random audit rules when the tax agency aims to maximize revenue collected. Cutoff audit rules, however, are thought to be unrealistic and not credible because they have the regressive result that the only taxpayers who get audited are low-income individuals who report truthfully. Scotchmer (1987) relaxed the assumption that a tax authority can only observe reported income and showed that if taxpayers are assigned into different audit classes, a tax schedule with a cutoff audit rule will be regressive within an audit class but progressive overall. Finally, Sanchez and Sobel (1993) characterized all the conditions under which the optimal audit rule is a unique cutoff.

2 Model and Framework

Taxpayers are characterized by their true income, i, independently and identically drawn from a known distribution, F, from an interval $[l, h]$. All taxpayers have the same lying aversion parameter θ. The lying aversion parameter is common knowledge whereas income, i, is private knowledge. Each taxpayer reports income, r, to maximize her utility. The tax agency observes reported income and taxes everyone, using an increasing tax function $t(r)$ and chooses an audit probability, $p(r)$, to maximize its revenue subject to a budget constraint. Auditing is costly, denoted by k per audit, and the budget, B, is not large enough for the tax agency to audit everyone with a probability that ensures truthful reporting. In case of an audit, real income is revealed and taxpayers who are caught cheating have to pay a penalty, π, levied on the evaded tax.

2.1 Taxpayer's Problem

After observing their true income, taxpayers choose reported income, r, to maximize the reduced form of utility function defined below. [1]. Maximizing this function is same as maximizing $u(i, r; \theta)$.

$$\max_r u(i, r; \theta) = -t(r) - \mathbf{I_{r \leq i}}[p(r)(1 + \pi)(t(i) - t(r))] - c(i, r; \theta) \tag{1}$$

The first term is the tax owed on the reported income and the second term is the expected payment in case of an audit. The third term, $c(i, r; \theta)$ is the cost of lying, scaled by the parameter θ. The higher θ is, the higher the cost of lying. The cost of lying is also assumed to increase in the degree of lying downwards, i.e. evasion, and non-decreasing in the degree of lying upwards, i.e. over-reporting, and is equal to zero when the taxpayer reports her income truthfully.

$$\frac{\partial c(i, r; \theta)}{\partial \theta} > 0, \quad \frac{\partial c(i, r; \theta)}{\partial (i - r)}|_{i > r} > 0, \quad \frac{\partial c(i, r; \theta)}{\partial (i - r)}|_{i < r} \leq 0, \quad c(i, r; \theta)|_{i=r} = 0, \quad c(i, r; \theta)|_{\theta=0} = 0$$

For brevity, without loss of generality, θ will be suppressed for the rest of the paper.

Let $r^*(i)$ denote the optimal report of the taxpayer with income i. The following are the sufficient and necessary conditions:

$$r^*(i) = \arg\max_r u(i, r) \tag{IC}$$

[1] The actual utility is $i - (t(r) + \mathbf{I_{r \leq i}}[p(r)(1 + \pi)(t(i) - t(r))] + c(i, r; \theta))$

$$\frac{\partial u(i,r)}{\partial r} = 0$$
$$-t'(r) - p'(r)(1+\pi)(t(i)-t(r)) + p(r)(1+\pi)t'(r) - \frac{\partial c(i,r)}{\partial r} = 0 \tag{local IC}$$

$$\begin{aligned}\frac{dU(i)}{di} &= \frac{\partial u(i,r)}{\partial i} + \underbrace{\frac{\partial u(i,r)}{\partial r}|_{r=r^*(i)}}_{=0} \frac{\partial r^*(i)}{\partial i} \\ &= -p(r^*(i))(1+\pi)t'(i) + \frac{\partial c(i,r)}{\partial i}\end{aligned} \tag{EC}$$

Where $g'(.)$ denotes the derivative of the function g, and U denotes the indirect utility function. The first expression is the standard incentive compatibility constraint that suggests that the optimal report should be the solution to the taxpayer's maximization problem. The second is the first order condition resulting from the taxpayer's maximization condition. Finally, the third one is the envelope condition.

Below is a simple result that's an adaptation from Scotchmer (1987).

Lemma 1. *No taxpayer reports more than her true income. A sufficient condition for a taxpayer to report honestly is* $p(r) \geq \frac{1}{1+\pi}\ \forall r \in [l,h]$

Proof. The first claim follows from the fact that t(.) is increasing in reported income and there are no rewards from over-reporting. Moreover, $c(.)$ is non-decreasing in the over-reported income, hence, over-reporting is strictly dominated by reporting truthfully. To prove the second claim, consider the utility comparison between reporting truthfully, i, and evading $r < i$

$$\begin{aligned}&t(i) \leq t(r) + p(r)(1+\pi)(t(i)-t(r)) + c(i,r) \\ &t(i)(1-p(r)(1+\pi)) \leq t(r)(1-p(r)(1+\pi)) + c(i,r)\end{aligned} \tag{2}$$

$i > r$ implies that $c(i,r) > 0$. Therefore a sufficient condition for the left-hand-side to be smaller than the right-hand-side is that $p(r) \geq \frac{1}{1+\pi}$. Notice that unlike the result in Scotchmer (1987) and Sanchez and Sobel (1993), we can find $p(.)$, such that $p(r) < \frac{1}{1+\pi}$ but still high enough to deter evasion.

□

First, notice that the tax agency's problem presented here is very similar to an optimal mechanism design problem, especially, the optimal auction design model introduced by the seminal work of Myerson (1981). The tax agency has to come up with an optimal mechanism, i.e. audit rule, in order to maximize its tax revenue. In a way, the tax agency's problem is similar to an auction of a "bad" instead of a good. The "bad", i.e. being audited, is awarded to taxpayers with a probability function, i.e. audit rule, that takes reported type, i.e. income, as an input.

For a mechanism to be optimal, it has to be feasible and efficient. A feasible mechanism has to be in the set of all Bayesian incentive compatible mechanisms. (Myerson (1981)). A Bayesian incentive compatible mechanism, i.e. audit rule, has to ensure that in equilibrium no taxpayer has an incentive to change her report to an income another taxpayer is reporting in equilibrium. The following proposition 1 gives us the conditions for an audit rule to be feasible which is a necessary but not a sufficient condition for it to be optimal.

Proposition 1 (Bayesian Incentive Compatibility). *Given any $p(.)$, and $c(.)$, if $r^*(i)$ and $r^*(j)$ maximize taxpayer i and j's utility respectively and without loss of generality $r^*(j) < r^*(i) < j < i$* [2]*, then*

(a)

$$p(r^*(j))(1+\pi)+\frac{c(i,r^*(j))-c(j,r^*(j))}{t(i)-t(j)} \geq p(r^*(i))(1+\pi)+\frac{c(i,r^*(i))-c(j,r^*(i))}{t(i)-t(j)} \quad (3)$$

(b)

$$U(i,r)=-t(l)-\int_l^i (p(r^*(j))(1+\pi)t'(j)+c(\theta,j,r^*(j))dj \quad (4)$$

Proof. Part (a) follows from the incentive compatibility constraint of taxpayers. To see this consider the incentive compatibility constraint of a taxpayer with income i where $i > j$.

$$\begin{aligned}
u(i,r^*(i)) &\geq u(i,r^*(j)) \\
t(r^*(i)+p(r^*(i))(1+\pi)(t(i)-t(r^*(i))+c(i,r^*(i)) &\leq t(r^*(j))+p(r^*(j))(1+\pi)(t(i)-t(r^*(j)) \\
-u(i,r^*(i)) &\leq -u(j,r^*(j))+p(r^*(j))(1+\pi)(t(i)-t(j))+c(i,r^*(j))-c(j,r^*(j)) \\
-(u(i,r^*(i))-u(j,r^*(j)) &\leq p(r^*(j))(1+\pi)[t(i)-t(j)]+c(i,r^*(j))-c(j,r^*(j)) \\
p(r^*(j))(1+\pi)+\frac{c(i,r^*(j))-c(j,r^*(j))}{t(i)-t(j)} &\geq \frac{-(u,r^*(i))-u(j,r^*(j))}{t(i)-t(j)}
\end{aligned} \quad (5)$$

The expression above implies that if $r^*(i)$ maximizes the utility function of the taxpayer with true income i, this taxpayer should not prefer reporting $r^*(j)$, which is the report that maximizes the utility of taxpayer with true income j, instead. Following the same steps

[2] Assuming $i > j$ will indeed not cause any loss of generality. Moreover, by Lemma 1, it should be the case that $r^*(i) < i$ and $r^*(j) < j$ and therefore $r^*(j) < i$. For the same reason, a taxpayer with income j will never report $r^*(i) > j$, therefore we do not need to consider that case.

using the incentive compatibility constraint of a taxpayer with true income j will give us the following expression.

$$\frac{-(u(i,r^*(i)) - u(j,r^*(j))}{t(i)-t(j)} \geq p(r^*(i))(1+\pi) + \frac{c(i,r^*(i)) - c(j,r^*(i))}{t(i)-t(j)} \tag{6}$$

Combining these two inequalities we get

$$p(r^*(j))(1+\pi) + \frac{c(i,r^*(j)) - c(j,r^*(j))}{t(i)-t(j)} \geq \frac{-(u(i,r^*(i)) - u(j,r^*(j))}{t(i)-t(j)} \geq p(r^*(i))(1+\pi) + \frac{c(i,r^*(i)) - c(j,}{t(i)-t(j)}$$

$$p(r^*(j))(1+\pi) + \frac{c(i,r^*(j)) - c(j,r^*(j))}{t(i)-t(j)} \geq p(r^*(i))(1+\pi) + \frac{c(i,r^*(i)) - c(j,r^*(i))}{t(i)-t(j)} \tag{7}$$

Now for the second part recall the envelope condition (EC)

$$\frac{dU(i)}{di} = -p(r^*(i))(1+\pi)t'(i) + \frac{\partial c(i,r^*(i)}{\partial i}$$

Then using the fundamental theorem of calculus we get

$$U(i,r) = U(l,r(l)) - \int_l^i (p(r^*(j))(1+\pi)t'(j) + c(\theta,j,r^*(j))dj \tag{8}$$

Moreover, $U(l,r(l)) = -t(l)$ because the agent with the lowest income cannot evade.

□

Corollary 1. *Without lying aversion, a feasible audit probability function has to be non-decreasing in reported income. However, the audit probability function does not have to be monotone in reported income in the presence of lying aversion.*

Proof. This corollary is a direct result of the part (a) of Proposition 1.

For the first part of Corollary 1[3], can be shown by setting $\theta = 0$, hence $c(i,r) = 0 \quad \forall i, r$, and rewriting Inequality 3 in part (a) of the Proposition 1.

$$p(r^*(j))(1+\pi) \geq p(r^*(i))(1+\pi) \tag{9}$$

Because $(1+\pi) > 0$, the inequality above implies that

$$p(r^*(j)) \geq p(r^*(i)) \quad \forall i > j > r(i) > r(j)$$

[3]This part is a result in Sanchez and Sobel (1993).

The prove the second part of Corollary 1, notice that because $i > j > r^*(i) > r^*(j)$ the following is true.

$$\begin{aligned} \frac{c(i, r^*(j)) - c(j, r^*(j))}{t(i) - t(j)} > 0 \\ \frac{c(i, r^*(i)) - c(j, r^*(i))}{t(i) - t(j)} > 0 \end{aligned} \tag{10}$$

However, it is possible to have a lying cost function such that

$$\frac{c(i, r^*(j)) - c(j, r^*(j))}{t(i) - t(j)} < \frac{c(i, r^*(i)) - c(j, r^*(i))}{t(i) - t(j)} \tag{11}$$

Which in turn allows for $p(r^*(j)) < p(r^*(i))$ □

The monotonicity of the audit probability is a necessary condition in Sanchez and Sobel (1993), and a crucial one in characterizing the cutoff policy. Intuitively, this is because of the fact that if lower reports are audited less frequently, then taxpayers have more incentives to report them because, in this case, reporting a lower report not only decrease tax liability but also decreases the chances of being audited. The monotonicity requirement, in turn, implies that if a report is never audited then all other reports that are greater should also not be audited, i.e. if $\exists\, \overline{r}$ s.t. $p(\overline{r}) = 0$, then $p(r) = 0\ \forall r > \overline{r}$.

In contrast, the above result suggests that, depending on the rate the cost function changes in the size of evasion, it might be optimal to audit a higher income with higher probability than a lower income.

2.2 Tax Agency's Problem

In a similar fashion to Sanchez and Sobel (1993), let $E(i, r; p(.)) = t(r) + p(r)(1+\pi)(t(i) - t(r))$ denote the expected tax of an individual with income i and report r, given the audit function $p(.)$. Also, let and $T(i, p(.)) = E(i, r^*(i); p(.))$ be the expected tax payment of this taxpayer, given that her optimal report is $r^*(i)$[4]. Finally, let k denote the cost of audit.

Then the tax agency's problem can be stated as follows:

[4]Notice that $r^*(i)$ does not minimize possible tax payments of taxpayer i, but it minimizes possible tax payment plus the cost of lying.

$$
\begin{aligned}
&\max_{p(.)} \int_l^h T(i,p(.))dF(i)\\
&\text{subject to}\\
&\int_l^h kp(r^*(i))dF(i) \le B\\
&\text{where } \forall i\\
&r^*(i) = \arg\min_r E(i,r;p(.)) - c(i,r)
\end{aligned} \tag{12}
$$

One thing to notice is that, contrary to Sanchez and Sobel (1993), the tax agency's objective function does not have a one-to-one relationship with the taxpayer's objective function because the tax agency does not care about taxpayers' lying cost. However, it is still possible to simplify the tax agency's problem using the taxpayer's maximization problem.

$$
\begin{aligned}
\frac{dT(i)}{di} &= \frac{\partial E(i,r)}{\partial i} + \frac{\partial E(i,r)}{\partial r}|_{r=r^*(i)} \frac{\partial r^*(i)}{\partial i}\\
&= \frac{\partial E(i,r)}{\partial i} + \underbrace{\frac{\partial U(i)}{\partial r}|_{r=r^*(i)}}_{=0} - \frac{\partial c(i,r)}{\partial r}|_{r=r^*(i)} \frac{\partial r^*(i)}{\partial i}\\
&= -p(r^*(i))(1+\pi)t'(i) - \frac{\partial c(i,r)}{\partial r}\frac{\partial r^*(i)}{\partial i}
\end{aligned} \tag{EC-TA}
$$

Then the objective function of the tax agency can be rewritten in the following form:

$$
\begin{aligned}
\int_l^h T(i,p(.))dF(i) &= \int_l^h [T(l,p(.)) + \int_l^i (p(r^*(j))(1+\pi)t'(j) - \frac{c(j,r^*(j))}{\partial r^*(j)}\frac{\partial r^*(j)}{\partial j})dj]dF(i)\\
&= \int_l^h (p(r^*(i))(1+\pi)t'(i) - \frac{c(i,r^*(i))}{\partial r^*(i)}\frac{\partial r^*(i)}{\partial i})\frac{1-F(i)}{f(i)}dF(i) + \underbrace{T(l,p(.))}_{t(l)}
\end{aligned} \tag{13}
$$

Moreover, because Lemma 1 suggests that any $p(r) > 1/(1+\pi)$ is enough to deter evasion, no budget constraint tax agency will ever choose an audit probability higher than $1/(1+\pi)$. Therefore the optimization problem can be restated as follows:

$$
\begin{aligned}
&\max_{p(.)} \int_l^h (p(r^*(i))(1+\pi)t'(i) - \frac{c(i,r^*(i))}{\partial r^*(i)}\frac{\partial r^*(i)}{\partial i})\frac{1-F(i)}{f(i)}dF(i) + T(l,p(.))\\
&\text{such that}\\
&p(r^*(j))(1+\pi) + \frac{c(i,r^*(j)) - c(j,r^*(j))}{t(i)-t(j)} \geq p(r^*(i))(1+\pi) + \frac{c(i,r^*(i)) - c(j,r^*(i))}{t(i)-t(j)} \quad \forall i > j > r^*(i) > r^*(j)\\
&\text{and } p(r^*(i)) \in [0, 1/(1+\pi)] \quad \forall i\\
&\text{subject to}\\
&\int_l^h kp(r^*(i))dF(i) \leq B\\
&\text{where } \forall i\\
&r^*(i) = \arg\min_r E(i,r;p(.)) - c(i,r)
\end{aligned}
\tag{14}
$$

Lemma 2. *The model presented in Sanchez and Sobel (1993) is a limiting case of the model presented here.*

Proof. First, recall the following properties of $c(i, r; \theta)$.

$$
\frac{\partial c(i,r;\theta)}{\partial \theta} > 0, \quad c(i,r;\theta)|_{\theta=0} = 0
$$

Then the following must be true

$$
\begin{aligned}
\lim_{\theta\to 0} c(i,r^*(i)) = 0 \lim_{\theta\to 0} \frac{c(i,r^*(i))}{\partial r^*(i)} &= 0\\
\lim_{\theta\to 0} \frac{c(i,r^*(j)) - c(j,r^*(j))}{t(i)-t(j)} &= 0\\
\lim_{\theta\to 0} \frac{c(i,r^*(i)) - c(j,r^*(i))}{t(i)-t(j)} &= 0
\end{aligned}
\tag{15}
$$

Then the tax agency's problem reduces to

$$\begin{aligned}
&\max_{p(.)} \int_l^h p(r^*(i))(1+\pi)t'(i)\frac{1-F(i)}{f(i)}dF(i) + T(l, p(.)) \\
&\text{such that} \\
&p(.) \quad \text{is non-increasing} \\
&\text{and } p(r^*(i)) \in [0, 1/(1+\pi)] \quad \forall i \\
&\text{subject to} \\
&\int_l^h kp(r^*(i))dF(i) \leq B \\
&\text{where } \forall i \\
&r^*(i) = \arg\min_r E(i, r; p(.))
\end{aligned} \tag{16}$$

Which is equivalent to the tax agency's problem in Sanchez and Sobel (1993). Therefore, as θ converges to zero, i.e. lying aversion diminishes, the problem presented here converges to the one presented in Sanchez and Sobel (1993). □

Corollary 2. *As lying aversion diminishes, the optimal audit rule converges to a cutoff rule.*

Proof. The above is a result we get by direct application of Lemma 2. By Lemma 2, we know that as lying aversion diminishes, both the taxpayer's and tax agency's problem converges to the counterparts of the same problems presented in Sanchez and Sobel (1993). Moreover, Sanchez and Sobel (1993) show that in their setting an optimal audit rule has to be in the form of a cutoff rule. Therefore, as lying aversion diminishes, optimal audit rule converges to a cutoff rule. □

In order to show that a cutoff rule in this setting might not be optimal, consider the simplified problem where $t(r) = tr \ \forall r$ and $c(i, r) = \frac{\theta}{2}(i-r)^2 \ \forall i, r$. Moreover for simplicity assume that $i \sim U[0, h]$

Proposition 2. *A general cutoff rule such that*

$$p^*(r) = \begin{cases} 1/(1+\pi) & \text{if} \quad r \in [l, a) \\ 0 & \text{if} \quad r \in [a, h] \end{cases} \tag{17}$$

where $F(a) = \frac{B(1+\pi)}{k}$*, is not optimal for the simplified problem with lying aversion.*

Proof. We start by deriving the optimal reported strategy of taxpayers, given that the audit rule is $p^*(i)$. In Sanchez and Sobel (1993) setting there are two types of reports- taxpayers who report truthfully and taxpayers who report the cutoff. In contrast, in this setting, there are three types of reports: (i) taxpayers who report truthfully, (ii) taxpayers who report exactly the threshold, a, (iii) taxpayers who evade by a constant amount.

By Lemma 1 we know that all taxpayers with real income less than a report truthfully.

First, consider all taxpayers who have real income above the audit threshold, a. The utility from reporting any income, r, above the threshold is as follows.

$$u(i,r) = -tr - \frac{\theta}{2}(i-r)^2 \tag{18}$$

Because this function is continuous we can maximize it with respect to r[5].

$$\begin{aligned} \frac{\partial u(i,r)}{\partial r} &= -t + \theta(i-r) = 0 \\ r^*(i) &= i - \frac{t}{\theta} \end{aligned} \tag{19}$$

Notice that even if there's no risk of auditing, taxpayers still do not evade to the extreme extent.

Finding the taxpayer who is indifferent between reporting the cutoff or evading by a constant amount will characterize the interval of taxpayers who report truthfully.

$$\begin{aligned} r^*(i) = a &= i - \frac{t}{\theta} \\ i &= a + \frac{t}{\theta} \end{aligned} \tag{20}$$

Then the following expression characterizes the optimal reported income of taxpayers given $p^*(i)$

$$r^*(i) = \begin{cases} i & \text{if} \quad i \in [l, a] \\ a & \text{if} \quad i \in [a, a+\frac{t}{\theta}] \\ i - \frac{t}{\theta} & \text{if} \quad i \in [a+\frac{t}{\theta}, h] \end{cases} \tag{21}$$

Tax revenue in this case is equal to the following expression where $a = \frac{B(1+\pi)}{k}$

$$\begin{aligned} TR_a &= \int_0^a i dF(i) + \int_a^{a+\frac{t}{\theta}} a dF(i) + \int_{a+\frac{t}{\theta}}^h (i - \frac{t}{\theta}) dF(i) \\ &= \frac{1}{2}\left(\frac{a^3}{h} - a^2 + \frac{2at}{\theta} + \frac{(t-h\theta)^2}{\theta^2}\right) \end{aligned} \tag{22}$$

[5] Assuming $r^*(i) \in [0, i]$.

On the other hand, consider a constant audit probability, which is used to audit all taxpayers, that exhausts the government's budget.

$$p(r) = \overline{p} = \frac{Bh}{k} \quad \forall r$$[6]

Given the probability of an audit, the taxpayer's first order condition can be characterized by the equation below.

$$\begin{aligned} -t + p(1+\pi)t - \theta(i-r) &= 0 \\ r^*(i) &= i - \frac{t(1-p(1+\pi))}{\theta} \end{aligned} \tag{23}$$

Then the tax agency's expected revenue in the case where $p(r) = \overline{p}$ is

$$\begin{aligned} TR_{\overline{p}} &= \int_0^h (tr^*(i) + \overline{p}(1+\pi)t(i - r^*(i)))dF(i) \\ &= \frac{t\left(h\theta - 2t(1-(1+\pi)\overline{p})^2\right)}{2\theta} \end{aligned} \tag{24}$$

It is enough to show that there exists one case where $TR_{\overline{p}} > TR_a$ To see that consider following parameter values:

$$\theta = 2, \;\; \pi = 0.5, \;\; p = 0.375, \;\; t = 0.8$$

which implies that

$$TR_{\overline{p}} = 1.91 > 1.9 = TR_a$$

□

The previous proposition shows that a random audit with a constant probability can perform better than the cutoff rule suggested by the previous literature. One main reason behind this result is that, in the standard model, higher income individuals have a greater opportunity for evasion compared to lower income individuals. By consistently auditing lower reported incomes and making them unattractive to report, the tax agency limits the extent of evasion caused by higher income individuals. When lying aversion is introduced into the model, the previous observation is not necessarily true anymore. Equation 19 shows that even in the case where no one is audited, taxpayers will not lie to an extreme extent.

[6] Notice that this probability function satisfies the monotonicity condition defined in part(b) of Proposition 1.

In other words, evasion opportunities do not vary drastically with respect to real income. Therefore, the tax authority can treat all reported income the same and increase tax revenue by choosing a constant audit probability. One caveat of Proposition 2 is the assumption of uniform income distribution. If income is not distributed uniformly, then the tax authority might want to focus on income intervals where the income distribution is heavier.

3 Conclusion

By developing a model of taxation and tax compliance where taxpayers are homogeneously lying averse, I have shown that the frequently used cutoff optimal rules do not survive this modification of the standard model. Although this paper does not claim that the lying aversion model introduced here captures the actual way individuals behave, it does provide insights about how current models of optimal enforcement rules are not robust.

Seemingly counter-intuitive at first, cutoff rules are optimal in the standard models, especially in settings where higher income individuals have a better opportunity for hiding their income than lower-income individuals. Therefore, in these models, it is intuitive to audit lower incomes more frequently than higher incomes. However, if individuals' willingness to evade as well as their opportunity to evade does not increase in income, it is possible that higher-income individuals are also audited in equilibrium. In the case of this model, under certain parameter specifications, auditing all reports with a constant probability performs better than applying a cutoff audit rule.

This paper assumes that the tax agency's objective is to maximize net revenue. Even though it will be interesting to see if there are other audit rules that deliver higher social welfare than the cutoff rules, defining a social welfare in this setting is tricky because the government has to know the true income and the report of all taxpayers. One way to circumvent this problem is to use a variant of the revelation principle. If one can find an optimal audit rule that can implement revelation principle, then the government can trivially solve the lying problem by asking taxpayers to report their true income and assigning them the expected utility they receive in equilibrium.

A natural extension to this paper will be to solve for the optimal audit rule in this setting. Even though, the actual rule itself might no be implementable in the real world, doing comparative statics can provide insights about how the rule changes with respect to the level of lying aversion.

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