Tax compliance with endogenous audit selection and heterogeneity of income

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Abstract It has been shown in the experimental tax compliance literature that endogenous audit selection mechanism (ASM) increases tax compliance. However, this literature assumes that the tax authority has an unbiased observation of the actual taxpayers’ income and consequently the taxpayers with the largest difference between the observed and reported income are most likely to be selected for audit. In reality the tax authority might not have unbiased information about the actual incomes as these might be observed only for taxpayers who have been selected for audit. In this case the ASM can be based on reported incomes only. The aim of the paper is to design an endogenous ASM that uses only the reported incomes and experimentally compare the tax compliance under the endogenous and random ASMs. We develop a theoretical model where taxpayers have heterogeneous income and the ASM is based only on the reported income. We show that in the symmetric Bayes-Nash equilibrium the proposed endogenous ASM entails a higher compliance than the random ASM. The experimental test of the design confirms the theoretical prediction that taxpayers have higher compliance under the endogenous ASM than under the random ASM.

Keywords Tax compliance · Heterogeneous income · Endogenous audit selection

JEL classification H26

1 Introduction

This paper proposes an endogenous audit selection mechanism (ASM) based solely on reported incomes and uses experimental methods to test whether the mechanism has a positive impact on compliance of taxpayers with heterogeneous incomes.

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The experimental design addresses the problem of high information requirements of the audit selection mechanisms proposed in the literature: Gilpatric et al (2011) assume that the auditors possess noisy but unbiased information about taxpayers' true income, and Alm and McKee (2004) suppose that the tax office can divide the taxpayers into subgroups with the same income. This might not be possible because the true income can be observed only when taxpayers are audited, which means that the tax office might have the income data only for a few taxpayers in some sectors. Even in sectors with a high number of audits, the tax office may face additional problems. For example, the income of some taxpayers may vary significantly between years, or the incomes of individual taxpayers may depend on idiosyncratic factors, such as personal contacts or luck, which are not known to the auditors. This means that at least in some sectors, the auditors do not have unbiased estimates of true income at the individual level, and the incomes will be heterogeneous in any group that the tax office is able to select.

Competitive audit mechanisms based on reported income were theoretically studied by Bayer and Cowell (2009) and Oestreich (2015). They both show that these competitive audit mechanisms lead to higher tax compliance. Our theoretical predictions follow from a model which is similar to the declaration stage in the model presented by Bayer and Cowell (2009). It shows that the endogenous ASM, in which the audit probability depends on reported incomes of taxpayers, leads to higher reported incomes compared to a random audit selection, in which all taxpayers are selected with the same exogenously given probability.

This prediction is tested using an economic experiment. We propose a design in which all taxpayers receive income that is drawn from a uniform distribution. Their task is to choose the reported income which is then taxed at a fixed rate. They may be selected for audit with a certain audit probability. Subjects who are selected for audit and report less than their income pay a penalty. The experiment has two treatments that differ in the way the audit probability is determined: the random ASM and the endogenous ASM. In the random ASM, the probability of audit is exogenous and the same for all taxpayers. In the treatments with endogenous ASM, the subjects are divided into groups of five taxpayers and their audit probability is decreasing in the difference between each subject’s reported income and the average reported income of the other four subjects in their group. The findings confirm the theoretical prediction. Tax compliance is higher under the endogenous ASM than under the random ASM.

The rest of the paper is structured as follows. Section 2 introduces the theoretical model. Section 3 provides the experimental design. Section 4 presents the data and the results of the experiment. Section 5 concludes.

2 Model

2.1 Model setup

Taxpayer \( i \) receives an income \( I_i \) drawn from a distribution \( F(I) \) with support \([L, 7] \). The taxpayer chooses the reported income \( R_i \in (0, I_i) \). Reported income is taxed by rate \( \tau \), so the taxpayer pays a tax \( \tau R_i \). The taxpayer \( i \) is audited with a probability \( \pi_i(R_i, R_{-i}) \). The formula for \( \pi_i \) depends on the audit selection mechanism used by the tax authority. If the taxpayer is chosen for audit, she pays
We examine two different audit selection mechanisms. Under the random audit selection mechanism, the audit probability is the same for all taxpayers regardless of their reported income, \( \pi_i = p \). When the endogenous audit selection rule is applied, the audit probability depends on the income reported by the taxpayer and also on the income reported by other taxpayers \( \pi_i = p - \delta (R_i - \frac{\sum (R - i)}{N}) \), where \( N \) is the number of taxpayers in a group. This mechanism assigns higher audit probability to the taxpayers with relatively lower reported income. Parameter \( p \) defines the basic audit probability and parameter \( \delta \) defines the sensitivity of the audit selection rule to the disclosed income (or competitiveness). The random audit selection mechanism is obviously a special case of endogenous audit selection mechanism where \( \delta = 0 \).

The important aspect of the proposed audit selection mechanism is that the audit probability depends only on the difference between reported income and average reported income of other taxpayers. Therefore, the audit selection mechanism does not need any information about the income distribution.

### 2.2 Equilibrium

Risk-neutral taxpayer \( i \) chooses the reported income \( R_i \) in order to maximize her expected wealth

\[
W = (1 - \pi(R_i, R_{-i})(I_i - \tau R_i) + \pi(R_i, R_{-i})((1 - \tau)R_i + (1 - \phi)(I_i - R_i)).
\]

Under the random audit selection mechanism the first derivative of the expected wealth can be written as \( p\phi - \tau \). It follows that if the tax rate \( \tau \) is higher than \( p\phi \), the optimal choice of the risk-neutral taxpayer is to evade all his income.

Now, we derive the solution for the endogenous audit selection mechanism. Suppose that the other player’s strategy is \( R(I_i) \), where \( R \) is a non-decreasing function. The first order condition is given as follows:

\[
(p - \delta R_i + \delta \int R(I_i) dF(I)) \phi - \tau + \delta \phi(I_i - R_i) = 0
\]

We focus on symmetric equilibria of the model. The solution of the first order condition is a linear function \( R = a + bI \) where the reported income has to lie in the interval \([0, I]\). Taking this into account we get two possible equilibrium strategies depending on the value of exogenous parameters.

The first equilibrium occurs when the tax rate is low compared to the audit probability and the fine. In this situation, the taxpayers with lower income declare their whole income as they face high probability of being audited. The taxpayers with higher income face lower probability of being audited and they optimally react by evading some amount of their income. Formally, the equilibrium strategy has the following form:

\[
R(I_i) = \begin{cases} 
I_i & \text{if } I_i < \hat{I} \\
 a + bI_i & \text{if } I_i \geq \hat{I}
\end{cases}
\]

where \( a > 0 \).
The equilibrium values of the parameters $a$, $b$ and $\hat{I}$ are given by the solution of the following three conditions (the last condition is derived from the equation $a + b\hat{I} = \hat{I}$):

$$a = \frac{p\phi - \tau}{\delta\phi(1 + F(\hat{I}))} + \frac{F(\hat{I})}{1 + F(\hat{I})}E(I|I < \hat{I}) + \frac{1 - F(\hat{I})}{2(1 + F(\hat{I}))}E(I|I > \hat{I})$$

$$b = \frac{1}{2}$$

$$F(\hat{I})E(I|I < \hat{I}) + \frac{(1 - F(\hat{I}))}{2}E(I|I > \hat{I}) - \frac{1 + F(\hat{I})}{2}\hat{I} = \frac{\tau - p\phi}{\delta\phi}$$

The second equilibrium is characterized by high tax rate is compared to the audit probability and fine. The taxpayers with lower income evade all their income in this equilibrium as they lose low amount of money when they are audited. On the other hand, taxpayers with high income have a lot of money at stake so they will optimally disclose some income. In formal terms, the equilibrium strategy has the following form:

$$R(I_i) = \begin{cases} 0 & \text{if } I_i < \hat{I} \\ a + bI_i & \text{if } I_i \geq \hat{I} \end{cases} \quad (2)$$

The theoretical result show that both equilibria under the endogenous audit selection mechanism result in higher tax compliance even if the ASM is endowed only with limited information. This constitutes the main hypothesis of our experiment.

3 Experimental design and procedures

This hypothesis is tested in an economic experiment. Each experimental session consists of 30 rounds. At the beginning of each round, taxpayer $i$ receives income $I_i$ that is drawn from a uniform distribution between 0 and 200 CZK\(^1\), so the income of each taxpayer differed in each period. The task of each subject is to choose the reported income $R_i \in (0, I_i)$. This reported income is taxed at a rate $\tau = 0.6$. Subjects who are selected for audit and report less than their income pay a penalty equal to their unreported income $I_i - R_i (\phi = 1)$. The experiment contains two treatments which differ in the way audit probability is calculated. In the treatment with random ASM, the audit probability of taxpayer $i$ equals to

\(^1\) This amount equaled approx. to €7 at the time of the experiment.
In the treatments with endogenous ASM, subjects are divided into groups of five taxpayers. We use partner matching in order to increase the learning effect. Their audit probability equals to

$$\pi = 0.4 - 0.004 \frac{R_i - \text{avg}(R_{-i})}{\sum R_{-i}}$$,

where $R_{-i}$ stands for incomes of the four remaining members of the group. The payoff of taxpayer $i$ in a given period depends on whether she has been selected for audit in this period. She receives $0.4R_i$ if audited, and $0.4R_i + (I_i - R_i) = I_i - 0.6R_i$ if not selected for audit.

The experiment was conducted in MUEEL in Brno, Czech Republic, in May 2017. Subjects were student. They were recruited through hroot (Bock et al, 2012). The experimental environment was prepared in zTree (Fischbacher, 2007). We used neutral instructions, i.e. the tax motivation of the game is not clear from the instructions (the instructions are available upon request from the corresponding author). We ran 4 sessions using the between-subjects design. We ran only one session for the random-ASM treatment where each subject is one independent observation and three sessions for the endogenous ASM treatment where a group of five is an independent observation. The total number of participants was 80 with no less than 15 participants at each session. The sessions lasted almost 90 minutes. The subjects received payoffs from five randomly selected rounds. The mean payoff was 240 CZK (approx. €9).

4 Data and results

We have 80 subjects playing 30 periods each, that is 2,400 observations. We filter out the 6 observations in which the income $I = 0$, because here compliance, calculated as the ratio of the reported income to the total income ($R/I$), is not defined. There does not seem to be any trend in compliance in the data, so we use all 30 periods. Table 1 presents the summary statistics of the main variables.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>N</th>
<th>Mean</th>
<th>St. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td>2,394</td>
<td>101.7</td>
<td>57.54</td>
<td>1</td>
<td>200</td>
</tr>
<tr>
<td>Reported income</td>
<td>2,394</td>
<td>57.47</td>
<td>45.97</td>
<td>0</td>
<td>199</td>
</tr>
<tr>
<td>Compliance</td>
<td>2,394</td>
<td>0.56</td>
<td>0.33</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

In the analysis, we use parametric approaches to estimate the effect of the endogenous ASM on compliance ($R/I$) first. The left column of Table 2 presents an OLS model with errors clustered at the level of subjects and groups. It shows that endogenous audit selection increases compliance by 0.11 and the change is significant at the 5% level. The change is also economically important as the level of compliance increases from 48% to around 59%, i.e. by more than 20%. However, summary statistics show that the variable compliance ranges from 0 to 1 (see Table 1), as some subjects did not report anything and others reported
their entire income. Hence the data is both left- and right-censored. We therefore estimate the model using random-effects Tobit model to account for the panel structure of the data with subjects as the cross-sectional variable. The results are reported in the right column Table 2. The effect is very similar to the OLS estimate: The endogenous ASM increases tax compliance by a magnitude that is both economically and statistically significant.

Table 2 The effect of the ASM mechanism on compliance: OLS with errors clustered at the level of subjects and groups and the Random-effects Tobit model

<table>
<thead>
<tr>
<th>Model:</th>
<th>OLS with two-way clusters</th>
<th>Random-effects Tobit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable:</td>
<td>Compliance</td>
<td>Compliance</td>
</tr>
<tr>
<td>Constant</td>
<td>0.480***</td>
<td>0.462***</td>
</tr>
<tr>
<td>(0.041)</td>
<td>(0.056)</td>
<td></td>
</tr>
<tr>
<td>Endogenous</td>
<td>0.109 **</td>
<td>0.135**</td>
</tr>
<tr>
<td>(0.054)</td>
<td>(0.068)</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>2,394</td>
<td>2,394</td>
</tr>
<tr>
<td>316 left-censored observations</td>
<td>316 left-censored observations</td>
<td></td>
</tr>
<tr>
<td>1771 uncensored observations</td>
<td>1771 uncensored observations</td>
<td></td>
</tr>
<tr>
<td>307 right-censored observations</td>
<td>307 right-censored observations</td>
<td></td>
</tr>
</tbody>
</table>

Note: *p < 0.1; ** p < 0.05; *** p < 0.01

We also test the treatment effect using non-parametric methods. We calculate mean compliance in all 36 independent observations and find that there is a statistically significant difference between the treatments using the Mann-Whitney U test (W = 79, p-value = 0.04521).

5 Conclusion

In this paper we propose an endogenous audit selection mechanism that is based only on reported incomes of taxpayers. In this mechanism, the audit probability depends on reported incomes of taxpayers in a reference group. Using experimental methods, we show that the proposed mechanism leads to higher tax compliance than a random mechanism in which all taxpayers are audited with the same baseline probability. In particular, we show that the mechanism works even if the income of taxpayers in the reference group differs substantially. Furthermore, the mechanism is designed in a way that keeps the expected level of audits constant, which means that the additional cost of implementing the mechanism consist only in the administration of the more complex audit selection procedure. In sum, our paper suggests that the endogenous ASM might be an affordable and effective tool for reducing tax evasion even if the tax office does not have information about the actual income of taxpayers, and is not able to match taxpayers into reference groups with similar incomes.
References