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WHO IS AUDITED?
EXPERIMENTAL STUDY
OF RULE-BASED TAX AUDITING

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Who is audited? Experimental study of rule-based tax auditing

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Abstract

We employed a game-theoretic framework to formulate and analyze a number of tax audit rules, especially the lowest income reporter audited rule. We explicitly considered the auditor's resource constraint to choose one target from a continuous type of taxpayer. We then tested the theoretical predictions in a laboratory experiment, using three audit rules: the random, cut-off, and lowest income reporter audited rules. While the cut-off rule is known to be optimal in theory, it has not thus far been examined in a controlled laboratory experimental setting. Contrary to the theory, the lowest income reporter audited rule increased average compliance behavior significantly more compared with the optimal cut-off rule and, especially, the random rule. This holds with and without controlling the subjects' demographics and attitudes regarding tax payment. This finding is practically important because the tax authorities in most countries assign higher priority to enhancing tax compliance.

Keywords: audit rule; tax evasion; laboratory experiment; cut-off rule; lowest income reporter audited rule

JEL Classification: C91; C92; D81; H26

1. Introduction

Securing government tax revenues is a persistent and fundamental global problem (Webber and Wildavsky 1986). There is high incentive for individuals and companies to avoid excessive tax payments, which leads to tax avoidance, tax evasion, and payment delays. Results of the National Research Program—a well-known audit program conducted by the U.S. Internal Revenue Service—estimated the tax gap (i.e., tax due but not paid in a voluntary or timely manner) as $450 billion in 2006; this amount represented approximately 3.2% of the nominal gross domestic product for that year (Alm et al. 2015). Although analyses of the tax gaps in other countries are limited for several reasons (e.g., resource constraints and non-publication of survey results), the gaps are estimated or speculated to be considerable (see Slemrod 2007). Government reports, at least in the U.S. and Japan (e.g., U.S. House of Representatives' Committee on Ways and Means, 2019, prominently argue that this is due to a decrease in human resources in audit institutes (Higo, 2018). Thus, research on policy devices to enhance tax compliance has become increasingly significant.

A basic theoretical model of tax evasion is presented by Allingham and Sandmo (1972) and Yitzhaki (1974). These prior studies assume that a taxpayer chooses the extent of tax evasion by comparing the expected benefit from evasion with the expected cost. These studies imply that the audit probability, tax rate, and penalty rate affect tax compliance. These findings are supported by the results of both empirical research (Kleven et al. 2011; Slemrod et al. 2001) and laboratory experiments (Collins and Plumlee 1991; Gërxhani and Schram 2006; for a more recent survey, see Malezieux, 2018). Although tax compliance could be improved by increasing the audit probability and penalty rate, most governments face severe budget restrictions related to auditing, and changing the penalty rate would be controversial. Thus, an audit rule whose introduction incurred little additional cost and did not change the penalty rate would be worth considering for actual use.

The above discussion motivates us to analyze three rule-based audit rules with explicit use of resource constraints. Under the first and most often used audit rule, a taxpayer is chosen randomly and inspected irrespective of his/her reported income. This is the most common rule used in experiments to examine the canonical tax evasion model of Allingham and Sandmo (1972) and Yitzhaki (1974) and to measure the behavioral aspects of tax evasion (Kastlunger et al. 2009).[1]

The second audit rule examined herein is the cut-off rule under which the probability of inspection is high for taxpayers whose reported income is below a certain threshold; by contrast, taxpayers whose reported income is above the threshold are never inspected. Based on their working experience with the federal tax authority and several state tax authorities in the U.S., Andreoni et al. (1998) report that "many tax agencies apparently do establish cut-off points and focus their audit resources on returns falling below the cut-offs" (p. 832). Based on the principal–agent theory, Reinganum and Wilde (1986) and Sánchez and Sobel (1993) show that the cut-off rule enhances tax

[1] Fatas et al. (2015) consider redistribution of penalty revenue, using public goods game framework.

compliance and increases net tax revenue. Although Alm et al. (1993) examine the usefulness of this rule experimentally, their comparison of several audit rules is not fair in the sense that the audit resources are not kept fixed among the rules. In addition, no study has thus far investigated the cut-off rule based on the optimal audit probability and threshold, and thus research on the cut-off rule is still limited.

Finally, under the third rule, lower reported incomes have higher probability of being audited. Given the restriction that an auditor can inspect only one reported income, this rule becomes the lowest income reporter audited (LIRA) rule, wherein, among a category of similar taxpayers, the auditor investigates the taxpayer whose reported income is the lowest.[2] Collins and Plumlee (1991) and Coricelli et al. (2010) also experimentally examine the LIRA rule in an incomplete information setting with multiple types of taxpayer incomes; however, these studies do not theoretically investigate the LIRA rule.

We compare these three audit rules theoretically and experimentally. As noted above, due to its importance, we explicitly consider the auditor's resource constraint, due to which the auditor chooses one target from among four taxpayers (in expectation). The presented theoretical analysis shows that the cut-off rule with an optimal choice of threshold dominates the other rules in terms of increasing the compliance rate (ratio of reported income to true income), minimizing the evaded income, and maximizing tax revenue. The LIRA rule yields a higher compliance rate and less evaded income than the random rule does; however, the random rule yields higher penalties and total revenue (sum of the tax revenue and penalty revenue) than the LIRA rule does.

We conduct a laboratory experiment to test how much the above audit rules enhance compliance behavior, including one sub-optimal version of the cut off rule. We fix a basic tax rate and penalty rate, with a between-subject design wherein one subject can participate in only one audit rule. To create a one-shot, incomplete information environment, in each period, a group of four is newly formed and each subject privately receives his/her income drawn independently from the uniform distribution. The regressions analysis shows that the LIRA rule significantly increases the compliance rate compared with the optimal cut-off and random rules do. Nevertheless, there is no significant difference in the compliance rate between the LIRA and suboptimal cut-off rules. The income quartile affects compliance behavior in accordance with predictions.

We contribute to the extant literature in three ways. First, we compare the rules in the same environment and under the same resource constraint, while prior studies typically investigate these rules one by one. We compare them in the setting of an incomplete information game with a continuous

[2] One justification for implementing the LIRA rule is that in the U.S., the Internal Revenue Service calculates a discriminant inventory function score for each return, on which it determines the tax returns to audit. Alm and McKee (2004) model an audit rule based on the score, such that the most downward deviating income from the average of the reported incomes is inspected (i.e., the LIRA rule). Specifically, they analyze the LIRA rule theoretically and experimentally in a complete information setting with identical taxpayer incomes.

type of taxpayer under a resource constraint wherein the expected number of audited taxpayers in equilibrium is one across the rules. Second, we find that the LIRA rule can empirically outperform the cut off rule with optimal parameters of audit probability and threshold. Third, we derive the equilibrium under the LIRA rule in an incomplete information game with *n* players for the first time to the best of our knowledge.

The remainder of this paper is organized as follows. Section 2 presents the basic theory of tax evasion decision making; subsequently, we present our theoretical predictions related to the three tax audit rules. Section 3 describes our experimental design and procedure. Section 4 reports the results of our experiment. Section 5 concludes.

2. Theory of tax audit rules

2.1. Basic model

This section summarizes the canonical model of taxpayer decision making proposed by Allingham and Sandmo (1972) and Yitzhaki (1974). A taxpayer decides whether and to what extent to evade taxes in the same way that an individual would weigh a risky gambling decision. The taxpayer (an individual or a firm) has a true taxable income of $Y,$ where $Y > 0$; the true taxable income is private information. Let t be the basic tax rate. The taxpayer pays tY as tax if (s)he reports his/her true income. However, if the income is under-reported, the taxpayer should pay $tR,$ where R represents the under-reported income $(R \le Y),$ and $Y - R$ represents the amount of evaded income.[3] However, detailed auditing is randomly executed at probability p, where tax evasion is detected. In our model, tax evasion is revealed if the tax authority inspects the under-reporting taxpayer. In the event of an inspection, the individual must pay $tq(Y - R),$ as a penalty for the tax evasion, where q represents the penalty rate for the illegal activity $(q > 1).$

The expected utility for an individual reporting his/her income as R (where $0 \le R \le Y$) is $EU = (1 - p)U(Y - tR) + pU(Y - tR - tq(Y - R))$, where U is a utility function with $U(Y) > 0$ and $U'(Y) > 0$ for any $Y > 0$. By differentiating EU by $0 \le R \le Y$ and evaluating it at $R = Y$, we obtain $\frac{\partial EU}{\partial R}|_{R=Y} = t\left(pq - 1\right)U'\left(\left(1 - t\right)Y\right).$ Thus, tax evasion occurs when $pq < 1$ or $p < 1/q.$

Although the evasion decision depends on neither basic tax rate t nor true income Y, the extent of evasion may depend on these variables.[4] However, if we assume risk neutrality, the taxpayer fully

[3] Other types of reporting decisions exist, such as the non-filing and late payment of taxes owed. However, according to the 2001 Internal Revenue Service estimate of the tax gap, under-reporting represents approximately 82% of the gap, and non-filing and late payment represent 8% and 10% of the gap, respectively (see Slemrod 2007). Thus, under-reporting is the major source of the tax gap.

[4] Yitzhaki (1974) shows that under the assumption of decreasing absolute risk aversion, the extent of evasion decreases as the basic tax rate increases, and the extent of evasion increases as income increases.

evades his/her tax liability (i.e., reports zero income) whenever (s)he decides to evade taxes. In the discussion that follows, we assume risk neutrality for taxpayers.[5]

The canonical model does not address how the detection probability (p) is determined. Alm and McKee (2004) report that p is determined from the strategic interdependence between auditors and taxpayers. Thus, the detection probability vary with reported income (Reinganum and Wilde 1986; Sánchez and Sobel 1993), past cheating or auditing (Friesen 2003), and relative positions of the reported income (Alm and McKee 2004; Collins and Plumlee 1991). To ensure strategic interdependence among taxpayers, we assume that there are n taxpayers. In Sections 2.2–2.4, we describe the three audit rules and theoretically show how taxpayers' decisions differ.

To improve our understanding, we explain the three audit rules by using the parameters in our experiment: $n = 4$, $t = 0.2$, and $q = 3$. To compare these audit rules in a fair manner, we propose the condition that the (expected) number of investigated taxpayers in equilibrium is one because of the resource constraints of the audit authority. We assume that the true income of each player is an i.i.d. draw from uniform distribution of [0, 1000]. For each taxpayer i ($i \in \{1, 2, 3, 4\}$), Y_i and R_i denote i's true income and reported income, respectively.

2.2. Random rule

The auditor chooses one of the four taxpayers at random, irrespective of their reported incomes. The chosen taxpayer is inspected. In our setting, the probability of detection (p) is $1/n = 1/4$, and the penalty rate q is 3. Thus, $p < 1/q$ holds true, indicating that the optimal strategy for each taxpayer is to report zero income.

2.3. Cut-off rule

The detection probability varies according to the reported income. In particular, we choose a cut-off rule, wherein reported income of less than 750 is inspected with probability 1/3 and reported income above or equal to 750 is never inspected. According to our selected parameters, the detection probability of 1/3 is the lowest probability for a taxpayer to report his/her income truthfully. The range of [0, 750] is determined by the restriction that the expected number of inspections is one out of four taxpayers $((1/3) \times (750/1000) = 1/4)$. An optimal strategy for a taxpayer under the cut-off rule is to report his/her income truthfully when his/her income is below or equal to 750, and report the threshold when his/her income is above 750. Thus, a taxpayer with higher income evades the tax burden. It is theoretically known that the cut-off rule discussed here is a tax-revenue maximizing audit rule (Sánchez and Sobel 1993); hence, we denote it as Cut-off O.

Next, we consider the suboptimal cut-off rule (denoted as Cut-off S), which gives participants a

[5] See Andreoni et al. (1998) for a survey of theory.

sufficient incentive to report truthfully. In Cut-off S, reported income of less than 500 is inspected with probability 1/2, and that above or equal to 500 is never inspected.

2.4. LIRA rule

The auditor investigates the lowest income among the four reported incomes. Thus, strategic interdependence exists among the taxpayers. Under the LIRA rule, the lower is the reported income, the more likely it is that the income will be inspected. Therefore, the optimal strategy for taxpayers is to report their income truthfully if their true income is below some critical value $c*$ and to cheat otherwise. Intuitively, critical value $c*$ is calculated as follows.[6] Assume that the four players follow the same strategy; thus, they report the true income when their income is below $c*$. Consider a taxpayer whose true income is $c \leq c*$. The probability of detection when (s)he reports c is $(1-c/1000)^3$, and this probability decreases in c. A detection probability greater than or equal to 1/3 (= $1/q$) is needed to truthfully report income (see Section 2.1). Since income $c*$ is the marginal value between reporting the true income and cheating, $(1-c*/1000)^3$ must be equal to $1/q = 1/3$. Thus, we have $c* = 1000 \times (1-(1/q)^{1/3}) \approx 306$. In fact, under the LIRA rule, in the equilibrium strategy of each i, a participant truthfully reports his/her income ($R_i = Y_i$) if $Y_i < c*$, while (s)he cheats by $e(Y_i)$ ($R_i = Y_i - e(Y_i)$) if $Y_i \geq c*$, where e represents the extent of cheating with $e(Y_i) > 0$, $e(Y_i) > 0$ for $Y_i > c*$, and $e'(Y_i) > 0$ for $Y_i \geq c*$.

2.5. Summary of predictions

In summary, the cut-off rule dominates the other rules, and the LIRA rule dominates the random rule in terms of compliance rate.[7] Further, the predicted strategies under the LIRA rule and the two cut-off rules have kinks at Y=306.6, 500 and 750, respectively.[8] We mainly focus on compliance rate $r = R/Y$, as a measure for the degree of truthful reporting. For example, if a player with income of 500 reports 220, the corresponding compliance rate is $r = 220/500 = 44.0\%$. If the compliance rate is sufficiently close to one (e.g., 90%), then the tax is almost correctly levied, and hence such an audit rule works.[9]

3. Experimental design

Each of the four treatments (Random, Cut-off O, Cut-off S, and LIRA) has two sessions with groups of four. We conducted all sessions at Kochi University of Technology, Japan, in July 2014 and April

[6] See Electronic Supplementary for the derivation of a symmetric Bayesian Nash equilibrium.
[7] See Electronic Supplementary for the figure of predicted compliance rate.
[8] Incorporating risk aversion into our model does not change the ranking of the compliance rate.
[9] See Electronic Supplementary for the revenue ranking.

2015. Each session lasted for 90 minutes. We used the experimental software z-Tree (Fischbacher 2007). We recruited 140 student subjects through campus-wide advertisements. No subject participated in more than one session. None of them had prior experience of a similar type of experiment. Subjects were seated at individually partitioned computer terminals assigned randomly. We did not allow any communication among subjects.

Each subject received a copy of the instructions (see Electronic Supplementary). Additionally, an experimenter read the instructions aloud. Subsequently, subjects answered a quiz about the audit rule. Then, an experimenter publicly announced the answers of the quiz. Subjects then proceeded to 20 payment periods. In each session, we employed the stranger-matching protocol so that each group in each period included four subjects. Subjects were informed that they would be randomly re-matched in every period.

In each period, once a group was formed, each subject faced the reporting screen. On the reporting screen, (s)he privately received and confirmed his/her income, which was drawn independently from the uniform distribution of [0, 1000] (JPY), with an increment of 10. Note that income was newly drawn by period, leading to a one-shot incomplete information environment. Every subject could confirm $t = 0.2$ and $q = 3$. Given this information, the subject determined how much income to report, and (s)he input a number between 0 and his/her income, in increments of 10. Once every subject input the reported income and clicked the OK button, the subjects proceeded to the results screen. In every period after the second period, the history box appeared.

After participating in 20 payment periods, the subjects completed two questionnaires. The first questionnaire asked about their attitude toward tax payment, following Gërxhani (2004) and Lefebvre et al. (2015). Second, all participants completed the questionnaire to measure the risk attitudes; the questionnaire consisted of 4 sets of 11 pairs of lotteries and certain amount of money. After the questionnaires were completed, the subjects were immediately paid in cash, privately. Each subject was paid a participation fee of 800 yen (approximately $7 USD) plus the total earnings over the three periods chosen randomly. The average reward per subject was approximately $19 USD.

4. Experimental results

We clarify the impact of each audit rule on the compliance rate. The total number of observations were 2,800 (140 subjects × 20 times). Among these, 12 subjects (240 observations) were excluded from the analyses, since they did not reply to the questions after the experiment. Further, five observations for which we were unable to calculate the decision time and nine observations for which the compliance rate could be defined due to zero income were excluded. Thus, 2,546 observations were used as the sample in our statistical analysis.

Table 1 summarizes the main independent variables in which we are interested to explain the compliance rate. First, we used each audit rule dummy. Second, we included each income quartile dummy.

Table 1. Variable definitions

Variable	**Definition**
IncomeQ1 (reference)	= 1 if 10≦Income≦250, and 0 otherwise
IncomeQ2	= 1 if 260≦Income≦500, and 0 otherwise
IncomeQ3	= 1 if 510≦Income≦750, and 0 otherwise
IncomeQ4	= 1 if 760≦Income≦1,000, and 0 otherwise
LIRA (reference)	= 1 if an audit rule is LIRA, and 0 otherwise
Random	= 1 if an audit rule is Random, and 0 otherwise
Cut-Off O	= 1 if an audit rule is Cut-Off O, and 0 otherwise
Cut-Off S	= 1 if an audit rule is Cut-Off S, and 0 otherwise

Before proceeding to the regression, we illustrate the whole tendency of the compliance rate. Table 2 summarizes the compliance rate averaged across subjects by the audit rule. Figure 1 illustrates the compliance rate averaged across subjects, by both the audit rule and income quartile. The vertical bar indicates the 95% confidence interval. A first look tells us that neither the LIRA nor Cut-Off rules sufficiently induce a fully sincere report, but all of LIRA, Cut-off O, and Cut-off S outperformed Random, in line with theory. Moreover, LIRA and Cut-off S outperform Cut-off O, especially in Q1 and Q2, in contrast with theory.

Table 2. Observed overall average compliance rates (%)

LIRA	**Cut-Off O**	**Cut-Off S**	**Random**
67.50	59.73	65.92	50.47
N=695	*N*=674	*N*=760	*N*=417

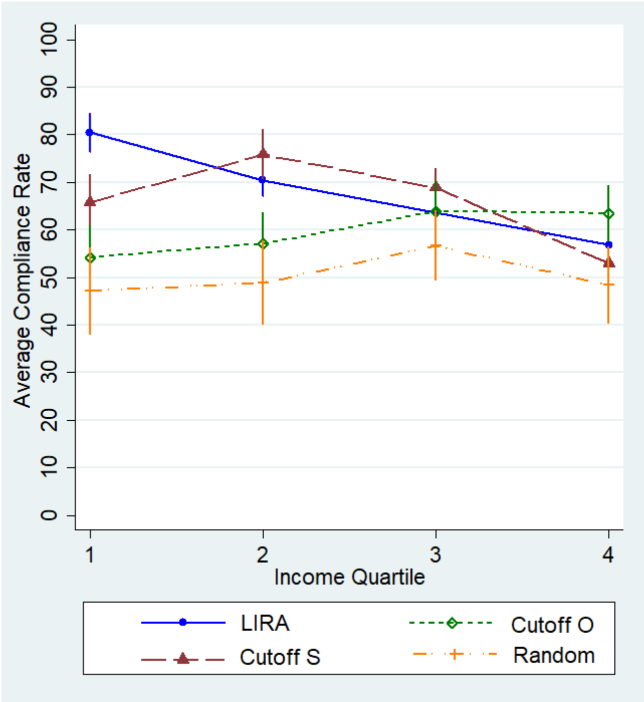

Figure 1. Observed average compliance rates (%)

Table 3 shows the regression results. We first look at Panels A and B. The dependent variable is each compliance rate, r_{it}, where i is the subject ID and t is period. The standard error is adjusted for 128 clusters among the subjects. The main result in Panel A is that Random and Cut-off O are negatively correlated with the compliance rate (Random: z = -3.13, p =0.002; Cut-off O: z = -1.67, p=0.095). It is noteworthy that LIRA induces a greater increase in the compliance rate compared with Cut-off O and Random, in contrast with theory (See Electronic Supplementary for the questionnaire and demographic information variables).

The Panel B regression includes the interaction terms between audit rule and income quartile, to obtain further insights on how LIRA outperforms the other two audit rules. Post-estimation tests show the following. In Q1 and Q2, LIRA promotes tax compliance more than Cut-Off O and Random, and in Q3 and Q4, LIRA has a total effect similar to Cut-Off O. The results are intuitive: LIRA subjects with low income perceive that they are more likely to be audited, while LIRA subjects with high income are tempted to conceal their income more, expecting that other members are more likely to be audited. Cut-off S outperforms LIRA in Q2 and Q3.[10]

We note two additional results. First, the ranking of revenue including penalty (Panels C and D with DV=revenue for each report) is not so clear and depends on income quartile. LIRA earns significantly more (resp., less) revenue than Random in Q1 (resp., Q2 and Q3), while it earns similar revenue as the Cut-offs except for Q4. Second, our results on the questionnaire and demographic

[10] See Electronic Supplementary for details.

variables—that is, individual aggressiveness for tax evasion significantly decreases compliance rate—corroborate the results in prior literature: (Kirchler 2007; Coricelli et al. 2010). Subjects try to evade more after being audited (Kastlunger et al. 2009), and male subjects tend to evade taxes (Lefebvre et al. 2015).[11]

5. Conclusion

We employed a game-theoretic framework to analyze three audit rules, namely, the random, cut-off, and LIRA rules, and we tested the theoretical predictions in a laboratory experiment. The contributions of this study can be stated as follows. First, we compared the three representative audit rules using an incomplete information game, given the auditor's resource constraint. Second, we showed that both the LIRA rule and cut-off rules actually work in a laboratory setting. These sophisticated audit rules perform better than random auditing. Third, we derived an equilibrium strategy under the LIRA rule for the first time to the best of our knowledge.

The observed higher compliance rate in LIRA than the optimal cut-off rule has some practical importance, because tax authorities in most countries assign higher priority to the enhancement of tax compliance. Determining the optimal parameter for a real-world population could be difficult. By contrast, the LIRA rule works without information on the other parameters, because it uses the profile of reported incomes to determine whom to audit.

Finally, we discuss possible future research directions. In this study, the auditor commits the rule to choose the taxpayer. Another interesting experimental setting would be the human audit condition. The auditor subject freely chooses some of the taxpayers as the target after seeing the reports and incurring costs for additional audits. Then, an increase in tax compliance may be driven by taxpayer subjects' overestimation of the probability of being audited under ambiguity, as Tan and Yim (2016) observed.

[11] See Electronic Supplementary for details.

Table 3. Determinants of the compliance rate and tax revenue

Variables	A: DV = Compliance Rate Coef.	Std.Err.	z	B: DV = Compliance Rate Coef.	Std.Err.	z	C: DV = Tax Revenue Coef.	Std.Err.	z	D: DV = Tax Revenue Coef.	Std.Err.	z
Constant	60.503	12.752	4.74***	68.393	12.816	5.34***	97.561	17.163	5.68***	33.091	13.748	2.41**
LIRA (reference)												
Random	-18.024	5.759	-3.13***	-29.111	7.854	-3.71***	3.068	5.195	0.59	-15.512	4.952	-3.13**
Cut-Off O	-8.717	5.215	-1.67*	-22.694	6.208	-3.66***	7.231	5.221	1.38	-6.240	5.766	-1.08
Cut-Off S	2.436	3.826	0.64	-7.819	5.808	-1.35	-5.659	5.226	-1.08	-6.814	4.372	-1.56
IncomeQ1 (reference)												
IncomeQ2				-7.047	3.263	-2.16**				48.661	4.536	10.73***
IncomeQ3				-14.218	3.945	-3.60***				64.289	4.721	11.24***
IncomeQ4				-17.162	4.331	-3.96***				109.457	8.305	13.18***
*Random*IncomeQ2*				5.688	6.534	0.87				-3.277	8.650	-0.38
*Random*IncomeQ3*				20.704	8.239	2.51**				39.405	10.765	3.66***
*Random*IncomeQ4*				16.360	8.518	1.92*				35.703	14.341	2.49**
*Cut-Off O*IncomeQ2*				9.881	5.714	1.73*				9.390	10.006	0.94
*Cut-Off O*IncomeQ3*				17.146	5.809	2.95**				13.369	10.471	1.28
*Cut-Off O*IncomeQ4*				20.882	5.731	3.64***				26.973	9.205	2.93**
*Cut-Off S*IncomeQ2*				16.536	5.174	3.20***				10.507	7.400	1.42
*Cut-Off S*IncomeQ3*				18.192	6.213	2.93**				23.238	8.338	2.79**
*Cut-Off S*IncomeQ4*				5.064	6.900	0.73				-14.865	11.531	-1.29
Demographics		Included			Included			Included			Included	
Tax attitude		Included			Included			Included			Included	
Risk attitude		Included			Included			Included			Included	
Number of observations		2546			2546			2546			2546	
wald chi^2		71.32			208.97			28.88			1841.23	
Prob > chi^2		0.000			0.000			0.006			0.000	
R^2		0.101			0.132			0.008			0.243	

Note: * *p*<0.10, ****p*<0.05, and ****p*<0.01.

Conflict of Interest

The authors declare that they have no conflict of interest.

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