AMBIGUITY ABOUT AUDIT PROBABILITY, TAX COMPLIANCE, AND TAXPAYER WELFARE

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We show that an increase in uncertainty about the probability of being audited (ambiguity) increases tax compliance for ambiguity-averse taxpayers but reduces compliance for ambiguity lovers. Because experimental evidence reveals considerable heterogeneity with respect to ambiguity preferences, we conclude that fostering uncertainty about the probability of being audited may not be an effective policy for increasing taxpayer compliance. Moreover, because the tax authority can neither categorize nor screen taxpayers on the basis of their preferences for ambiguity, it is not likely to be either a useful or a desirable instrument for increasing taxpayer welfare. (*JEL* H26, D81)

I. INTRODUCTION

To encourage voluntary compliance with the tax code, the U.S. Internal Revenue Service (IRS) relies heavily on a policy of auditing tax returns and levying penalties when undeclared income is detected, with penalties linked to the amount of tax evasion discovered. The selection of returns for auditing is based on both strategic and random procedures. Strategic audits are determined by a closely guarded formula for choosing specific tax returns that exceed certain thresholds for reported income, deductions, and credits. After a decade-long hiatus, the IRS recently revived a program of random audits to measure tax compliance and update the formula for triggering strategic audits.[1]

The IRS has testified to the importance of both the randomness and secrecy of its audit policies as instruments for increasing taxpayer compliance, because auditing all returns is not cost-effective.[2] However, the relatively small penalties levied for detected evasion, combined with the low probability of an audit, would seem to provide taxpayers with a strong incentive to engage in rational evasion behavior. Indeed, the commissioner of the IRS has estimated that the amount of federal tax evaded annually exceeds 10% of the total revenue actually collected.[3]

Experimental analyses of the compliance decision have supported the IRS view that tax evasion is reduced by uncertainty about or upward bias in perceptions of the probability

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1. See IRS News Release IR-2002-05, January 16, 2002.

2. See *Roberts v. Internal Revenue Service*, 584 *Federal Supplement* 1241 (Eastern District, Michigan), 1984.

3. See IRS News Release IR-2002-05. As Andreoni et al. (1998, p. 821) observe, extensive reporting requirements for institutions that pay out either labor or capital income limit opportunities for many individuals to evade their tax liabilities, particularly those who take the standard deduction. Andreoni et al. (1998, p. 850) also point out that some individuals have a moral compulsion to report their taxable incomes to the IRS honestly. However, individuals who are both able and willing to evade face a low probability of being detected and a relatively small penalty if they are detected. For fiscal year 2002, the IRS audited fewer than 0.6% of individual income-tax returns, as reported at www.irs.gov/taxstats. Andreoni et al. (1998, p. 820) report that taxpayers face gross penalty rates ranging from 1.2 for negligent understatement of liabilities to 1.75 for intentional fraud. The substantial amount of evasion estimated by the IRS indicates that many individuals who are able and willing to evade do so. It is these individuals who are the targets of IRS audits, and it is their behavior that the IRS intends to affect through policies aimed at discouraging noncompliance.

ABBREVIATIONS

IRS: Internal Revenue Service
SOP: Second-Order Probability

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of audit. For example, Spicer and Thomas (1982) report on an experiment showing that the strength of the (negative) correlation between the fraction of taxes evaded and the probability of an audit falls as taxpayer information about the probability of being audited becomes less precise. Alm et al. (1992a) discuss experimental evidence suggesting that uncertainty about the probability of being audited increases compliance when taxpayers believe that their evasion decisions will have no effect on the level of government spending. Clark et al. (2004) compare purely random auditing with two strategic ("conditional") audit rules in an experimental setting in which the subjects faced random assignment to one of two audit pools that differ with respect to audit probability. They find that the purely random audits achieve the highest rate of compliance.

Andreoni et al. (1998, pp. 844–46) survey the empirical literature on taxpayers' subjective beliefs about the probability of audit and conclude that individuals generally make poor predictions about this probability. Alm et al. (1992b) report results from several experiments suggesting that many subjects overestimate the low probability of being audited, leading to less evasion than predicted by the expected utility model. Scholz and Pinney (1995) also provide evidence that taxpayers have upwardly biased subjective estimates of the true audit probability, with the size of the bias negatively correlated with their expected gain from evasion behavior. Sheffrin and Triest (1992) use survey data from a cross-section of taxpayers to estimate a factor-analytic model of tax compliance, allowing for the endogeneity of the perceived probability of evasion detection. They find that taxpayers who perceive a higher probability of detection report significantly less understating of income or overstating of deductions.

The experimental results presented by Spicer and Thomas (1982), Alm et al. (1992a, 1992b), and Clark et al. (2004), as well as the evidence reported by Sheffrin and Triest (1992) and by Scholz and Pinney (1995), point to the importance of imprecise or biased estimates of audit probability in explaining the extent of voluntary tax compliance. The expected utility theory of tax evasion, however, provides an inadequate framework for incorporating these considerations. Because expected utility is linear in the outcome probabilities, increasing uncertainty about the probability of being audited (that is, increasing Knightian uncertainty or ambiguity about the audit probability) has no implications for the evasion decisions of expected utility maximizers, as the expected probability of an audit remains unchanged.

A large number of empirical studies, beginning with Allais (1953) and Ellsberg (1961), have revealed behaviors inconsistent with the expected utility model. Most of these studies have reported apparent violations of the independence axiom, which is responsible for the decision criterion being linear in the outcome probabilities.[4] In response to these anomalies, several alternative theoretical models have been advanced that introduce the potential for nonlinear dependence on the outcome probabilities. These include the rank-dependent expected utility model developed by Quiggin (1982) and Yaari (1987), the decision weighting model of Kahn and Sarin (1988), and cumulative prospect theory advanced by Tversky and Kahneman (1992).

In each of these models, the decision maker may have a systematically biased perception of the probability of a gain or loss caused by a nonlinear transformation of probability through a probability weighting function. We follow this approach, and associate attitudes toward ambiguity with the shape of the probability weighting function. In this manner, we advance the theory of tax evasion by introducing ambiguity preferences that allow taxpayer welfare to depend nonlinearly on the probability of an audit. In our approach, the taxpayer's uncertainty about this probability can be systematically biased in such a way that the perceived probability of an audit differs from the true probability, with the direction of bias depending on whether the taxpayer is ambiguity averse or ambiguity loving.

In the next section, we set out a nonexpected utility model of tax evasion in which the taxpayer faces ambiguity about the probability of being audited and may also have biased perceptions concerning this probability. In section III, we show that tax evasion declines (increases) as the probability of being audited becomes more ambiguous when taxpayers are ambiguity averse (loving). In section IV, we discuss the welfare implications for audit policy of heterogeneity among taxpayers with

4. See Camerer (1995) for a summary of empirical violations of the expected utility model.

respect to ambiguity preferences. We conclude that the presence in the taxpaying population of individuals who are either ambiguity loving or ambiguity neutral weakens the case for using uncertainty about the probability of being audited as a policy instrument intended to increase taxpayer compliance and enhance the welfare of taxpayers.

II. TAX EVASION WITH AMBIGUITY

We consider an individual taxpayer with a fixed taxable income W facing a certain tax rate t who chooses an amount of undeclared income x to shield from the tax authority. If the taxpayer is not audited, then income is $W_N \equiv W(1-t)+tx$. If the taxpayer is audited, then all evasion is detected and the taxpayer is charged this amount plus a proportional penalty. In this event, income is $W_A \equiv W_N - \theta tx$, where $\theta > 1$ is the gross penalty rate, which is known to the taxpayer.

The taxpayer is assumed to have a strictly concave utility function for wealth $U(W)$, reflecting strict risk aversion. The objective probability of being audited is $p \in (0,1)$, but the taxpayer is uncertain about this probability and therefore faces ambiguity. Let π denote the taxpayer's subjective probability of being audited, and denote by $F(\pi; a,p)$ the cumulative distribution function describing the taxpayer's uncertainty about π, with $F(0; a,p) \equiv 0$. This second-order probability (SOP) distribution is parameterized by an index of ambiguity a, discussed shortly, and the objective audit probability p.[5]

We assume that the taxpayer's expectation about π is unbiased in the sense that

$$(1) \qquad \int_0^1 \pi dF(\pi;\ a,p) = p$$

for all values of a. The taxpayer's perception of π, however, is distorted according to the probability weighting function $\varphi(\pi, p)$, which may have a value greater or less than π. However, we assume that $\varphi(\pi, p)$ equals p when π equals p. The probability weighting function introduces a systematic bias in the perceived probability of an audit that depends on the concavity of φ as a function of π in a manner described next.

The taxpayer chooses an amount of undeclared income x^* to maximize the objective function

$$(2) \quad E[U] \equiv U(W_N) - \left[\int_0^1 \varphi(\pi,\ p)dF(\pi;\ a,p)\right] \times [U(W_N) - U(W_A)],$$

where the taxpayer's distorted perceptions of and uncertainty about the probability of being audited determine the perceived probability of an audit,

$$(3) \qquad \int_0^1 \varphi(\pi,\ p)dF(\pi;\ a,p) \in (0,1)$$

on which the evasion decision is based. We assume that this expected probability is always sufficiently low that x^* is positive.[6]

In the absence of ambiguity ($a = 0$), F is the improper distribution equal to 0 for all $\pi < p$ and equal to 1 otherwise, so that

$$(4) \qquad \int_0^1 \varphi(\pi,\ p)dF(\pi;\ a,p) = \varphi(p,p) = p$$

In this case, the taxpayer's objective function reduces to the expected utility of wealth with an audit probability of p. We assume that an increase in the index of ambiguity results in a mean preserving spread of the SOP distribution. Hence, in the presence of ambiguity ($a > 0$), $F(\pi; a,p)$ is a mean preserving spread of the improper distribution with mass at $\pi = p$. Because of the probability weighting function $\varphi(\pi, p)$, however, the taxpayer's perceived probability of being audited typically differs from p.

We assume that an increase in p causes a first-order stochastic dominance (*FSD*) shift in F, with the effect on the taxpayer's welfare given by[7]

5. Because the taxpayer's uncertainty is defined over probabilities, rather than outcomes, the distribution function $F(\pi; a,p)$ is known in the decision theory literature as a SOP distribution. See Camerer and Weber (1992) for a survey of several SOP models.

6. We assume that undeclared income cannot exceed taxable income W, and that this constraint is never binding.

7. The second equality follows after using integration by parts. Variables used as subscripts denote partial derivatives.

$$(5)\quad \partial E[U]/\partial p = -\left[\int_0^1 \varphi_p dF + \int_0^1 \varphi dF_p\right] \times [U(W_N) - U(W_A)] = \left[-\int_0^1 \varphi_p dF + \int_0^1 \varphi_\pi F_p d\pi\right] \times [U(W_N) - U(W_A)].$$

Because F_p is uniformly nonpositive as an *FSD* shift, we are assured that the taxpayer's utility declines when the probability of an audit increases by assuming that φ is monotonically increasing in π and that the expected value of φ_p is positive.

Because an increase in ambiguity results in an increase in risk in the sense of Rothschild and Stiglitz (1970), the partial integrals of F_a are nonnegative, so that

$$(6)\quad \int_0^\tau F_a(\pi;\ a,p)d\pi \geq 0,$$

for all $\tau \in [0,1]$, with strict inequality at some $\tau \in [0,1]$, and equality at $\tau = 1$. The qualitative effect of an increase in ambiguity on the taxpayer's welfare is given by[8]

$$(7)\quad \partial E[U]/\partial a = -\left[\int_0^1 \varphi dFa\right][U(W_N) - U(W_A)] = -\left[\int_0^1 \varphi_{\pi\pi}\int_0^1 F_a d\pi d\tau\right] \times [U(W_N) - U(W_A)].$$

It follows that the taxpayer is always neutral to ambiguity ($\partial E[U]/\partial a = 0$) if and only if the probability weighting function φ is linear with respect to π ($\varphi\pi\pi = 0$). As in the case where there is no ambiguity, an ambiguity neutral taxpayer's objective function $E[U]$ reduces to the expected utility of wealth with an audit probability of p, and the introduction of ambiguity has no effect on the taxpayer's welfare.[9]

In contrast, the introduction of ambiguity reduces (raises) the welfare of a taxpayer who is ambiguity averse (loving) [$\partial E[U]/\partial a < (>)\ 0$]. Because W_N exceeds W_A, we conclude that the probability weighting function φ is strictly convex (concave) [$\varphi_{\pi\pi} < (>)\ 0$] when the taxpayer is ambiguity averse (loving). Hence, in the presence of ambiguity the perceived probability of an audit, $\int_0^1 \varphi dF$ is greater (less) than the true probability, p, for taxpayers who are ambiguity averse (loving).[10]

The probability weighting function $\varphi(\pi,p)$ need not be uniformly convex or concave with respect to π, but can take the inverse S shape found in experimental tests of cumulative prospect theory, including those conducted by Tversky and Kahneman (1992), Camerer and Ho (1994), and Wu and Gonzalez (1996). The evidence reported in these studies indicates that the probability weighting function of a representative agent facing a favorable prospect is concave over probabilities below 30% to 40% and convex at higher probabilities. Such an individual is therefore, ambiguity averse at low probabilities of gain and ambiguity loving at high probabilities. This evidence implies that $\varphi(\pi,p)$ is concave, reflecting ambiguity loving preferences, over probabilities of being audited below 60% to 70%.[11] If taxpayers' beliefs about the probability of an audit, $F(\pi;\ a,p)$, are realistic, then the supports for these distributions surely lie below 60%, implying ambiguity-loving behavior.

Cumulative prospect theory also allows for different probability weighting functions for gains and for loses. Tversky and Kahneman (1992), Abdellaoui (2000), and Etchart-Vincent (2004) estimate the probability weighting function for a representative agent facing the prospect of a loss, and find that it, too, is concave over probabilities below 30% to 40% and convex at higher probabilities. In the loss context, this implies ambiguity loving behavior ($\varphi_{\pi\pi} < 0$) at probabilities below 30%. Thus, the evidence

8. The second equality follows after using integration by parts twice.

9. In the absence of ambiguity, the expected probability of an audit is p, as indicated by equation (4). Because the introduction of ambiguity, ceteris paribus, has no effect on the expected utility of a taxpayer who is ambiguity neutral, even when some tax liability is being evading, it must be the case that the expected probability of an audit remains equal to p, implying that $\varphi(\pi,p) = \pi$ for all $\pi \in [0,1]$ when the taxpayer is ambiguity neutral.

10. Since there are only two wealth states, with $W_N > W_A$, our model of ambiguity preferences is consistent with several of the nonexpected utility theories discussed. The model of ambiguity developed by Kahn and Sarin (1988) is a special case of ours in which the perceived probability of an audit is equal to $p - \lambda\sigma$, where $\lambda > (<)\ 0$ captures the degree to which the decision maker is ambiguity averse (loving) and σ is the standard deviation of the SOP, $F(\pi;\ a,p)$.

11. Letting Φ represent the probability weighting function for a gain, we have $\Phi(1 - \pi,\ 1 - p) = 1 - \varphi(\pi,p)$, implying $\partial^2\Phi/\partial\pi^2 = -\varphi_{\pi\pi}$. Hence, φ is concave when Φ is convex.

from cumulative prospect theory suggests that taxpayers are ambiguity loving with respect to uncertainty about the probability of being audited.

III. THE EFFECT OF AMBIGUITY ON TAXPAYER COMPLIANCE

The first-order condition for the choice of undeclared income is

$$(8)\qquad \partial E[U]/\partial x \equiv \left\{ U'(W_N) - \left[\int_0^1 \varphi dF \right] \times [U'(W_N) - U'(W_A) \times (1-\theta)] \right\} t = 0.$$

Because the taxpayer is risk averse, the second-order condition is satisfied, and an increase in ambiguity increases (decreases) compliance [$\partial x^*/\partial a < (>)\ 0$] if the marginal value of undeclared income declines (rises) as ambiguity increases; that is, if we have

$$(9)\qquad \left[-\int_0^1 \varphi_{\pi\pi} \int_0^\tau \varphi F_a d\pi d\tau \right] [U'(W_N) - U'(W_A)(1-\theta)] < (>) 0.$$

Because the gross penalty rate is greater than 1, the sign of the expression on the left-hand side of these inequalities is the same as the sign of the first term within brackets. It follows that an increase in ambiguity increases (decreases) compliance if the taxpayer is ambiguity averse (loving).

Because experimental tests of cumulative prospect theory reveal that individuals are ambiguity loving with respect to uncertainty about a small probability of loss, this body of evidence suggests that greater taxpayer uncertainty about the probability of being audited increases tax evasion, contrary to the intentions of the IRS. However, a second strand of the empirical literature treats experimental subjects as individuals, rather than combining their responses to create a representative agent, and these studies reveal considerable heterogeneity with respect to ambiguity preferences. Einhorn and Hogarth (1986) conduct an experiment in which the true (but unknown) probability of experiencing a loss is 0.001, so their setup is similar to the environment faced by a taxpayer contemplating evasion. They report that three-quarters of the subjects exhibited ambiguity aversion. Kivi and Shogren (2002) find that nearly two-thirds of the participants in a similar experiment, who also faced a loss probability of 0.001, were ambiguity averse. Because an ambiguity averter's perceived probability of an audit is greater than the true probability, these findings are consistent with the results obtained by Alm et al. (1992b) and Scholz and Pinney (1995) indicating that individuals typically overestimate the true probability of an audit. Nonetheless, both Einhorn and Hogarth (1986) and Kivi and Shogren (2002) also find that many of their experimental subjects were ambiguity neutral, and some were ambiguity loving.[12]

In a similar vein, Lattimore et al. (1992) find considerable heterogeneity with respect to the shape of the probability weighting function. They find that when facing the prospect of a gain, 70% of their subjects showed evidence of ambiguity aversion at low probabilities and preference for ambiguity at high probabilities, whereas 4% showed the reverse, and 26% exhibited behavior consistent with the expected utility model. When facing the prospect of a loss, the distribution of preferences over ambiguity was similar (79% of the subjects with an inverse S shape, 5% with an S shape, and 16% who were expected utility maximizers).

This experimental evidence indicates that a substantial proportion of the population is ambiguity averse, and for these individuals a policy of deliberately fostering uncertainty about the probability of an audit has the desired effect of reducing tax evasion. However, this evidence also reveals that a nontrivial proportion of the population is ambiguity neutral, for whom fostering uncertainty has no effect on evasion decisions but simply wastes resources. Moreover, the presence of ambiguity lovers in the population raises the possibility that the introduction of uncertainty about the probability of being audited could reduce tax collections in the aggregate by encouraging more evasion than it deters.

12. Specifically, Einhorn and Hogarth (1986) report that 5% of their subjects exhibited ambiguity-loving behavior and 20% were ambiguity neutral, while Kivi and Shogren (2002) find that 9% of their subjects were ambiguity loving and 30% were ambiguity neutral. Camerer and Weber (1992) present an extensive review of the empirical evidence on ambiguity preferences.

IV. THE EFFECT OF AMBIGUITY ON TAXPAYER WELFARE

When taxpayers are heterogeneous with respect to ambiguity preferences, the introduction of uncertainty about the probability of being audited imposes conflicting demands on tax policy if the aim is to enhance welfare. For those taxpayers who are ambiguity averse, the introduction of ambiguity reduces both expected welfare and the amount of tax evasion. The latter permits a reduction in the tax rate to return expected tax revenue to its original level. If this reduction in the tax rate overcompensates for the decline in expected welfare, then the introduction of uncertainty about audit probabilities is potentially welfare enhancing for ambiguity-averse taxpayers. However, the situation is reversed for taxpayers who are ambiguity loving. For these taxpayers, both expected welfare and the amount of tax evasion rise when ambiguity is introduced. The increase in welfare permits an increase in the tax rate to return expected welfare to its original level. If this increase in the tax rate overcompensates for the decline in expected tax revenue, then the introduction of ambiguity is potentially welfare enhancing for ambiguity-loving taxpayers.

Because the tax authority has no practical means of categorizing or screening taxpayers on the basis of ambiguity preferences, all taxpayers must be treated as if they are the same in this regard. If, as ambiguity is fostered, the tax rate is reduced in an effort to compensate ambiguity averters, then ambiguity lovers are made even better off. However, the shortfall in the expected tax revenue collected from them is exacerbated, making it more difficult to hold expected tax revenue constant in the aggregate. If, instead, the tax rate is increased in an effort to offset the shortfall in expected tax revenue collected from ambiguity lovers, then ambiguity averters are made even worse off. Hence, whichever direction policy takes, the potential for welfare gains is diminished by the presence of opposing ambiguity preferences in the taxpaying population.

V. CONCLUSIONS

Uncertainty about the probability of a tax return being audited reduces welfare but increases compliance for taxpayers who are ambiguity averse. As a consequence, the introduction of ambiguity is potentially welfare enhancing if ambiguity averters increase their compliance enough to allow a reduction in the tax rate sufficient to overcompensate for the loss in welfare while returning expected tax revenue to its original level. Ambiguity, however, reduces compliance for those who are ambiguity loving, implying that compliance in the aggregate may not increase. The available evidence suggests that ambiguity lovers are in the minority. Nonetheless, heterogeneity among taxpayers with respect to ambiguity preferences calls into question the use of uncertainty about the probability of being audited as an instrument for either discouraging tax evasion or increasing the welfare of taxpayers.

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