RAND Journal of Economics
Vol. 25, No. 1, Spring 1994

Honesty and evasion in the tax compliance game

Brian Erard*

and

Jonathan S. Feinstein**

Conventional models of tax compliance emphasize that taxpayers make strategic tax reports, underreporting income to the extent that this behavior is financially rewarded. In contrast to this view, considerable empirical evidence suggests that many taxpayers are inherently honest, reporting truthfully regardless of the incentive to cheat. In this article we build a game-theoretic model of tax compliance that includes both honest and potentially dishonest taxpayers. We show that including honest taxpayers significantly alters the model, leading to much-improved empirical predictions and somewhat different and novel policy implications.

1. Introduction

■ In economic models of tax compliance it has traditionally been assumed that taxpayer reporting behavior is driven primarily by the incentives of the tax system. According to this framework, taxpayers choose how much income to report on their tax returns by solving a standard expected utility-maximization problem that trades off the tax savings from underreporting true income against the risks of audit and penalties for detected noncompliance. This view of taxpayer behavior was first presented in the context of a formal model by Allingham and Sandmo (1972) and Srinivasan (1973), and it has continued to occupy a central place in the more recent work of Reinganum and Wilde (1986a, 1986b), who present a game-theoretic analysis that incorporates the strategic behavior of the tax

* Carleton University.

** Yale University and NBER.

We thank the Coeditor and the referee for helpful comments. For their many useful suggestions, we also thank conference participants at the NBER Summer Institute "State and Local Tax Compliance Meeting" held August 14–15, 1990, and at the joint International Seminar in Public Economics (ISPE) and Instituto de Estudios Fiscales "Conference on Tax Administration and Tax Policy" held in El Escorial, Spain on June 11–12, 1992, and seminar participants at Carleton University, Stanford University Graduate School of Business, the University of California at Berkeley Econometrics Workshop, the University of Toronto Public Economics Workshop, and Yale University. The first author gratefully acknowledges financial assistance from the Social Sciences and Humanities Research Council of Canada.

agency into the formal analysis, providing a link between tax agency audit policies and taxpayer reporting decisions (see also Reinganum and Wilde (1985), Scotchmer (1987), Mookherjee and Png (1989), and Sánchez and Sobel (1993) for related models using a principal-agent framework). In all of these models taxpayers show a similar willingness to cheat, differing in this regard only in their attitudes toward risk and their opportunities for evasion.

The behavioral assumption that taxpayers make strategic, financially motivated compliance decisions has generated important insights about tax compliance. However, it is based on a restrictive view of human nature that is at odds with the empirical evidence on tax compliance. Although some taxpayers undoubtedly do approach their reporting decisions in this way, others appear to be inherently honest, willing to bear their full tax burden even when faced with financial incentives to underreport their income. Evidence for such inherently honest taxpayers derives not just from casual introspection; it is also supported by econometric evidence and survey findings discussed later in this article.

Although the fact that many taxpayers are inherently honest has been recognized in both the economics and sociology literatures on tax compliance (see, for example, Graetz, Reinganum, and Wilde (1986), Alm, McClelland, and Schulze (1992), Alexander and Feinstein (1987), Spicer and Lundstedt (1976), and Smith and Stalans (1991)), the significant impact that honest taxpayers may exert on tax compliance systems and policy formulation has not been fully appreciated. In the original analyses of Allingham and Sandmo and Srinivasan, the presence of honest taxpayers has no effect on the reporting decisions of financially motivated taxpayers, and even in the simple two-state (high and low income) version of the tax compliance game introduced by Graetz, Reinganum, and Wilde, which explicitly includes honest taxpayers, a change in the proportion of taxpayers who are honest has only one effect, to reduce the probability that dishonest taxpayers cheat in equilibrium, while leaving unaffected the optimal audit strategy, expected net tax revenue, and all other aspects of the model's solution.

Our purpose in writing this article is to challenge what we believe is a widely held view: that honest taxpayers, although they may exist, do not significantly influence most aspects of tax compliance systems, including policy formulation. We hope to demonstrate that in fact honesty does matter and that it is important to account for the presence of inherently honest taxpayers when formulating models of noncompliance and auditing. To accomplish this aim, we build a game-theoretic model of tax compliance that is based on the model developed by Reinganum and Wilde (1986a, 1986b), modified to include an explicit budget constraint for the tax agency. We first solve the model for the case in which all taxpayers are willing to cheat if "the price is right"; then we extend the model to incorporate honest taxpayers who choose not to participate in the "tax lottery." We show that this straightforward extension significantly alters the model's fundamental equation and modifies and complicates the method that must be used to solve this equation. Perhaps more importantly, we find that the equilibrium solution of the extended model is different in several qualitative respects from the original model's equilibrium solution, resolving a number of troubling features of this original solution and generating somewhat different and novel policy implications.

Following Reinganum and Wilde, our framework assumes a continuum of taxpayers, corresponding to a continuous true income distribution. The analysis of our first model, in which all taxpayers are willing to evade, corresponds quite closely to the analysis that Reinganum and Wilde present. In particular, the model generates a simple linear first-order differential equation, which has as a solution an elegant fully separating equilibrium in which each true income value is associated with a unique income report. When all taxpayers are risk neutral they each underreport income by the same amount. Although the model's solution has considerable aesthetic appeal, it also has several undesirable properties. First, in equilibrium the tax agency knows the true income of each taxpayer, precisely because the equilibrium is fully separating; this seems to contradict the basic fact that the tax agency usually does not know the true income of a taxpayer before performing an audit. Second, the shape of the income distribution curve has no effect on the equilibrium audit schedule. Third, there exists a multiplicity of alternative pooling and partially pooling equilibria in the model. Most of these alternative equilibria share the two problems just described over at least some of the income range, and they also generally involve "empty" (off-equilibrium) regions in which no taxpayer reports, an implication that again seems counterintuitive. Moreover, since there is no absolute criterion for determining which one of these many alternative equilibria actually occurs in practice, it is difficult to identify the model's empirical implications. We discuss all of these difficulties in greater detail in Section 3; in addition, we show that when the tax agency faces a binding budget constraint, there exist equilibria (which involve partial pooling) that yield higher expected net revenue for the tax agency than the fully separating equilibrium.

We introduce honest taxpayers into our model by assuming that at each income level a fraction Q of taxpayers always reports truthfully. Somewhat surprisingly, we find that this one extension resolves, at least to some degree, each of the problems of the original model described above. First, since honest taxpayers make reports throughout the range of the true income distribution, nearly all of the pooling and partially pooling equilibria that are possible in the original model are eliminated from the extended model. Second, there are now typically at least two types of taxpayers making reports at each income level—dishonest taxpayers, whose true income is somewhat higher than what is reported, and honest taxpayers; hence, the tax agency is unable to deduce the true income of each taxpayer from his report. Finally, the shape of the income distribution curve now influences the equilibrium solution, and the level of tax evasion varies with true income. We note that solving the extended model is substantially more complex than solving the original specification, because the incorporation of honest taxpayers transforms the fundamental equation characterizing equilibrium from a linear first-order differential equation into a highly nonlinear second-order differential equation that must be analyzed using numerical techniques; hence, we rely extensively on computer simulations to characterize the model's solution.

We solve each of our models both for the case in which taxpayers are risk neutral and the case in which they are risk averse. Because the case of risk-neutral taxpayers generates simpler and more revealing formulae than the case of risk-averse taxpayers, we present explicit equations only for the former case in the main text, relegating the corresponding equations for the latter case (specifically, the case in which taxpayers exhibit constant relative risk aversion) to the Appendix. However, our simulation results are presented for the case of risk-averse taxpayers, which we believe is somewhat more realistic. Although there are a few differences between the solutions for the two cases (which we do mention), their qualitative features are generally very similar. This similarity stems from the fact, as opposed to the solutions of the single-agent models of Allingham and Sandmo (1972) and Srinivasan (1973), that most of the features of our results derive from the nature of the strategic interaction between the tax agency and taxpayers, not from the shape of the taxpayer utility function.

Incorporating honest taxpayers into the tax compliance game raises a number of interesting policy issues, which we explore in Section 4. One issue relates to the impact of Q on net tax and penalty revenue. Graetz, Reinganum, and Wilde (1986) show that in a model with two income states a change in the proportion of taxpayers who are honest has no impact on expected government net revenue. Simulations reveal that in our model expected net revenue does rise with Q but only quite slowly; in a scenario in which income is distributed log-normally, a rise in Q from .10 to .60 causes expected net revenue to rise by approximately 11%. A second issue that we explore is the effect of changes in Q on the shadow value of additional (marginal) audit resources. In contrast to our first finding, simulations for this case show a dramatic effect of changes in Q: when Q increases from .10 to .60, the shadow value of additional audit resources falls by 69%—to less than one-third of its original level. These two findings underscore the importance of the tradeoff between voluntary compliance and tax enforcement revenue. Although policies designed to promote an increase in Q can have a beneficial impact on voluntary tax payments, the resulting increase in tax revenue may be offset to a substantial extent by a decline in enforcement yield. In addition to these two issues, we also explore the implications of our model for horizontal and vertical equity and the sensitivity of our results to the form of the income distribution.

Although the primary focus of the economics literature has been on the role of financial incentives in taxpayer reporting decisions, the sociology, psychology, and legal literatures on tax compliance have consistently argued for a broader view of compliance behavior. For example, in an early article Schwartz and Orleans (1967) suggest that taxpayers can be convinced to pay their taxes fully through moral suasion. Many subsequent researchers make similar claims (see, for example, Spicer and Lundstedt (1976) and Smith and Stalans (1991)), arguing that compliance can be increased not just through deterrence but also by improving a tax agency's public image and its treatment of taxpayers. These arguments indicate that the degree of honesty in a taxpayer population may be endogenous, depending on a variety of social norms and government policies. We discuss these issues in the last section of the article, but we leave to future work the development of formal models that incorporate the endogeneity of honest reporting practices.

The remainder of the article is organized as follows. In the next section we develop the framework for our two models of tax compliance, deriving the equations governing both the reporting behavior of potential cheaters and the auditing strategy of the revenue-maximizing tax agency. Then in Section 3 we present our first model, in which all taxpayers are willing to cheat, characterize its solution, and discuss its limitations. In Section 4 we specify our model of honest and dishonest taxpayers, solve it, and provide an extensive set of simulation results. Section 5 concludes with our discussion of the factors affecting the degree of honesty in the population. An Appendix provides formulae for the models when taxpayers are risk averse.

2. Framework

■ In this section we present the basic framework that underlies both of our models. We proceed in three steps. First, we specify reporting behavior for potential cheaters, who decide how much income to report on the basis of a rational calculation that reflects their beliefs about the tax agency's audit rule. Second, we derive the tax agency's audit rule under the assumption that the agency seeks to maximize expected tax and penalty revenue net of audit costs, subject to an explicit budget constraint. Finally, we deduce the fundamental equation that describes the equilibrium solution for both of our models over the range in which the tax agency follows a mixed strategy and audits returns with a probability that is strictly between zero and one.

We assume a continuum of taxpayers with different true incomes. True income lies between $\underline{y}$ and $\bar{y}$, and taxpayers are distributed along this line segment according to the income density function $f(y)$. When interpreting our results it is best to think of the model in terms of a particular audit class (a group of taxpayers sharing a number of relevant features in common), so that $f(y)$ refers to the distribution of income within the class, rather than to the distribution of income within an entire national or regional population.

A taxpayer who behaves as a "rational cheater" chooses how much income to report, x, on his tax return to maximize expected utility. In making this calculation the taxpayer recognizes that he faces an audit probability schedule $p(x)$ that relates his report x to his probability of being audited. The taxpayer is also aware that if he is audited his true income, y, will be determined with certainty, and he will have to pay all additional taxes due plus a penalty. For simplicity, we assume here and throughout a proportional tax schedule with constant marginal tax rate t. We also assume a penalty schedule that assesses penalties in the amount θ times the level of evasion (a constant marginal penalty rate).[1]

As discussed in the introduction, for expositional purposes we confine our derivations in the main text to the case in which taxpayers are risk neutral. In the Appendix we present the corresponding equations for the case in which taxpayers possess a constant relative risk-aversion utility function with coefficient α, and we note these parallel equations as we go along in the text. When taxpayers are risk neutral, a taxpayer with income y chooses report x to maximize

$$p(x)[y - ty - \theta(y - x)] + (1 - p(x))[y - tx], \tag{1}$$

leading to the first-order condition, $p'(x)(x - y)(\theta + t) + p(x)(\theta + t) - t = 0$, which may be rewritten as

$$y = x + \frac{p(x) - \dfrac{t}{\theta + t}}{p'(x)} \tag{2}$$

to emphasize how true income y relates to the report x.[2] The taxpayer's second-order condition is

$$2p'(x) + p''(x)(x - y) \leq 0. \tag{3}$$

Finally, we note from the first-order condition that

$$\frac{dy}{dx} = 2 + \frac{p''(x)(x - y)}{p'(x)}. \tag{4}$$

The corresponding equations for the risk-averse taxpayer case are given in the Appendix as equations (A1) to (A4), respectively. The quantity $\frac{dy}{dx}$, which measures how fast true income rises relative to reported income, plays a crucial role in the analysis. In particular, note that satisfaction of the taxpayer's second-order condition for the risk-neutral taxpayer case is equivalent to the condition $\frac{dy}{dx} \geq 0$; although this simple equivalence breaks down in more complex models, such as when the taxpayer is risk averse, it continues to be the case that $\frac{dy}{dx}$ must be greater than zero for a valid solution of the kind we compute.[3] Note also that when $\frac{dy}{dx}$ equals one, all taxpayers are cheating by the same amount (the difference

---

[1] This implies that the only penalty a taxpayer faces for tax evasion is a dollar penalty proportional to the amount of tax evaded. In practice, few evaders actually go to jail or face additional fines, so this appears to be a reasonable assumption. We have solved our models with more complex penalty functions, such as functions that include both a proportional penalty rate and a fixed cost of being audited (which is either constant or proportional to true income), but we have not found that using these more complex functions substantially alters our qualitative results.

[2] As long as $p(y) < \frac{t}{\theta + t}$, the taxpayer will choose to evade by a strictly positive amount. We restrict attention to this case, because it is always the relevant case in the models we consider.

[3] We focus throughout the article on the case where taxpayers play pure strategies (though the tax agency

$(y - x)$ remains constant as y varies), whereas wealthier taxpayers cheat by relatively less if $\frac{dy}{dx}$ is less than one and by relatively more if $\frac{dy}{dx}$ is greater than one.

After each taxpayer has made his income report, the tax agency chooses the audit function $p(x)$ to maximize expected net revenue subject to a budget constraint, where net revenue includes voluntary tax payments as well as any audit-induced tax and penalty assessments less audit costs. It is assumed that the tax agency cannot precommit to an audit schedule and that it takes the tax rate, the penalty function, and the audit cost as given (see Melumad and Mookherjee (1989) for an interesting discussion of how the government can alter the tax agency's incentives to make it behave "as if" it were precommitted). Thus, the tax agency chooses $p(x)$ to maximize

$$\int_{\underline{x}}^{\bar{y}} [p(x)[tE(y \mid x) + \theta(E(y \mid x) - x)] + (1 - p(x))tx]f_X(x)dx \tag{5}$$

subject to $c\int_{\underline{x}}^{\bar{y}} p(x) f_X(x)dx = B$ and $0 \leq p(x) \leq 1$, where B is the average number of dollars per return filed that is available for audits, $\underline{x}$ is the lowest report made by any taxpayer, and $f_X(x)$ is the induced probability distribution over x. In equilibrium, $f_X(x)$ will be zero over some of the integral's range (such as near $\bar{y}$). For simplicity we hold the cost per audit c constant.[4]

To solve this optimization problem we specify a Lagrange multiplier λ for the budget constraint; λ may be interpreted as a shadow price that measures the expected change in net revenue from a marginal increase in the tax agency's audit budget. Differentiation with respect to p yields the pointwise condition that $[tE(y \mid x) + \theta(E(y \mid x) - x) - tx - \lambda c]f_X(x)$ is greater than, equal to, or less than zero as $p(x)$ is equal to one, between zero and one, or zero.[5] In what follows we focus especially on the mixed-strategy region, where

$$E(y \mid x) = x + \frac{\lambda c}{\theta + t}. \tag{6}$$

Equation (6), which resembles a comparable equation derived by Reinganum and Wilde, is the fundamental condition characterizing the game-theoretic model of tax compliance; in modified form, it will reappear in both our model of dishonest taxpayers and our model of honest and dishonest taxpayers. In order for the tax agency to be just indifferent about auditing a return, the expected gains from the audit, $(E(y \mid x) - x)(\theta + t)$ (representing the extra tax due plus the penalty), must equal the cost λc (representing the audit cost c multiplied by the shadow price λ).

3. The model of dishonest taxpayers

■ As a benchmark against which to compare our model of honest and dishonest taxpayers, we first study the properties of a model in which all taxpayers are willing to cheat; this model is very similar to the model of Reinganum and Wilde (1986a, 1986b). Although

---

plays a mixed strategy). In solutions involving mixed strategies for taxpayers, $\frac{dy}{dx}$ could possibly be negative in certain regions.

[4] Reinganum and Wilde (1986a) explore this case as well as the alternative case where c is a convex function of p.

[5] The second-order condition for the tax agency is $\frac{dE(y \mid x)}{dp(x)} \leq 0$. We have found that this condition is always satisfied in our simulations.

the assumptions of this model are simpler than those of our later model, we will show that its solution is less satisfying in a number of respects.

Note first that there exists a multiplicity of equilibrium solutions for this model. We initially focus attention on the fully separating equilibrium, which is comparable to the equilibrium originally derived by Reinganum and Wilde; alternative equilibria are explored later.

To solve for the fully separating equilibrium we use equation (6) to deduce y in terms of x and then substitute this expression for y into the taxpayer's first-order condition, deriving a linear first-order differential equation in x and $p(x)$. For the risk-neutral taxpayer case, the taxpayer's first-order condition is given by equation (2), and the resulting differential equation is particularly simple, taking the form $p(x) = \frac{t}{\theta + t} + \frac{\lambda c}{\theta + t} p'(x)$, which has an exponential form solution, $p(x) = \frac{t}{\theta + t} [1 - exp(\beta(x - \bar{x}))]$, where $\beta = \frac{\theta + t}{\lambda c}$ and $\bar{x}$ is the income report made by taxpayers who possess true income $\bar{y}$. When taxpayers are risk averse, the differential equation is somewhat more complicated, as is evident from equation (A5) in the Appendix.

The boundary condition for the fully separating equilibrium solution is $p(\bar{x}) = 0$, where $\bar{x} = \bar{y} - \frac{\lambda c}{\theta + t}$. One can use this boundary condition to compute the value of $p'(\bar{x})$ that "starts" the differential equation at its right-hand side, by substituting $\bar{x}$ and $\bar{y}$ into the taxpayer's first-order condition.

Supporting this equilibrium are "off equilibrium" beliefs that justify the tax agency's intentions to audit with high probability any reports below $\underline{x}$ and to audit with zero probability any reports above $\bar{x}$. In this separating equilibrium the audit probability function is monotonic, taking the value zero for values of x sufficiently close to $\bar{y}$, becoming positive just below $\bar{x}$, and increasing in a concave fashion as x falls.

Our introduction of a budget constraint has several implications for this model. First, it is easy to show that as the budget falls, λ rises, p falls at each x, $\bar{x}$ falls, and taxpayers cheat by more. Second, in their original model, in which the tax agency is not constrained by a limited budget, Reinganum and Wilde show that as the range of the true income distribution tends to infinity, the audit probability p approaches a constant value, $\frac{t}{\theta + t}$, which does not vary with the report x. Clearly this solution is not viable when the tax agency is sufficiently budget constrained, because such a scheme would require an infeasible level of audit resources. Instead, we can show that when the range of the true income distribution is infinite, a budget-constrained tax agency will choose not to audit along an infinite upper strip of the income range. Third, in the absence of a budget constraint, the separating equilibrium solution for the model is unstable in the following sense: if the audit cost c were to change even very slightly after the equilibrium tax reports were made, the tax agency would choose to deviate from its original equilibrium audit strategy to a strategy of auditing either all returns or no returns depending on whether c had decreased or increased. Thus, a slight change in audit costs would have dramatic behavioral consequences.[6] When the tax agency operates under a binding budget constraint, this problem does not arise. For example, if audit costs were to increase slightly after taxpayer reports were made, the tax agency would simply shift the audit probability schedule downward by a slight amount to equalize the new level of total audit costs and the overall audit budget.

[6] This undesirable feature does not carry over to the case where c is specified as a convex function of p.

An important feature of the above solution is that in equilibrium the tax agency actually knows the true income of each taxpayer. In particular, because only one type of taxpayer reports at each x, the tax agency need not follow any actual inference procedure (such as Bayes' rule) to determine $y(x)$. Because the true value of y is revealed in equilibrium, the shape of the true income distribution has no influence on the equilibrium verification and reporting policies when the tax agency is not budget constrained; thus, there is no scope in the original Reinganum and Wilde model for examining the policy implications (such as the effective progressivity of the tax and penalty structure) of alternative income distributions. In contrast, the shape of the income distribution does become important when a budget constraint is introduced into the model. This is because total audit costs are determined by the fraction of taxpayers reporting at each point on the audit schedule, which is influenced by the shape of the income distribution. For example, if the distribution of true income were skewed to the right, there would exist a relatively large number of low-income reports in equilibrium. These low-income reports would be associated with relatively high audit probabilities and, hence, relatively high audit costs. In order to satisfy the budget constraint, the entire audit probability schedule therefore would have to be relatively low. In the next section we show that the shape of the true income distribution matters for another important reason in our model of honest and dishonest taxpayers; namely, it determines the relative numbers of honest and dishonest taxpayers making the same report x.

The separating equilibrium of the Reinganum and Wilde model has several disturbing empirical implications. First, in equilibrium the tax agency knows the true income of each taxpayer prior to performing any audits. In actual practice a taxpayer's true income is often unknown to an examiner prior to an audit. The somewhat richer model presented in the following section resolves this problem. Second, if the tax agency is sufficiently budget constrained, the proposed separating equilibrium is unsatisfactory in that it yields negative expected net revenue for the tax agency. Third, the equilibrium has the property that when taxpayers are risk neutral, they all evade taxes by the same amount, $\frac{\lambda c}{\theta + t}$, which implies that the level of income is uncorrelated with the level of evasion, an implication that contradicts intuition and at least some empirical research; e.g., Feinstein (1991) finds that the level of income and the level of evasion are positively related. (When taxpayers are risk averse, higher-income taxpayers will evade by more if the degree of risk aversion falls with income.)

In examining alternative equilibria to this model, we have discovered that there exist equilibria that provide greater expected net revenue for the tax agency than the fully separating equilibrium described above. In particular, it can be shown that an equilibrium of the following form results in greater expected net revenue when the tax agency is budget constrained: the separating portion of the equilibrium audit probability schedule begins at $\bar{x}$ as above; but at some $x > \underline{y}$, the remaining taxpayers jump to a pooling point.[7] For all income distributions with a nonincreasing lower tail, we can further show that in the revenue-preferred equilibrium of this type, the pooling point is precisely $\underline{y}$. Even if the tax agency's budget were unlimited, this pooling equilibrium might be preferable to the fully separating equilibrium from a social point of view, because it would exhaust fewer resources on tax enforcement; however, we have not explored this issue. Nor have we explored all of the possible equilibria for this model; therefore, it remains an open question which equilibrium solution provides the maximum possible expected net revenue.

[7] One interpretation of this equilibrium is that the tax agency sets a "bright line" at the pooling point, promising to audit with high probability any taxpayer who reports below this level (contrast this with the fully separating equilibrium in which successively lower income taxpayers report ever lower amounts).

The above model has very many alternative equilibria. For example, there exists a fully pooling equilibrium in which all taxpayers make the same report x and the tax agency audits this report with a particular probability p. Supporting this equilibrium are "off equilibrium" beliefs that justify the tax agency's intention to audit with high probability any deviant report. There are also many partially pooling equilibria. In Reinganum and Wilde (1986b), the authors do show that the divinity refinement of sequential equilibrium can rule out these various pooling and partially pooling equilibria. We have not explored such refinements.

4. The model of honest and dishonest taxpayers

■ The idea that taxpayers should pay their taxes to the government voluntarily is surely as old as theories of civic virtue. Just as citizens have volunteered for military service or sent their children to fight, it traditionally has been maintained that citizens have a duty to pay their taxes.

There is considerable empirical support for the notion that some taxpayers are inherently honest and willing to pay their taxes voluntarily. For example, Alexander and Feinstein (1987) report, based on 1982 IRS audit data, that approximately one quarter of all taxpayers make accurate tax reports. According to their calculations, an additional 13.5% overstate their taxes, presumably in many cases because they commit errors in completing their returns. If another 13.5% understate their taxes due to error, then as many as one-half of all taxpayers may in fact have honest intentions. Of course, truthful reporting (or overreporting) does not necessarily indicate that a taxpayer is inherently honest, because the fear of being detected and penalized can induce truthful reporting. However, current U.S. audit and penalty rates are sufficiently low that in many cases taxpayers who chose their reporting policies according to the rational calculation outlined in the last section would find it in their interest to underreport income to some degree.

Survey evidence reported in Sheffrin and Triest (1992) provides further support for the notion that many taxpayers report truthfully. In a survey conducted by Harris and Associates, taxpayers were asked whether they fully reported and paid their taxes; the vast majority (more than 70%) responded affirmatively. Although self-rationalization and other factors are undoubtedly responsible for many of these self-reports of honest reporting behavior, the results certainly are consistent with the notion that a sizable minority of taxpayers are truthful in their reporting practices. (Further survey evidence is reviewed in Roth, Scholz, and Witte (1989).)

To incorporate the existence of honest taxpayers into the tax compliance game, we assume that at each income level y, a fraction Q of all taxpayers are "honest" in the sense that they always report y on their returns; the remaining $1 - Q$ taxpayers are assumed to be "dishonest" in the sense that they strategically choose an amount to report, x, (typically less than y) by solving a maximization problem just as in the previous section. Our approach has two obvious limitations. First, we do not allow Q to vary with income.[8] Perhaps more importantly, Q is specified as an exogenous parameter rather than allowing its value to be determined endogenously in the model.[9] In fact, historical, psychological, and sociological arguments all suggest that Q will vary across communities, cultures, and time, in response to variations in social norms and attitudes towards government. We address these issues in the conclusion.

[8] Not allowing Q to vary with income is not as much of a limitation as it may seem. What is critical to this model is the relative frequency of honest to dishonest taxpayers along the reported income distribution curve. Because honest and dishonest taxpayers come from different points on the true income distribution curve, the relative frequency can be influenced through the choice of $f(y)$.

[9] In fact we would argue that the best way to develop a model in which Q varies with income would be through such an endogenous modelling approach.

The incorporation of taxpayer honesty into the tax compliance game has an immediate implication: as long as all taxpayers follow pure strategies, so that reported income is nonincreasing as true income falls, the vast majority of all pooling equilibria in the previous specification are ruled out. This is because the existence of reports by both honest and dishonest taxpayers at each income level in the range $[\underline{y}, \bar{x}]$ makes it necessary for both the equilibrium audit function p and its derivative p' to be continuous throughout the interior of this region. To demonstrate the reasoning behind this result it is simplest to argue by contradiction. Suppose first that p itself were not continuous. Then if p were to jump, say at x^*, from p^1 to a higher value p^2, no dishonest taxpayer would choose to report where the audit probability was p^2, because the report corresponding to audit probability p^1 would yield higher expected utility. As a consequence, only honest taxpayers would make reports at x^* (or even in a neighborhood of x^*). But then the tax agency would want to reduce the audit probability at x^* from p^2 to zero. An exactly analogous argument shows that p cannot jump from a higher to a lower value, because again no dishonest taxpayers would report at the higher level. We conclude that p cannot jump. A similar but slightly more complex argument shows that p' also must be continuous. Suppose first that p' were to fall discontinuously (as x falls), causing p to take on a concave shape. In this case no dishonest taxpayer would make a report in a neighborhood to the left of the discontinuity in p', leaving only honest taxpayers to make reports in this range. Consequently, the tax agency would choose not to audit reports in this neighborhood causing p to jump to zero. But the possibility of a jump in p already has been ruled out. Alternatively, suppose that p' were to rise discontinuously (as x falls), causing p to take on a convex shape. In this case a group of dishonest taxpayers with different true incomes would choose to pool at the point of discontinuity in p'. If the tax agency were just indifferent about auditing at this pooling point, it clearly would prefer not to audit any taxpayers reporting in a neighborhood to the left of this point, whose true incomes would be strictly below the pool average. Thus p would jump to zero, a possibility we have ruled out above. We conclude that p' cannot be discontinuous. As a consequence of these results, all equilibria that involve pooling in the interior of the range $[\underline{y}, \bar{x}]$ are ruled out. Later in this section we explore the possibility of equilibria that involve pooling at the boundaries of this interval.

To determine an equilibrium of this model, it again is necessary to link together the reporting behavior of the taxpayer with the audit policy of the tax agency. It is straightforward to show that whenever the tax agency plays a mixed strategy, equation (6) must be satisfied. However, in this case the calculation of $E(y \mid x)$, which plays a prominent role in equation (6), is considerably more complex. Previously, the separating equilibrium involved a single type of taxpayer (only one true income) for each report x; hence, the determination of $E(y \mid x)$ was trivial. Now, however, two types of taxpayers report at each value of x over a wide range of the reporting region: (1) honest taxpayers whose true income y is equal to x; and (2) dishonest taxpayers whose true income y exceeds x. To compute $E(y \mid x)$ for this model it is necessary to determine the relative numbers of honest and dishonest taxpayers reporting in a neighborhood of x. For risk-neutral dishonest taxpayers the relationship between y and x continues to satisfy equation (2), while for risk-averse dishonest taxpayers equation (A2) in the Appendix applies. Honest taxpayers always report $x = y$.

Reporting in the small strip $[x, x + dx]$ are approximately $Qf(x)dx$ honest taxpayers. Also reporting in this region are dishonest taxpayers with true incomes in the range $[y(x), y(x + dx)]$. Their number is approximately $(1 - Q)f(y(x))\left|\frac{dy}{dx}\right|$. For risk-neutral dishonest taxpayers $\frac{dy}{dx}$ is given by equation (4), while for risk-averse dishonest taxpayers it is given by equation (A4) in the Appendix. We note that in both cases the Jacobian $\frac{dy}{dx}$ must be positive for a valid solution of the type we examine.[10] Therefore,

$$E(y \mid x) = \frac{Qxf(x) + (1 - Q)y(x)f(y(x))\dfrac{dy(x)}{dx}}{Qf(x) + (1 - Q)f(y(x))\dfrac{dy(x)}{dx}}. \tag{7}$$

Because $\frac{dy}{dx}$ involves the term $p''(x)$, the fundamental equation characterizing equilibrium has been transformed into a second-order differential equation in p. For the risk-neutral taxpayer case, substitution of (2) and (4) into (7) reveals that the differential equation to be solved is

$$(1 - Q)f(y(x))\left[\frac{p(x) - \dfrac{t}{\theta + t}}{p'(x)} - \frac{\lambda c}{\theta + t}\right]\left[2 + \frac{p''(x)\left(\dfrac{\dfrac{t}{\theta + t} - p(x)}{p'(x)}\right)}{p'(x)}\right] - Qf(x)\left(\frac{\lambda c}{\theta + t}\right) = 0. \tag{8}$$

For the risk-averse taxpayer case, the corresponding equation is considerably more complex, as is discussed in the Appendix.

□ **Solution of the model.** A full solution of the model requires not only the solution of either equation (8) for the risk-neutral taxpayer case or the comparable equation for the risk-averse taxpayer case; it also requires the specification of the appropriate boundary conditions and a choice of λ to satisfy the budget constraint. In addition, it is necessary to address the possibility of pooling by dishonest taxpayers at the boundaries of the reporting region. We explore each of these issues in this subsection. All of our comments apply to both the risk-neutral taxpayer and risk-averse taxpayer cases.

In general, equation (8) (or the comparable equation for the case of risk aversion), plus boundary conditions, cannot be solved analytically; thus, we rely on numerical analysis in the discussion that follows. Even obtaining a numerical solution to these equations is not a trivial matter: the solution path is of the "saddle-point" variety, and it is necessary to obtain accurate values for the initial conditions and for λ to obtain a valid solution (a solution that satisfies the budget constraint and does not violate the dishonest taxpayers' second-order conditions).

The solution to (8) (or the comparable equation for the case of risk aversion) does not involve pooling by dishonest taxpayers at the upper boundary of their reporting region. To understand this result, suppose that a pool of dishonest taxpayers—those from the upper tail of the income distribution—reported at this point. If the tax agency were just indifferent about auditing at $\bar{x}$, it clearly would prefer not to audit those taxpayers reporting in a neighborhood to the left of this point, whose expected true incomes would be strictly

[10] In the risk-neutral taxpayer case, $\frac{dy}{dx}$ must be positive to satisfy the taxpayers' second-order condition, while in the risk-averse taxpayer case, it must be positive for any equilibrium in which taxpayers play pure strategies, as discussed in footnote 3.

below the pool average. Consequently, such a pool cannot exist in equilibrium. Rather, this boundary point, $\bar{x}$, is characterized by reports from honest taxpayers with true income $\bar{x}$ and dishonest taxpayers with true income $\bar{y} > \bar{x}$. In order for dishonest taxpayers to report at $\bar{x}$, where $p(\bar{x})$ is zero, $p'(\bar{x})$ must be chosen to satisfy $p'(\bar{x}) = (-)\dfrac{\frac{t}{\theta + t}}{\bar{y} - \bar{x}}$ when taxpayers are risk neutral and a comparable expression when they are risk averse.

The equilibrium solution does generally involve pooling by dishonest taxpayers at the lower boundary of their reporting region. Define y_{pool} to be the highest true income amongst those dishonest taxpayers who pool. Then dishonest taxpayers with true income in the range $(y_{pool}, \bar{y}]$ fully separate in equilibrium, reporting over the range $[\underline{y}, \bar{x}]$, while dishonest taxpayers with true income in the range $[\underline{y}, y_{pool}]$ pool at some report x_{pool}.

In the model with only dishonest taxpayers, the equilibrium audit schedule could jump anywhere within the interior of the true income range. In contrast, we have demonstrated above that the equilibrium audit schedule for the honest/dishonest model cannot have a jump above $\underline{y}$, which rules out all equilibria involving pooling to the right of this point. Amongst those equilibria that are possible (namely, equilibria that involve some pooling at or below $\underline{y}$), we find that the one that maximizes expected net revenue for the tax agency generally will be characterized by a pooling point precisely at $\underline{y}$.[11] This equilibrium has the following features. Honest taxpayers each report their true income throughout the range $[\underline{y}, \bar{y}]$ (as one would anticipate); dishonest taxpayers with true income in the range $(y_{pool}, \bar{y}]$ fully separate and file reports over the range $(\underline{y}, \bar{x}]$; and dishonest taxpayers with true income in the range $[\underline{y}, y_{pool}]$ pool their reports at $\underline{y}$. The location of the upper boundary of the reporting region $\bar{x}$ determines the values of $p(\underline{y})$ and $p'(\underline{y})$, which together determine the expected revenue from auditing at the pooling point through their influence on the types of taxpayers joining the pool. The location of $\bar{x}$ is chosen so that the tax agency is just indifferent about auditing at $\underline{y}$.

In both the fully separating and the partially pooling solutions to the model with only dishonest taxpayers, $\frac{dy}{dx}$ did not depend on the shape of the income distribution. Moreover, in the risk-neutral taxpayer case it was constant at the value one throughout the fully separating region. In contrast, in the honest/dishonest model, $\frac{dy}{dx}$ generally does depend on the shape of the income distribution, and it generally is not constant even for the risk-neutral taxpayer case.[12] As we shall illustrate below through computer simulations, the behavior of $\frac{dy}{dx}$ in our model can be quite complex, depending on the exact shape of the

[11] In fact this pooling point is only feasible when the risk parameter α is sufficiently close to one and the budget is sufficiently small; when this equilibrium is not viable, the pooling point must be moved below $\underline{y}$. In practice, however, we have found that this equilibrium is valid for the range of parameter values of interest to us.

[12] One exception to this result is the case where true income y is uniformly distributed. In this case, there is indeed a solution in which $\frac{dy}{dx}$ equals one throughout a wide reporting range until there is a jump to a pooling point. The reader may verify this result by substituting the condition $\frac{dy}{dx} = 1$ into equation (11), which simplifies this expression to a first-order linear differential equation that is quite similar to the corresponding equation given in Section 3. However, even in this case there generally exist other partially pooling equilibria in which $\frac{dy}{dx}$ is not constant that yield greater expected net revenue for the tax agency. The exception is the very special

income distribution. For example, when income is uniformly distributed, the revenue-maximizing audit probability schedule has the property that for $Q < 1/2$, $\frac{dy}{dx}$ starts out below one (at $\bar{x}$) and falls; for $Q > 1/2$, $\frac{dy}{dx}$ starts out above one and rises; and for $Q = 1/2$, $\frac{dy}{dx}$ equals one throughout the range $(\underline{y}, \bar{x})$ (for both the risk-neutral and risk-averse taxpayer cases).

Our model of honest and dishonest taxpayers has several qualitative features that improve upon the model presented in the previous section. First, the tax agency now faces a true inference problem in its decision to audit a return: the return may have been reported either by an honest or a dishonest taxpayer. In contrast, in the previous model the fully separating equilibrium poses no inference problem for the tax agency, and the revenue-preferred partially pooling solution poses an inference problem only for reports at the pooling point. Second, the shape of the true income distribution $f(y)$ now has an important influence on the equilibrium solution of the model even in the absence of a budget constraint. The reason is that the relative numbers of honest and dishonest taxpayers making a report x depends directly on f, because these two kinds of taxpayers are coming from different points on the true income curve. As a consequence, the behavior of $\frac{dy}{dx}$, the choice of audit probabilities, and the effective level of tax progressivity all are sensitive to the shape of the true income distribution. Third, the equilibrium results are sensitive to the level of Q, the fraction of honest taxpayers. For a fixed budget, when Q is low, dishonest taxpayers cheat by relatively large amounts and face relatively low probabilities of audit. In contrast, when Q is high, dishonest taxpayers cheat by relatively small amounts and face relatively high probabilities of audit. Moreover, the distribution of tax evasion by true income level also is sensitive to the value of Q.

□ **Simulation results.** Simulation results help to clarify and illustrate a number of features of the model's solution. Parameter values for the simulations are chosen as follows. For all of the simulations we set the tax agency budget at a level that limits the total number of audits to 10% of the returns filed. In addition, for all of the simulations we set the risk-aversion parameter α to .7, the tax rate t to .3, and the penalty rate θ to 1.2 (meaning that the penalty is four times the extra tax due).[13] For the majority of simulations, we work with a truncated lognormal income distribution. For this distribution we set the parameter μ to 3.42 and the parameter σ to .3 (see Johnson and Kotz (1972) for a statement of the lognormal density function in terms of these parameters).[14] We then truncate this function so that it takes on nonzero values only over the range from 20 to 44; hence, taxpayers in these simulations each have true income somewhere within the range

---

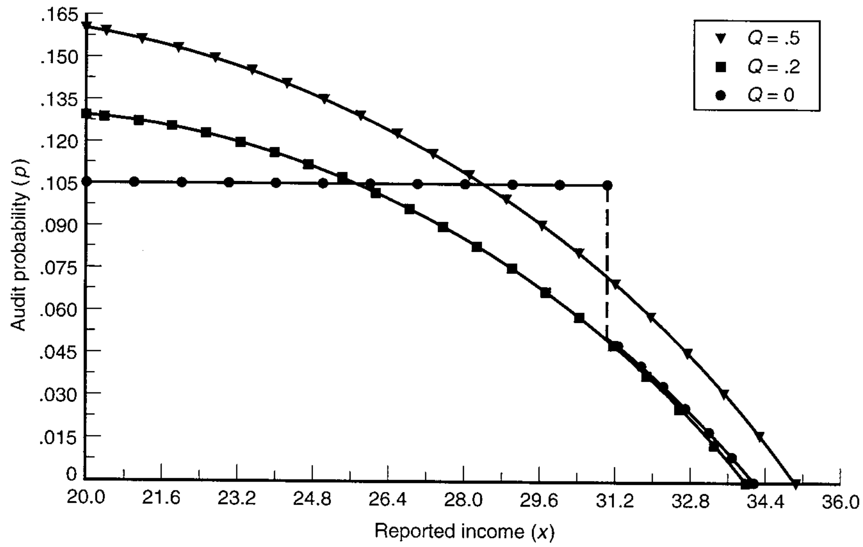
case where $Q = 1/2$ and income is uniformly distributed. In this case, the solution where $\frac{dy}{dx} = 1$ throughout the reporting range turns out to be the revenue-maximizing equilibrium for the tax agency.

[13] The referee has pointed out that this is a rather high penalty rate. We have chosen it because when the penalty rate is reduced (we have experimented with setting it as low as .5) the amount of pooling rises somewhat, leading to results that we believe are less instructive of some of the more interesting and intricate features of the model. Other than the increase in pooling, the qualitative results we report are not sensitive to variations in the penalty rate.

[14] See McDonald (1984) for a general discussion of alternative functional forms for income distribution curves, including the generalized beta family. Note, however, that our chosen density function describes the distribution of income within an audit class; therefore, it is not directly comparable to standard empirical estimates of income distribution curves for entire populations.

FIGURE 1

AUDIT PROBABILITY FUNCTIONS FOR VARIOUS Q VALUES



[20, 44] (measured in thousands of dollars), which includes 81% of the area under the lognormal curve (we normalize the density function by dividing it by .81 wherever it is used). This truncated probability density function provides for a mean income level of 30.7. For several simulations we use either a different lognormal density function or a uniform density function; we describe these other functions below as they are used.

Figure 1 displays the audit functions associated with (1) the revenue-preferred partially pooling solution to the model of Section 3 ($Q = 0$ in this model); (2) the honest/dishonest model with $Q = .2$; and (3) the honest/dishonest model with $Q = .5$. In each of these cases income is distributed according to the truncated lognormal density function described above. The results indicate that low-income reports tend to be associated with relatively high audit probabilities. In the honest/dishonest model, for a fixed audit schedule a greater number of low-income reports are filed when the fraction of honest taxpayers is small than when the fraction of honest taxpayers is large. As a consequence, the expected audit cost associated with a given audit schedule is a decreasing function of the fraction of honest taxpayers. Because the audit budget is fixed in our simulations, the audit schedule for the case $Q = .5$ lies above the audit schedule for the case $Q = .2$ in Figure 1.

The audit functions in Figure 1 feature the concave shape characterized by Reinganum and Wilde, which has become standard in the tax compliance game literature. Initially, we believed that this concave shape must always characterize the audit function for the honest/dishonest model as well. This notion is incorrect, however. We find that when the true income range becomes sufficiently wide, for example when income is distributed according to a truncated lognormal density function with the same μ and σ values as before but with range [20, 90] (hence, less truncation—it now includes 92.2% of the area under the lognormal curve), the audit function is characterized by a point-of-inflection followed by a convex upper tail. It is intuitively pleasing that the audit function is characterized by a convex asymptote when the true income range is sufficiently wide, because it implies that even very wealthy taxpayers face a small and slowly diminishing probability of audit as they report more on their return.

FIGURE 2

TAX EVASION BY INCOME LEVEL

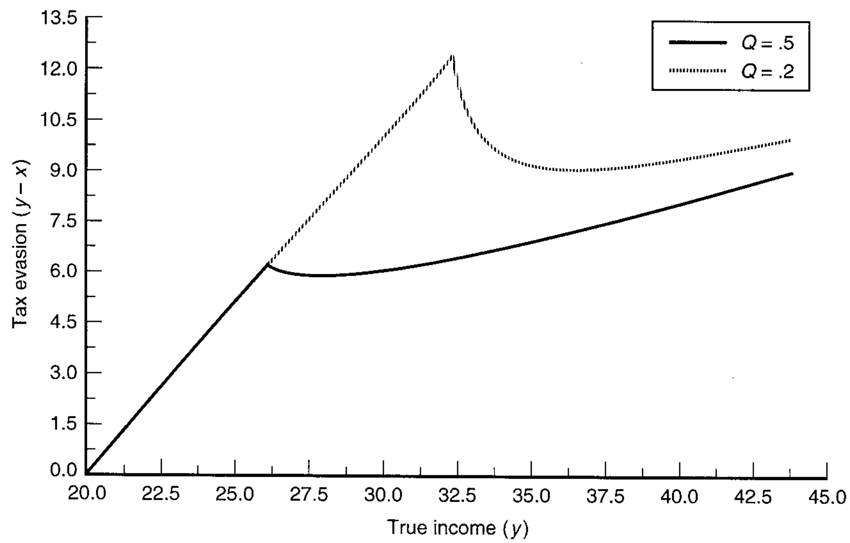
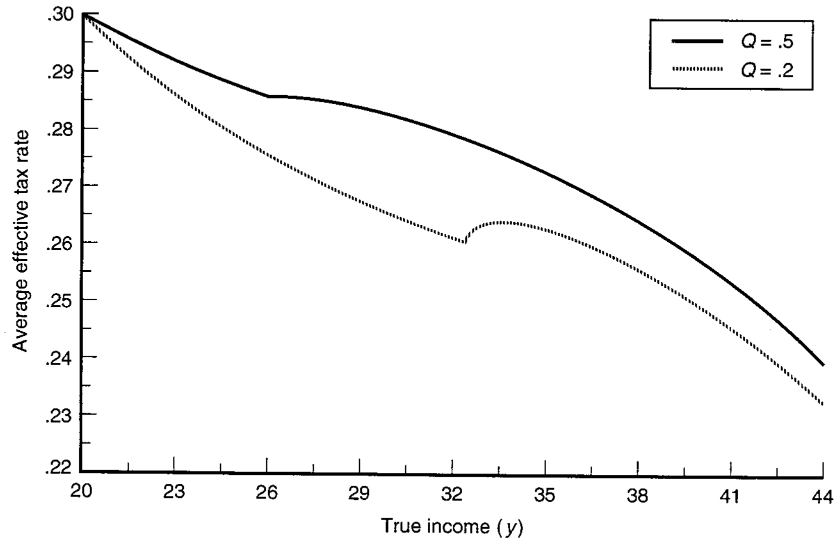


Figure 2 is a graph of true income, y, against the amount of evasion, $(y - x)$, again for the truncated lognormal density function described initially (with range [20, 44]), for the two cases $Q = .2$ and $Q = .5$. In both cases, amongst those taxpayers who pool their reports at the lower boundary of this distribution, evasion is a linear function of income. For the remaining taxpayers the level of evasion varies in a nonlinear fashion with the level of income reported. Figure 2 also indicates that the fraction of dishonest taxpayers pooling their reports at the lower edge of the income distribution is larger when $Q = .2$ than when $Q = .5$.

We mentioned above that $\frac{dy}{dx}$ need not be constant in the honest/dishonest model. A good example of how $\frac{dy}{dx}$ can vary is provided by exploring its behavior when income is distributed according to the truncated lognormal distribution with range [20, 44] introduced above, and Q is set equal to .2. In this case, $\frac{dy}{dx}$ is undefined throughout the lower range of the true income distribution, reflecting the pooling of reports that occurs over this range. Just above this range, at a true income level of 32.4, the value of $\frac{dy}{dx}$ is .17. Its value then rises sharply, crossing the value one at true income level 36.4, flattening out, and remaining above one (asymptoting to approximately the value 1.2) throughout the upper tail of the income distribution. Hence, for this distribution, evasion is increasing in income throughout the upper tail, a result that seems consistent with empirical facts. This result for the lognormal income distribution may be contrasted to the behavior of $\frac{dy}{dx}$ when income is distributed uniformly over the support [20, 41.4] (implying a mean income level of 30.7, the same as the mean of the truncated lognormal density function). In this case, $\frac{dy}{dx}$ is equal to .25 at the beginning of the income range (at true income level 32.5) above

FIGURE 3

AVERAGE EFFECTIVE TAX RATE FOR DISHONEST TAXPAYERS BY INCOME LEVEL



NOTE: Tax rate is inclusive of penalty payments.

the pooling point. Its value rises somewhat less sharply than in the lognormal case, flattens out, and remains below one throughout the upper part of the income distribution curve, implying that in this case evasion is nonincreasing in income. The comparison of these two cases illustrates how differently shaped income distributions translate into different patterns of evasion over the income range.

An important policy issue that arises in the analysis of tax compliance is how evasion affects equity in terms of the distribution of tax burden. In Figure 3 we illustrate simulation results concerning how tax burden varies with true income for dishonest taxpayers. The graph is based on the truncated lognormal income density function for the cases $Q = .2$ and $Q = .5$. For this purpose, burden is defined as the ratio of total expected taxes and penalties to true income; in other words, it is the average effective combined tax and penalty rate. By this measure the burden for honest taxpayers is always equal to the statutory tax rate of .3. In our simulations the tax and penalty system is effectively regressive for dishonest taxpayers over most income levels.[15] With the exception of the dishonest taxpayers at the very bottom of the true income distribution, dishonest taxpayers bear a lower-expected burden than honest taxpayers in our model. Of course, those dishonest taxpayers who experience audits bear a higher *ex post* burden than both honest taxpayers and dishonest taxpayers who escape detection. In practice, the effective progressivity of the tax and penalty system within and between audit classes is an empirical issue. The results for our model suggest that it will depend on such factors as the shape of the income distribution, the fraction of honest taxpayers, the statutory tax and penalty schedules, audit costs, and the audit budget. Our results also indicate that the tax burden for honest taxpayers can be substantially higher than the expected burden for dishonest taxpayers if audit costs are high or if the tax agency is sufficiently budget constrained.

To conclude our simulation analysis, we examine how expected net revenue and the shadow price of additional audit resources vary with Q (recall that the budget constraint limits the audit rate to 10% of all returns filed) using the truncated lognormal income

[15] Scotchmer (1987) makes a similar point; she also discusses how auditing policies affect the level of tax progressivity across audit classes.

density function. We find that Q affects these two variables very differently. On the one hand, changes in Q have a relatively modest impact on the maximum revenue the tax agency can collect with a fixed audit budget: increasing Q from .1 to .6 increases expected net revenue by less than 11%. On the other hand, increasing Q results in a dramatic reduction in the marginal expected benefit of additional audit resources: when Q is increased from .1 to .6, λ falls to less than one-third of its original value, from 28.8 to 8.9. (Although these shadow prices are quite high, it is important to remember that the possibilities of increasing administrative costs, imperfect evasion detection, and deadweight costs from auditing have not been taken into account.) This dramatic decline in λ has two causes. First, holding the audit probability schedule constant, an increase in Q raises the relative probability that an honest taxpayer will be selected for audit, which reduces marginal expected net audit revenue. Second, recall from Figure 1 that for a fixed audit budget, the audit schedule shifts upward with increases in Q. In response to this shift in the audit schedule, dishonest taxpayers will choose to cheat by smaller amounts, causing a further decline in marginal expected net audit revenue. Overall, these findings suggest that direct revenue gains achieved through policies designed to promote voluntary compliance (i.e., increase Q) may be offset to a substantial extent by a decline in enforcement yield.

5. Conclusion; thoughts about the endogeneity of honesty

■ Our purpose in this article has been to show how incorporating honest taxpayers into the tax compliance game substantially alters the equilibrium solution of the game and improves its fit with empirical facts. We hope that our research will help to move the theoretical literature on tax compliance closer to meaningful empirical implementation and policy formulation. We also hope that the model of honest and dishonest taxpayers that we have proposed will help to bridge the gap between the economic literature on tax compliance and the sociology and psychology literatures on this subject. Towards this end, we conclude our article with a few comments on an issue that naturally emerges from our model and which serves as a good example of how these different literatures overlap: namely, the "endogeneity of honesty" or, in other words, the social, psychological, and moral forces that induce individuals to pay their taxes in full.

Of the many different factors that may affect the decision to report honestly, we will briefly discuss two. One factor is taxpayer perceptions about the fairness of the tax system. It is useful to distinguish amongst two different kinds of perceptions. First, there are perceptions about the fairness of the tax code itself and about whether it allocates tax burdens equitably amongst different social groups, such as rich and poor or old and young. Second, there are perceptions about whether others are able to "play the system" better than oneself, either through illicit evasion or legal avoidance, thereby reducing their relative tax burdens. We believe that perceptions of fairness may have especially interesting implications for situations in which taxpayers evaluate the behavior of wealthy individuals, or individuals wealthier than themselves, differently from how they evaluate the behavior of poor individuals, or those poorer than themselves. A final issue is how taxpayers form their perceptions of the reporting behavior of other taxpayers; we suspect that they rely on a variety of sources, including aggregate statistics, reference group comparisons, and the media.

The second factor affecting honest reporting that we wish to consider is taxpayer reactions to government activities, policies, and personnel. We suggest distinguishing between two levels of interaction. On one level are broad government policies and ideologies. A famous example of how disapproval of a government policy may trigger noncompliance is provided by the story of Henry David Thoreau, who in 1837 refused to pay his taxes to the federal government as a protest against its unwillingness to combat slavery more actively; he spent one night in jail. Recent experimental work by Alm, Jackson, and

McKee (1990) provides evidence that tax compliance tends to be higher when taxpayers are aware of a direct link between their tax payments and the provision of a desirable public good. The other level of interaction between taxpayers and the government lies in the realm of personal interactions with tax agency employees. Considerable sociologic evidence suggests that taxpayers are more likely to report honestly if they feel that they are being treated courteously and respectfully by the tax agency.[16] Consistent with this perspective, Frey (1992) argues that tight monitoring and heavy punishment of noncompliant citizens can crowd out tax morale and ultimately result in greater noncompliance.

Although our discussion of the roots of honest reporting behavior has been brief, we believe that it points the way to broader and more interesting models of compliance behavior. For further consideration of these and other issues, refer to the models presented in Cowell (1990) and the historically oriented discussion in Levi (1988).

Appendix

■ When taxpayer utility exhibits constant relative risk aversion, the taxpayer chooses x to maximize

$$p(x)[y - ty - \theta(y - x)]^{\alpha} + (1 - p(x))[y - tx]^{\alpha}, \tag{A1}$$

leading to the first-order condition

$$p'(x)[(y - ty - \theta(y - x))^{\alpha} - (y - tx)^{\alpha}] + \alpha\theta p(x)[y - ty - \theta(y - x)]^{(\alpha-1)} - t\alpha(1 - p(x))[y - tx]^{(\alpha-1)} = 0. \tag{A2}$$

The taxpayer's second-order condition in this case is

$$A_1 + A_2 + A_3 \leq 0, \tag{A3}$$

where

$$A_1 = p''(x)(T_1^{\alpha} - T_2^{\alpha})$$

$$A_2 = p'(x)(2\alpha\theta T_1^{\alpha-1} + 2\alpha t T_2^{\alpha-1})$$

$$A_3 = \alpha(\alpha - 1)[p(x)\theta^2 T_1^{\alpha-2} + (1 - p(x))t^2 T_2^{\alpha-2}]$$

and

$$T_1 = y - ty - \theta(y - x)$$

$$T_2 = y - tx.$$

Also, we can compute $\frac{dy}{dx}$ in this case to be

$$\frac{dy}{dx} = -\frac{A_1 + A_2 + A_3}{A_4}, \tag{A4}$$

where

$$A_4 = \alpha(\alpha - 1)[p(x)\theta(1 - t - \theta)T_1^{\alpha-2} - (1 - p(x))tT_2^{\alpha-2}] + \alpha p'(x)(T_1^{\alpha-1}(1 - t - \theta) - T_2^{\alpha-1}).$$

When all taxpayers are dishonest, the differential equation that characterizes the solution over the range for which the equilibrium is fully separating is derived by substituting the expression for y from equation (6) (recall that $E(y \mid x) = y$ for this case, because only a single taxpayer-income type reports at x) into the first-order condition, equation (A2), with the following result:

$$p'(x)\left[\left(x(1 - t) + \lambda c\left(\frac{1}{\theta + t} - 1\right)\right)^{\alpha} - \left(x(1 - t) + \frac{\lambda c}{\theta + t}\right)^{\alpha}\right] + \alpha\theta p(x)\left[x(1 - t) + \lambda c\left(\frac{1}{\theta + t} - 1\right)\right]^{\alpha-1} - t\alpha(1 - p(x))\left[x(1 - t) + \frac{\lambda c}{\theta + t}\right]^{\alpha-1} = 0. \tag{A5}$$

[16] Tittle (1980) provides a summary of this evidence. In addition, Erard (1992) provides a discussion of this issue in the context of how the tax agency's treatment of taxpayers during audits may influence their subsequent reporting behavior.

When the model includes both honest and dishonest taxpayers, the solution involves a more complicated process. Note that $\frac{dy}{dx}$ involves $p''(x)$, as discussed in the main text. The solution of the model now involves working simultaneously with two equations: first, equation (7), which provides an implicit equation in $p''(x)$, as a function of $p(x)$, $p'(x)$, and $y(x)$; and secondly, the taxpayer's first-order condition, (A2), which implicitly defines $y(x)$ in terms of x, $p(x)$, and $p'(x)$.

References

ALEXANDER, C. AND FEINSTEIN, J.S. "A Microeconometric Analysis of Income Tax Evasion." Mimeo, MIT, 1987.

ALLINGHAM, M.G. AND SANDMO, A. "Income Tax Evasion: A Theoretical Analysis." *Journal of Public Economics*, Vol. 1 (1972), pp. 323–338.

ALM, J., JACKSON, B.R., AND MCKEE, M. "Alternative Government Approaches for Increasing Tax Compliance." Mimeo, Department of Economics, University of Colorado, Boulder, 1990.

———, MCCLELLAND, G.H., AND SCHULZE, W.D. "Why Do People Pay Taxes?" *Journal of Public Economics*, Vol. 48 (1992), pp. 21–38.

COWELL, F.A. *Cheating the Government: The Economics of Evasion*. Cambridge: MIT Press, 1990.

ERARD, B. "The Influence of Tax Audits on Reporting Behavior." In J. Slemrod, ed., *Why People Pay Taxes: Tax Compliance and Enforcement*. Ann Arbor: University of Michigan Press, 1992.

FEINSTEIN, J.S. "An Econometric Analysis of Income Tax Evasion and Its Detection." *RAND Journal of Economics*, Vol. 22 (1991), pp. 14–35.

FREY, B.S. "Tertium Datur: Pricing, Regulating and Intrinsic Motivation." *Kyklos*, Vol. 45 (1992), pp. 161–184.

GRAETZ, M.J., REINGANUM, J.F., AND WILDE, L.L. "The Tax Compliance Game: Toward an Interactive Theory of Law Enforcement." *Journal of Law, Economics, and Organization*, Vol. 2 (1986), pp. 1–32.

Internal Revenue Service. *Evaluation of the IRS System of Projecting Enforcement Revenue*. IRS Publication 1501, 1989.

JOHNSON, N.L. AND KOTZ, S. *Distributions in Statistics: Continuous Multivariate Distributions*. New York: Wiley, 1972.

LEVI, M. *Of Rule and Revenue*. Berkeley, Calif.: University of California Press, 1988.

MCDONALD, J.B. "Some Generalized Functions for the Size Distribution of Income." *Econometrica*, Vol. 52 (1984), pp. 647–663.

MELUMAD, N.D. AND MOOKHERJEE, D. "Delegation as Commitment: The Case of Income Tax Audits." *RAND Journal of Economics*, Vol. 20 (1989), pp. 139–163.

MOOKHERJEE, D. AND PNG, I. "Optimal Auditing, Insurance, and Redistribution." *Quarterly Journal of Economics*, Vol. 104 (1989), pp. 399–415.

REINGANUM, J.F. AND WILDE, L.L. "Income Tax Compliance in a Principal-Agent Framework." *Journal of Public Economics*, Vol. 26 (1985), pp. 1–18.

——— and ———. "Equilibrium Verification and Reporting Policies in a Model of Tax Compliance." *International Economic Review*, Vol. 27 (1986a), pp. 739–760.

——— and ———. "Settlement, Litigation, and the Allocation of Litigation Costs." *RAND Journal of Economics*, Vol. 17 (1986b), pp. 557–566.

ROTH, J.A., SCHOLZ, J.T., AND WITTE, A.D., eds. *Taxpayer Compliance: An Agenda for Research*. Philadelphia: University of Pennsylvania Press, 1989.

SÁNCHEZ, I. AND SOBEL, J. "Hierarchical Design and Enforcement of Income Tax Policies." *Journal of Public Economics*, Vol. 50 (1993), pp. 345–369.

SCHWARTZ, R.D. AND ORLEANS, S. "On Legal Sanctions." *University of Chicago Law Review*, Vol. 34 (1967), pp. 282–300.

SCOTCHMER, S. "Audit Classes and Tax Enforcement Policy." *American Economic Review*, Vol. 77 (1987), pp. 229–233.

SHEFFRIN, S.M. AND TRIEST, R.K. "Can Brute Deterrence Backfire? Perceptions and Attitudes in Taxpayer Compliance." In J. Slemrod, ed., *Why People Pay Taxes: Tax Compliance and Enforcement*. Ann Arbor: University of Michigan Press, 1992.

SMITH, K.W. AND STALANS, L.J. "Encouraging Tax Compliance with Positive Incentives: A Conceptual Framework and Research Direction." *Law and Policy*, Vol. 13 (1991), pp. 35–53.

SPICER, M.W. AND LUNDSTEDT, S.B. "Understanding Tax Evasion." *Public Finance*, Vol. 31 (1976), pp. 295–305.

SRINIVASAN, T.N. "Tax Evasion: A Model." *Journal of Public Economics*, Vol. 2 (1973), pp. 339–346.

TITTLE, C.R. *Sanctions and Social Deviance: The Question of Deterrence*. New York: Praeger, 1980.