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Audit selection and income tax underreporting in the tax compliance game*

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This paper uses a game-theoretic model of the tax compliance game to estimate a model of audit selection and income tax underreporting in Jamaica. The empirical analysis makes use of audited tax returns for individual taxpayers, and a random sample of tax returns for the population from which the audited returns are selected. The estimation results strongly indicate a nonrandom audit strategy, and thus provide support for the game-theoretic approach. The results also indicate that the probability of underreporting and the level of underreporting are positively related to the marginal tax rate and to income, and negatively related to marginal payroll tax benefits; in general, the underreporting elasticities are small.

1. Introduction

Perhaps the most common of all economic crimes is tax evasion, and the analysis of tax compliance has grown enormously in the last two decades.[1] However, this analysis has only recently begun to recognize a central – and

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[1]See Cowell (1990) for a comprehensive survey of much of this literature.

obvious – feature of the compliance process that is present in the tax systems of most countries: the government agency does not select tax returns randomly for audit but instead uses information from the returns to determine strategically whom to audit. While theoretical analysis has begun to incorporate the interactive aspects of the tax compliance game [Reinganum and Wilde (1985, 1986), Graetz et al. (1986), Erard and Feinstein (1992), Cronshaw and Alm (1992)], empirical work that applies this framework has been limited, primarily by the absence of information on individual compliance choices. Dubin and Wilde (1988), Dubin et al. (1990), and Beron et al. (1992) have estimated models in which individual and agency interactions are considered, but they are forced to use aggregate data supplied by the United States Internal Revenue Service (IRS).[2]

The use of aggregate data has several troubling and unavoidable implications. Most obviously, it has not generally been possible to estimate the specific factors (if any) that determine the selection on an *individual* tax return for audit.[3] Of perhaps more importance, it has not been possible to estimate the *individual* responses to changes in variables like income and marginal tax rates in a framework that accurately captures the interactive tax system that individuals actually face. Given the fundamentally covert nature of compliance, overcoming these problems is a formidable task.

There are, however, sources of information from countries other than the United States, sources that have not been fully utilized in the analysis of tax compliance. In particular, data from developing countries has seldom been used in compliance research.[4] The purpose of this paper is to use data from Jamaica to estimate the determinants of individual audit selection and individual tax evasion behavior in a way that treats the tax agency and the taxpayer as strategic players in the compliance game.

This estimation is made possible by the existence of two unique microlevel data sets for Jamaican taxpayers, generated as part of a comprehensive tax

[2]Dubin et al. (1990) use information on reported tax liabilities by state from the IRS. Dubin and Wilde (1988) and Beron et al. (1992) use data from the Taxpayer Compliance Measurement Program (TCMP) of the IRS. The TCMP consists of detailed line-by-line audits of a stratified random sample of roughly fifty thousand individual income tax returns conducted on a three-year cycle, so that each return has information on the income and tax liabilities reported by the taxpayer and an IRS estimate of the 'true' income and tax liability. Until recently the IRS has made these data available to researchers only in aggregate (or three-digit zip code level) form and only for the year 1969. There is now some work that uses more recent individual data [Feinstein (1991), Erard (1992)].

[3]Note, however, that Dubin and Wilde (1988), Dubin et al. (1990) and Beron et al. (1992) are able to test for the endogeneity of audit rates in their aggregate data and so are able to test for the presence of an endogenous agency. They generally find that the audit rate is endogenous, which is consistent with an agency that forms an enforcement strategy based on information provided by the taxpayer. Also, Erard (1992) allows for the endogeneity of audit selection.

[4]See Bird (1992) for a discussion of tax compliance and administration in developing countries.

reform study that had the full cooperation of the Government of Jamaica.[5] The first data set has direct, independently derived estimates of individual income tax evasion based upon audited income tax returns for self-employed Jamaican taxpayers for the period 1980 to 1982; this data set represents virtually all returns audited during this period. The second data set has detailed individual information from the tax returns of randomly selected self-employed individuals in the population from which the audited returns are selected. These data sets make it possible to estimate for the first time the factors that determine both the selection of an individual tax return for audit and the amount of underreporting on that return. They therefore allow an empirical test of tax compliance as a sequential move game between the tax agency and the taxpayer. They also allow consistent estimation of the behavioral responses of individuals to policy innovations.

A three-stage estimation procedure is used, which applies the Heckman (1979) self-selectivity process and which allows for strategic behavior by taxpayers and by the Jamaica Income Tax Department (ITD).[6] In the initial two stages, bivariate probit analysis is applied to the pooled data sets to estimate the factors that determine the ITD's selection of returns that are to be audited and the factors that determine the likelihood of noncompliance. Factors that determine the first-stage audit selection include items that the taxpayer reports on the return, as well as information capturing the resource capacity of the ITD. The first component of the bivariate probit analysis controls for and identifies the audit selection criterion; this first-stage estimation therefore makes explicit the systematic selection of tax returns by the audit agency. The second component of the bivariate probit analysis is applied only to the audited returns, in order to analyze the factors that determine whether or not the individual is noncompliant in terms of underreported taxes or underreported income; these factors in the second-stage probit estimation include income, the marginal tax rate, the benefits to which payroll contributions entitle the taxpayer, and various socioeconomic variables. In the third stage, linear regressions are estimated using both the level of income and the level of tax underreporting as dependent variables. Explanatory variables include those from the second component of the bivariate probit estimation, as well as selectivity bias controls derived from both stages of the bivariate probit model in order to control for nonrandom selection. The three-stage procedure therefore allows estimation of the major factors that determine individual compliance behavior in a way that recognizes the possible endogeneity of ITD behavior. The results also provide

[5]The tax reform project was called the Jamaica Tax Structure Examination Project. For a discussion of the project, see Bahl (1991) and Gillis (1989); Gillis (1989) also discusses other recent tax reforms.

[6]Note also that several alternative estimation methods are used in order to examine the robustness of the results. These alternative methods are discussed in more detail later.

evidence on the empirical relevance of the sequential equilibrium model of the tax compliance game.

The empirical results provide strong support for the relevance of the game-theoretic approach to tax compliance. The first-stage results clearly support the systematic nature of the tax agency's behavior, as illustrated by a variety of reported items that influence the probability of an audit. The second- and third-stage results demonstrate that economic factors play a large role in the individual's compliance decision. In general, the probability and the level of underreporting are positively related to the marginal tax rate and income and negatively related to marginal payroll tax benefits, although the responses are often small (except for higher income taxpayers); socioeconomic variables also affect noncompliance. The impact of a recent major reform of the Jamaican income tax is also simulated using the empirical results.

Section 2 discusses the structure of the Jamaica individual income tax. Section 3 specifies the models of tax evasion that are estimated, as well as the data and estimation techniques that are employed. The estimation results and the simulation of tax reform are presented in section 4. Summary and conclusions are provided in section 5.

2. The Jamaica individual income tax

The individual income tax in Jamaica is similar to that in many other countries, and, like the experience of countries elsewhere, the tax is a productive – and unpopular – source of government revenue. Dissatisfaction with the income tax, as well as with other components of the tax system, led the Government of Jamaica to institute a comprehensive reform of the entire Jamaican tax system in early 1986. Reform meant the replacement of the existing tax with a simpler, flat-rate tax on an expanded definition of income. The data in this paper are based on the tax system as it existed from 1980 through 1982, and were obtained with the cooperation of the Government of Jamaica as part of the tax reform project. The discussion of the income tax is based upon the previous, not the reformed, system.

Revenues from the individual income tax (in Jamaican dollars) were J$442.1 million in fiscal year 1983/84, or 28.8 percent of total government revenues.[7] Nearly all of these revenues (over 93 percent) were derived by employer withholding of employee taxes on wages and salaries under the Pay-As-You-Earn (PAYE) system. In principle, the PAYE system is designed so that at year's end taxes withheld by the employer will exactly equal the taxpayer's true tax liability. If a discrepancy does result, the wage earner is required to file a tax return to correct the (positive or negative) difference. An individual with income from other sources (such as rent, interest,

[7]At that time the exchange rate between Jamaican and U.S. dollars was 3.94.

Table 1

Rate structures of the individual income and the payroll tax systems.

Individual income tax

Income level	Marginal tax rate
J$0–7,000	30 percent
7,001–10,000	40 percent
10,001–12,000	45 percent
12,001–14,000	50 percent
J$14,001 and over	57.5 percent

Payroll taxes

Program	Self-employed worker	PAYE worker: Employee share	PAYE worker: Employer share
Education tax	1 percent of income No ceiling	1 percent of income No ceiling	1 percent of income No ceiling
HEART[c]	NA[d]	NA[d]	3 percent of income No ceiling[a]
NHT[c]	3 percent of income No ceiling	2 percent of income No ceiling	3 percent of income No ceiling
NIS[c]	J$0.30/week plus 5 percent of income on income between J$12–150/week	J$0.15/week plus 2.5 percent of income on income between J$12–150/week	J$0.25/week plus 2.5 percent of income on income between J$12–150/week
CSFBS[c]	NA[d]	4 percent of income No ceiling[b]	NA[d]

[a]The employer's payroll must exceed J$7,222 per month; the tax bill is reduced by the amounts paid to HEART trainees (J$2,600 for a full-time trainee); and government agencies are exempt.

[b]Only central government employees in pensionable offices are eligible to participate.

[c]Human Employment and Resource Training (HEART); National Housing Trust (NHT); National Insurance Scheme (NIS); and Civil Service Family Benefits Scheme (CSFBS).

[d]NA: Not applicable.

dividends, or self-employment) must also file a return on which taxes on these sources of income are paid. This second group is called the self-employed.

The rate structure of the income tax prior to the reform was both high and steeply progressive (see table 1). The marginal tax rates rose rapidly, from 30 percent on the first J$7,000 of statutory income to 57.5 percent on income above J$14,000. These rates were applicable to both PAYE and self-employed workers. An individual's income tax liability under the old system could be reduced to zero by the application of up to 16 tax credits, ranging from personal and children allowances to allowances for alimony and medical expenses. These credits reduced tax revenues by roughly the amount of revenues actually collected.

The income tax is not the only tax on earnings. There are also five different payroll taxes that are imposed on much the same base as the income tax. Two of these taxes – the National Insurance Scheme (NIS) and the National Housing Trust (NHT) – are more properly viewed as contributions, since individuals are entitled to social insurance (NIS) and housing (NHT) benefits whose size varies with the amount of contributions. Another program is the Education Tax, which is an employer- and employee-paid surcharge on the income tax. All individuals face these taxes. PAYE employees also face one of two additional taxes depending upon their sector of employment. The first is the Civil Service Family Benefits Scheme (CSFBS), a mandatory insurance and pension contribution program for those employed in the public sector. The second is the Human Employment and Resource Training (HEART) Trust Fund, which is a training and employment program financed by taxes on private-sector firms with monthly wage payments in excess of J$7,222.

Examined in their entirety, these payroll programs constitute a significant additional burden on Jamaican taxpayers (see table 1). Total revenues from all payroll programs are substantial, amounting to roughly 50 percent of revenues from the income tax.

The income and payroll tax systems in combination therefore created a large incentive to underreport income or taxes. The marginal tax rate faced by some taxpayers could reach nearly 70 percent, and was never less than 35.5 percent. However, it is important to note that the payroll tax programs have potentially offsetting effects on the incentive to evade. On the one hand, they increase the cost of compliance because they increase the tax burden on reported earnings. On the other hand, some of the payroll programs generate benefits that increse with the amount of reported income and contributions; these benefits stem from the housing, insurance, and pension features of the NHT, CSFBS, and NIS. The benefits to which reported income entitles the contributor have typically been ignored in theoretical and empirical work on tax compliance. An important feature of the specification of both the theoretical and the empirical models is the recognition that these benefits in fact exist and alter the incentive to evade income.

3. Methodology: Theory, specification and data

3.1. Theoretical specification

The theoretical model of audit agency and taxpayer interaction is based upon the actual income reporting and filing process for those who file tax returns in Jamaica, a process that is like that in other countries. The sequence of moves is as follows. The Jamaican taxpayer first observes his true income, and files a return with reported income, credit, and tax information. The Income Tax Department of the Government of Jamaica then decides whom to audit on the basis of the items reported on the return, in order to maximize its expected revenues and subject to a budget constraint; that is, the ITD determines its actions after the returns have been filed. In equilibrium, both the taxpayer and the agency must behave optimally, given the response of the other.[8] The model therefore requires specification of individual and agency behavior.

Consider first the behavior of the taxpayer who must choose how to allocate a fixed endowment of true income Y between declared income D and unreported, or evaded, income E, given the unknown audit selection rule of the tax agency. The taxpayer pays income and payroll taxes on declared income at the rate t; in addition, he or she receives benefits on declared income from various payroll programs at the rate b. The individual does not pay any income and payroll taxes (and thus receives no benefits) on evaded income E. However, if the individual is audited by the agency and found to be underreporting income, then he or she must pay a fine on evaded income taxes at the rate f. The income of the individual who is caught underreporting income with probability p is therefore $Y_C \equiv D+E-tD+bD-ftE=Y(1-t+b)-E(ft-t+b)$, while the income if he or she is not caught with probability $(1-p)$ is $Y_N \equiv D+E-tD+bD=Y(1-t+b)+E(t-b)$, where $D+E=Y$. The parameters t, b, and f are assumed for the moment to be fixed for the individual.[9] Recall that the probability p depends in part upon the items reported by the taxpayer.

The taxpayer is assumed to choose E so as to maximize an expected utility function $\mathscr{E}U(Y)$ that depends upon income in the two states of the world, or $\mathscr{E}U(Y)=pU(Y_C)+(1-p)U(Y_N)$, where $\mathscr{E}$ is the expectation operator. The first-order condition for an interior solution requires that the expected marginal utilities of income in the two states of the world, weighted by the tax, benefit, and penalty rates in the respective states, must be equated; given concavity of the utility function, the second-order condition is satisfied.[10] It is easy to demonstrate that an (exogenous) increase in the probability of

[8]See Reinganum and Wilde (1986) for a detailed discussion of this sequential move game, as well as an analysis of its workings. Erard and Feinstein (1992) extend this model to allow both for a budget-constrained tax agency and for the existence of taxpayers who always report their true income.

[9]Note that taxes and benefits are assumed to be imposed and accrued at the constant rates t and b. This is done primarily for convenience. In the Jamaican tax system – as is the case for most countries – these are more accurately seen as tax and benefit functions. The empirical specification of the model fully reflects the fact that t and b are imposed at nonlinear rates.

[10]The first-order condition can be rearranged to give

$$pU'(Y_C)[ft-t+b]=(1-p)U'(Y_N)[t-b],$$

and the second-order condition is

$$pU''(Y_C)[ft-t+b]^2+(1-p)U''(Y_N)[t-b]^2<0.$$

Note that p is assumed to be a constant in arriving at these conditions, since the taxpayer has no knowledge of the actual audit selection rule.

detection and an increase in the fine on evaded income will decrease evaded income; however, the effects of changes in the tax rate, the benefit rate, and income are ambiguous and depend upon the individual's attitude towards risk.[11]

This framework suggests that the demand for evaded income E can be written as a function of income, the (combined) income and payroll tax rate, the benefit rate, the fine rate, and the probability of detection:

$$E = E(Y, t, b, f, p). \tag{1}$$

Remember, however, that the probability of detection is not a fixed parameter but instead depends in part on items reported by the individual on the tax return.

Note that an alternative specification of the individual's choice problem, attributable to Christiansen (1980), views the individual as selecting the amount of evaded taxes, rather than the amount of evaded income. In terms of the above model, the individual now chooses G, where $G \equiv tE$. This alternative specification suggests that there is a demand for evaded taxes

$$G = G(Y, t, b, f, p), \tag{1'}$$

in which the determinants are the same as for evaded taxes.

Consider next the behavior of the revenue agency. Following Reinganum and Wilde (1986) and Erard and Feinstein (1992), the tax agency is assumed to select an enforcement strategy in order to maximize expected tax and penalty revenues net of audit costs and subject to a limited audit budget.[12] Based on the items reported by the taxpayers on their tax returns and the agency's conjectures about the impact of the reported items on the expected tax dollars to be collected in any audit, the agency establishes an audit selection rule. It is assumed that this selection rule can be represented by an index of expected audit productivity (inclusive of penalties and net of audit costs) for each individual i, which depends upon the taxpayer's return declarations and the available auditing budget. The linearized version of this index can be expressed as

$$I_A^* = Z\Gamma + R\gamma + \varepsilon, \tag{2}$$

where I_A^* is the measure of expected audit productivity, the vector Γ consists

[11]See Allingham and Sandmo (1972) for the initial theoretical analysis of the taxpayer choices. Cowell (1990) surveys the subsequent theoretical literature.

[12]The net revenue assumption on agency behavior is not essential to the empirical analysis, and there are other assumptions that could easily be made. For example, Slemrod and Yitzhaki (1987) argue that the agency might choose an enforcement strategy to maximize a social welfare function. As long as the agency selects returns for audit on the basis of reported return information, the empirical specification is not affected.

of assessment weights that are applied to some subset of the individual's reported return items as contained in Z, and γ is the coefficient on audit resources R. The error term ε is assumed to be normally distributed, and is necessary because the tax agency is unable to determine audit productivity perfectly.

Based upon the values of I_A^* across all taxpayers, a determination is then made as to whether or not to audit individual i. This audit selection rule can be expressed in probabilistic terms as

$$p = p(I_A^*), \tag{3}$$

where p represents the probability of audit (with $0 \leq p \leq 1$) as some function of the subset of return information declared by individual i, the assessment weights, and the auditing resources. In general, the taxpayer is unaware of the specific way in which his return is selected; that is, the taxpayer has no specific knowledge of the intensity of agency audit efforts (R), the return items that trigger an audit (Z), and the way in which agency efforts and return items trigger an audit (γ and Γ). The tax agency is, however, well aware of the decisions of the taxpayers as reported on the tax returns, and optimally chooses its policies given these prior actions.

Eqs. (1) [or (1′)], (2), and (3) constitute a game-theoretic, sequential equilibrium model of the tax compliance game. The individual first decides how much income to report (or how much tax to pay), knowing that the items reported on the return may affect the probability of audit. The tax agency then selects the returns to be audited, using the information provided by the tax return. The outcome of this game is a compliance strategy for the individual, as well as an audit strategy for the agency. In equilibrium, these strategies must be a best response strategy for each player. Procedures for estimating this model are discussed next.

3.2. Empirical specification

There are several ways to estimate the theoretical framework presented above. One approach is suggested by the empirical work of Erard (1992), and draws on the extensive literature on estimation of models with self-selectivity. This approach gives rise to a three-equation empirical model that may be referred to as a sequential model with multiple criteria for selectivity.[13] In the first stage, the audit selection rule of the tax agency is estimated. In the second stage, the probability of individual noncompliance is estimated for those individuals who are selected for audit. In the third stage, the level of compliance is estimated for those individuals who are both

[13]See Maddala (1983) for a detailed discussion of this literature.

selected for audit and who choose to cheat. There are, of course, alternative estimation approaches. These methods are discussed at various points below.

The first equation in the self-selectivity model is the audit selection process. Contingent upon the specific selection rule, the individual return characteristics, and audit resources, a return is chosen from the population for audit if $I_A^* > 0$. The stochastic version of the linearized audit selection rule is simply eq. (3), and is rewritten here for convenience:

$$I_A^* = Z\Gamma + R\gamma + \varepsilon. \tag{4}$$

Although the index I_A^* is itself unobservable, the audit ($p=1$) and nonaudit ($p=0$) cases are observed, which gives rise to the indicator variable

$$I_A = \begin{cases} 1 & \text{iff} \quad I_A^* > 0, \\ 0 & \text{otherwise.} \end{cases} \tag{5}$$

Eq. (5) can be estimated by probit analysis.

The second-stage estimation pertains to the identification of the noncompliant, conditional upon an audit. The (detected) noncompliant individuals correspond to that subset of audited individuals for whom the expected benefits of noncompliance exceed the expected costs. Measuring the expected benefits and costs of noncompliance by the index I_N^*, the stochastic index of the net benefits of noncompliance can be written as

$$I_N^* = X\beta + \omega, \tag{6}$$

where the vector of coefficients β measures the impact of taxpayer characteristics X and ω is the error term. Like I_A^*, I_N^* is unobservable, although it is possible to identify the compliant and the noncompliant who have been subjected to audit. This gives rise to a second indicator variable

$$I_N = \begin{cases} 1 & \text{iff} \quad I_A^*, I_N^* > 0, \\ 0 & \text{otherwise,} \end{cases} \tag{7}$$

which, like eq. (5), can be estimated by probit analysis.

In the final stage, the level of noncompliance L (underreported income or underreported taxes) is observed iff $I_A^* > 0$ and $I_N^* > 0$; that is, two selection hurdles must be overcome before a nonzero level of noncompliance is observed:

$$L = X\psi + \mu, \tag{8}$$

where ψ is a vector of coefficients and μ is the error term.

Note that in the general case of a trivariate normal distribution where $\text{cov}(\varepsilon,\mu)\neq 0$, $\text{cov}(\omega,\mu)\neq 0$, and $\text{cov}(\varepsilon,\omega)\neq 0$, the conditional expectation of μ is

$$\mathscr{E}(\mu \mid I_A^*>0, I_N^*>0)=\text{cov}(\varepsilon,\mu)\frac{\phi(Z\Gamma+R\gamma)\Phi(X\beta)^*}{\Omega(Z\Gamma+R\gamma, X\beta;\rho)}$$

$$+\text{cov}(\omega,\mu)\frac{\phi(X\beta)\Phi[(Z\Gamma+R\gamma)^*]}{\Omega(Z\Gamma+R\gamma, X\beta;\rho)}, \qquad (9)$$

where

$$(X\beta)^*=\frac{X\beta-\rho(Z\Gamma+R\gamma)}{(1-\rho^2)^{1/2}},$$

$$(Z\Gamma+R\gamma)^*=\frac{(Z\Gamma+R\gamma)-\rho X\beta}{(1-\rho^2)^{1/2}},$$

and where $\Omega(\cdot)$ is the bivariate normal distribution function with correlation ρ, $\Phi(\cdot)$ is the univariate normal distribution function, and $\phi(\cdot)$ is the univariate normal density function.

The result in eq. (9) motivates a straightforward extension of the selectivity process discussed by Heckman (1979). The application here is in the spirit of the double hurdle model introduced by Cragg (1971) and generalized by Catsiapis and Robinson (1982) and Blundell and Meghir (1987); see also Lee and Maddala (1985). In the combined first and second stages, consistent estimates of $\hat{\Gamma}$, $\hat{\gamma}$ and $\hat{\beta}$ are obtained by maximum likelihood bivariate probit estimation of eqs. (5) and (7), which in turn allows construction of consistent estimates for the terms in eq. (9). In the third and final stage, linear regression is applied to eq. (8), with the two constructed variables from the bivariate probit model used to control for double selection as implied in eq. (9). As with the standard Heckman (1979) model, the final stage is potentially heteroscedastic.

It should be noted that there are other methods of estimation. For example, it is possible to use univariate probit analysis to estimate the first and second stages separately, under the assumption that the error terms of the two probit equations are independent [i.e., cov $(\varepsilon,\omega)=0$]. Also, the second and third stages could be viewed in combined form as a single Tobit process, and can be estimated with and without the selectivity control from the first-stage probit estimation. Another, and perhaps more intuitive, approach is to use the first-stage probit estimation to generate for each audited return a predicted probability of audit, and then to use this predicted probability as an additional explanatory variable in the subsequent estimation of the individual's noncompliance equations. Because of the more extensive econometric basis for the three-stage selection model, the selection approach is emphasized here, despite its potential limitations.[14] Nevertheless, the results from the alternative methods are also presented below (see footnotes 26 and 27). In general, the estimation results are quite robust across the different specifications.

3.3. Data and variable construction

Two data sets are utilized in the empirical analysis. The first consists of 148 audited tax returns for self-employed Jamaican taxpayers. This 'audit data set' represents virtually the entire population of self-employed returns subjected to intense audit by the ITD for the three-year period from 1980 to 1982, with 67 returns from 1980, 56 from 1981, and the remaining 25 from 1982.[15] All returns were chosen for line-by-line audit by the ITD on the basis of some undisclosed selection criteria. Not all of those returns audited were found to indicate noncompliance. Of the 148 returns audited, 101 were found to contain understatements of income and 110 were found to contain tax understatements.[16]

Since each tax return in the audit data set was subjected to line-by-line audit by ITD personnel, there is information on both reported and post-audit, or 'true', return items. In particular, reported and true information is provided on the type and level of income earned (wage income, income from trade or business, rental income, and dividend income). This information

[14]These potential limitations are of several types. For example, suppose that the error term in the second-stage equation is large and positive, which implies a high level of evasion and therefore a low level of reported taxes (or reported income). If the error terms in the first- and second-stages are also correlated, then the error term in the first-stage audit equation may be correlated with reported taxes (or reported income). In a nonlinear model, the remedy for this specification problem is not straightforward. Also, the effects of the audit probability on the second- and third-stage compliance equations are not explictly considered in the selection model (although it should be noted that these effects are directly estimated in several of the alternative models); again, there is no obvious solution in a nonlinear model. Finally, the selection model is estimated with limited, not full, information methods. Limited information methods are used because full information maximum likelihood (FIML) techniques are computationally burdensome; as noted by Erard (1992), it is especially difficult to estimate the cross-equation correlations. The use of FIML would also provide only efficiency gains relative to the limited information maximum likelihood methods used here. Despite these potential limitations, it is important to note that, as discussed later, the empirical results are similar across the various estimation methods.

[15]A small number of returns that were audited could not be located by ITD personnel. All available returns are included in the current analysis.

[16]Not all income underreporters were found to have understated their tax liability. Some taxpayers reported negative values of statutory income that were revised upward, but still remained negative, after audit. There were also those who correctly revealed their statutory income but misstated their tax liability either by calculating an incorrect tax liability (based on correct income) or by making inappropriate use of tax credits.

allows the construction of one measure of noncompliance: underreported income. The data also contain detailed information on individual tax credits, and the reported and corrected income tax liability for each taxpayer. The tax liability information allows the construction of a second measure of noncompliance: underreported taxes.[17]

In table 2, descriptive statistics are presented for those audited. While the average amounts of income and taxes underreported are J$5,894 and J$2,799, respectively, the averages mask considerable variation in noncompliance across income tax brackets. For example, 35 percent of those audited earn less than J$7,000 in (post-audit) income and fall into the lowest tax bracket. For these taxpayers, the average amounts of income and taxes understated are J$1,690 and J$375, respectively. For the 28 percent in the top marginal tax bracket, average underreported income amounts to J$14,413 and average underreported taxes equal J$8,089.

The second data set (the 'self-employed sample') is a 932 observation stratified random sample of nonaudited tax returns for self-employed Jamaican taxpayers for tax year 1980, which provides detailed information on the population from which the audited returns are selected. The audit and the self-employed data sets are similar in that both contain the full range of reported tax return information for the self-employed; they differ in that only the audit data contain post-audit return information. Table 3 provides summary statistics and variable definitions for the self-employed sample.

Three-stage estimation techniques are applied to these two data sets, as suggested by the self-selectivity model above. The first and second stages are estimated jointly using weighted bivariate probit analysis. In the first component of the bivariate probit model the ITD's audit selection rule [eq. (5)] is identified by combining the audit data with the self-employed data. The dependent variable is whether or not a return is selected for audit. Since the audit data comprise all audits covering the 1980 to 1982 period, the self-employed sample is weighted through the use of a replication factor so that

[17]It is important to recognize that the audit information has some of the same weaknesses identified by Clotfelter (1983) for the TCMP survey. First, it is unlikely that the ITD auditors have detected all forms of unreported income and overclaimed tax credits; even the ITD personnel acknowledge the difficulties they face with a shrinking and undertrained staff. Second, the audit sample relates only to those who file tax returns and provides no information on taxpayers who do not file returns. There is some evidence in Jamaica that nonfilers are responsible for a greater amount of evasion than filers [Alm et al. (1991)]. Third, the interpretation of the two measures of tax evasion is not entirely straightforward. An individual may underreport income (or underpay taxes) because of simple mistakes, because of what are incorrectly viewed as legal exclusions or tax credits, or because of fraud. The first two cases are 'honest' mistakes; only the third should be considered true evasion. However, it is not possible to determine the actual reason for underreporting by simply looking at the tax return information for each taxpayer. Instead, all underreporting is identified here as tax evasion; therefore, the measure of evasion used in the empirical analysis may over- or understate true evasion.

Table 2

Variable definitions and descriptive statistics for audit data (dollar amounts in Jamaican dollars).

	Continuous variables			
Variable	Definition	Mean	Maximum	Minimum
UNDERINC	Underreported income, equal to post-audit income minus reported income	J$5,894	J$75,235	J$ 0.0
UNDERTAX	Underreported taxes, equal to post-audit taxes minus reported taxes	2,799	43,257	0.0
MTR	Effective marginal income and payroll tax rate	0.433	0.615	0.0
INC	Post-audit net of tax income	8,447	41,278	−13,005
BENEFIT	Marginal payroll tax benefits	0.027	0.075	0.009
FAMSIZE	Family size as imputed from tax credit usage	3.23	10	1
RTAX	Taxes as reported by taxpayer	1,620	32,383	0.0
POST-AUDIT TAXES	Correct tax liability after audit	4,384	47,730	0.0
RINC	Income as reported by taxpayer	7,173	63,552	−27,313
POST-AUDIT INCOME	Correct income after audit	12,585	89,008	−13,005

	Discrete variables		
Variable	Definition	Frequency	Percent
RDIVDUM	Reported dividend income dummy	7	4.7
RWAGDUM	Reported wage income dummy	6	10.8
RCAPDUM	Reported self-employment income and capital allowance dummy	68	45.9
DIVDUM	Post-audit dividend income dummy	7	4.7
WAGDUM	Post-audit wage income dummy	15	10.1
CAPDUM	Post-audit self-employment income and capital allowance dummy	73	49.3
INCNON	Income underreporters	101	68.2
TAXNON	Tax underreporters	110	74.3

the combined data reflect the population of self-employed filers for this period.[18]

The specification of the first component or stage of the bivariate probit model relies largely upon taxpayer return characteristics that seem likely to influence the ITD's index of audit productivity. One variable is the taxpayer's reported tax liability (*RTAX*); alternatively, reported income (*RINC*) is

[18]The audit data have been pooled across years because of the small number of observations per year. Regressions confined to individual years exhibit a sign pattern similar to the results reported, although there are tendencies for insignificant coefficients. These results imply stability in audit selection criteria across years.

Table 3
Variable definitions and descriptive statistics for self-employed data (dollar amounts in Jamaican dollars).

	Continuous variables			
Variable	Definition	Mean	Maximum	Minimum
RINC	Income as reported by taxpayer	J$7,932	J$372,962	J$ – 162,148
RTAX	Taxes as reported by taxpayer	1,466	72,490	0.0

	Discrete variables		
Variable	Definition	Frequency	Percent
RDIVDUM	Reported dividend income dummy	216	23.2
RWAGDUM	Reported wage income dummy	212	22.7
RCAPDUM	Reported self-employment income and capital allowance dummy	280	30.0

included. In addition, two dummy variables are used to indicate the reported income source, including dividends (*RDIVDUM*) and wages subject to source withholding (*RWAGDUM*); also included is a dummy variable to reflect income or adjustments to income from self-employment (*RCAPDUM*). Since the audit selection criteria is unknown, it is difficult to speculate on the hypothesized signs for these variables. Other individual-specific factors, such as payroll tax benefits and the marginal tax rate, are not included in the first stage because it seems unlikely that ITD officials focus on these variables when selecting returns for audit. Finally, a variable is included to reflect the budget constraint and coverage capacity of the ITD auditing division in identifying the noncompliant, specified as the ratio of the ITD's budget to the population for 1980, 1981, and 1982 (*ITDRES*).[19] Note that *ITDRES* is unknown to the taxpayer.

It is important to emphasize that this component of the bivariate probit estimation allows a direct test of systematic audit agency behavior. If the taxpayer in fact faces a predetermined probability of audit, then information reported on the tax return should have no impact on the likelihood of an audit, and the explanatory variables should not be statistically significant. However, if the agency systematically selects returns for audit on the basis of reported information, then some or all of the explanatory variables should be significant. Significance would imply that the probability of audit is not fixed for the individual.

The second component or stage of the bivariate probit equation focuses on factors influencing the probability of taxpayer noncompliance, and the third-stage linear regression examines determinants of the level of noncompliance.

[19]The mean value of *ITDRES* is 31.4, and reflects a substantial increase in the ITD's budget for 1982 relative to previous years.

Due to the similarity of these behavioral processes, the explanatory variables used in the final two stages are the same, with the exception of the two selectivity terms in the third stage.

Two alternative indicators of noncompliance are used to estimate the individual's behavioral response in the second part of the bivariate probit model [eq. (7)]. The first measure indicates income noncompliance (*INCNON*) and the second indicates tax noncompliance (*TAXNON*). These variables equal 1 if noncompliance is present and detected and 0 otherwise. Two corresponding measures of noncompliance are also used as dependent variables in examining the level of noncompliance in the third stage, for those identified as noncompliant [eq. (8)]: the log of the difference between the taxpayer's reported income and the post-audit level of income (*UNDERINC*), and the log of the difference between the taxpayer's reported tax liability and the post-audit tax liability (*UNDERTAX*).[20]

All explanatory variables in the second- and third-stage estimations are based upon true, or post-audit, information. The first variable is income (*INC*), specified as post-audit, net-of-tax income. Calculation of *INC* using post-audit income and taxes ensures its exogeneity, since post-audit variables can be considered independent of the taxpayer's decisions.

The marginal tax rate (*MTR*) is specified to include both income and payroll tax rates. In addition, the use of income tax credits is taken into account in calculating the effective marginal tax rate. To the extent that a taxpayer has credits that can be applied to the income tax liability, the accrual and taxation of an additional dollar of income may not generate any additional income tax liability, and as a result the effective marginal income tax rate may be zero. Nonetheless, a positive payroll tax liability is likely to occur since tax credits cannot be applied to payroll tax obligations; as such, the payroll tax component of *MTR* will in general be positive. Post-audit income is used to determine the taxpayer's tax bracket for both the payroll and income taxes in order to ensure exogeneity.

In addition to the inclusion of payroll tax rates in the specification of

[20]The treatment of refund cases in the audit data set (or 'negative' evaders), of which there are only eight income and six tax overreporters, is somewhat complicated. Overreporters of either type are classified as compliant for the second-stage probit estimation. This approach is motivated by, and consistent with, Clotfelter (1983). In general, it is likely that different behavioral responses are at work on the part of individuals and auditors in the context of over- versus underreporting; that is, taxpayers may choose to underreport, whereas overreporting may be the result of job changes, tax code complexity, and the like. A similar asymmetry may be present on the part of auditors, who likely expend greater efforts and resources to identify noncompliance as opposed to excess compliance. The second-stage probit formally estimates and distinguishes between refund cases and noncompliant cases; in the third stage, the factors influencing noncompliance are examined. An alternative third-stage procedure could focus on overreporters, given a second-stage probit that selected the refund cases (as opposed to the noncompliant cases). Of course, the second stage could also be estimated with the refund cases excluded from the compliant cases. However, such exclusion would introduce selection bias.

MTR, a measure of marginal payroll tax benefits (*BENEFIT*) is included as a separate regressor. This variable measures the present value of payroll tax benefits that accrue from payroll taxation in the present period. Its calculation is summarized in table 4. As with the marginal tax rate, marginal payroll tax benefits are based upon true income. These benefits raise the cost of underreporting; however, they have an ambiguous theoretical effect on compliance due to their income effect.

Three dummy variables are included to reflect the accrual of different types of income that are subject to varying degrees of source withholding and cross-verification. The first dummy variable indicates the presence of wage income (*WAGDUM*). Since wage income is provided in the PAYE sector where evasion is more difficult, a negative *WAGDUM*-noncompliance relationship is hypothesized. The presence of dividend income is represented by *DIVDUM*. Since there is no source withholding of taxes on such income, a positive relationship between noncompliance and the presence of dividend income is expected. An additional income variable pertains to those individuals engaged in their own business who may incur losses, may have loss carryovers from previous years, or may have other return adjustments relating to self-employment. These features are measured by a dummy variable (*CAPDUM*) for the existence of such return characteristics. Since self-employment affords many opportunities for evasion, a positive relationship is anticipated between *CAPDUM* and underreporting.

One explanatory variable is also included to control for taxpayer heterogeneity, a family-size control variable (*FAMSIZE*) that is constructed from tax credit information. Other socioeconomic variables such as age or sex are not included because few taxpayers actually report these items and the ITD auditors make no attempt to measure them.[21]

Identification of the empirical model is established through the nonlinearity of the selection terms themselves. Recall also that some restricted versions of the model are estimated without selection terms. In these cases, the model is identified by the assumption of independence of error terms. Further, the model with no selection terms can also be identified by the use of exclusion restrictions; that is, the first-stage eq. (5) is identified by the exclusion of all true tax return variables that are included in eqs. (7) and (8), while exclusion of the ITD resource variable from the second- and third-stage estimations establishes identification of eqs. (7) and (8).

4. Empirical analysis

4.1. Estimation results

Estimation results for the first and second stages are reported in table 5

[21]The fine on evaded taxes is necessarily omitted from the second and third stages because a

Table 4

Marginal payroll tax benefit functions.

Payroll tax program	Marginal benefit function		Comments and discussion
Civil Service Family Benefits Scheme	$\sum_{i=t}^{T} \frac{0.10}{(1+r)^i}$	if reported income > \$3,000 and public sector employee	Benefits consist of a pension to surviving dependents of public sector officials. Marginal benefits per dollar of wage income equal 10 cents. Benefits are taxable by law but in practice are untaxed. The benefit and discounting periods are specified as follows: (1) taxpayer age is imputed from the Jamaica Consumer Expenditure survey on the basis of income; (2) $i=0$ is the present period; (3) taxpayer life expectancy is life expectancy at birth (lower case t represents the difference between life expectancy and imputed age); (4) spouse age is assumed to equal that of the public sector official; (5) spouse life expectancy determines T, and is assumed to be the conditional life expectancy given age; and (6) the discount rate r is 11 percent, an average of the prevailing savings and prime lending rates for 1983.
	0	otherwise	
National Housing Trust	$\frac{[(0.02)(1.03)]}{(1+r)^8}$	all taxpayers	The only quantifiable marginal benefits consist of a cash grant. The participant may claim in the eighth year of contributions the first year's contribution (2 cents per dollar) plus a 3 percent bonus. Employer contributions to the NHT are not vested with the employee. The discount rate is 11 percen .

National Insurance Scheme-Employment Injury Program	0.044 cents	if \$1,109 < reported income < \$7,800	Any disabled PAYE sector worker is entitled to benefits that equal seventy five percent of wages, payable for *one year*. Each additional dollar of wage income may generate 75 cents in future benefits. Benefits are weighted by the percentage of PAYE workers receiving employment injury awards in 1983. Single period discounting is employed.
	0	otherwise	
National Insurance Scheme-Pension Program (Old age)	$\sum_{i=t}^{T} \frac{0.01}{(1+r)^i}$	if \$624 < reported income < \$7,800	Marginal payroll tax benefits from the accrual and taxation of one dollar of reported income equal 1 cent. The difference between the retirement age (65) and the imputed age reflects the difference between when the D-E choice is made ($i=0$) and when benefits begin to be received (t). The benefit receipt period ($T-t$) is assumed to equal the difference between conditional life expectancy given age and the retirement age. The discount rate is 11 percent.
	0	otherwise	
National Insurance Scheme-Pension Program (Widows-Widowers)	$\sum_{i=t}^{T} \frac{0.005}{(1+r)^i}$	if \$624 < reported income < \$7,800	Marginal benefits equal 0.5 cents. The specification of T, t, and i is analogous to the CSFBS. Benefits are weighted by the percentage of NIS awards granted to widows and widowers in the 1982/1983 period to arrive at a measure of expected benefits. The discount rate is 11 percent.
	0	otherwise	
National Insurance Scheme-Pension Program (Invalidity)	$\sum_{i=t}^{T} \frac{0.01}{(1+r)^i}$	if \$624 < reported income < \$7,800	Marginal benefits equal 1 cent and are payable to those permanently disabled. Lower case t is assumed to equal 5; upper case T is assumed to equal life expectancy minus age plus 5. Benefits are weighted by the percentage of NIS awards attributable to the invalidity program. The discount rate is 11 percent.
	0	otherwise	

under two alternative assumptions regarding the error structure of the model and for two alternative specifications of the dependent variable of the second stage. The first and third columns give univariate probit estimates of the first and second stages of the empirical model. (Note that the first-stage univariate probit models of audit selection are necessarily identical.) These univariate results assume that the error terms of the two probit equations are independent, which implies that unobservable factors influencing the likelihood of audit are uncorrelated with unobservable factors influencing the likelihood of underreporting. In the second and fourth columns of table 5 are first- and second-stage estimates under the more general bivariate probit specification.

In general, the results are consistent across estimation techniques in terms of coefficient signs and significance patterns. The jointly estimated bivariate probit models both exhibit highly significant χ^2 statistics. The univariate probit model of audit selection and the univariate probit models of the probability of tax and income underreporting exhibit somewhat smaller, but nonetheless statistically significant χ^2 statistics. The bivariate specification yields a rather large and significant estimate of *RHO*, the correlation coefficient between the jointly estimated probits.[22] This positive point estimate indicates a high correlation between unobservable factors influencing the probability of audit and unobservable factors influencing the probability of noncompliance.[23]

The first-stage estimation results for the probability of audit are reported in the upper part of table 5. The positive and significant estimate of *RHO*, complemented by the statistical significance of the full array of explanatory variables, provides support for the game-theoretic approach to tax compliance in which there is systematic audit selection. Higher levels of reported taxes (*RTAX*) serve to increase the probability of audit, as does the presence of capital losses, loss carry-overs, and other capital allowances (*CAPDUM*).[24] The latter result indicates an auditing focus on those engaged in their own trade or business. Historical experience of the ITD may have shown this to be a profitable focus for auditing activities. The positive coefficient on the auditing resource variable (*ITDRES*) shows that greater auditing resources translate into higher audit probabilities, as might be expected.

Somewhat surprisingly, the reported receipt of dividend income

common surcharge of 50 percent is imposed on delinquent tax liabilities.

[22]Narrower specifications of the model, including a constrained version estimated with only a constant to conduct likelihood ratio tests, also yield similar point estimates of *RHO*.

[23]A similar result is found by Dubin and Wilde (1988) and Dubin et al. (1990).

[24]Estimation of the audit selection equation with reported income substituted for reported taxes yields similar conclusions, and produces a statistically significant coefficient for the income variable. Reported income and reported taxes are not included together because of a high degree of collinearity between reported taxes and reported income.

Table 5

First- and second-stage univariate and bivariate probit estimates: Audit selection and underreporting.[a]

Independent variable	Probability of audit and of income underreporting		Probability of audit and of tax underreporting	
	Univariate	Bivariate	Univariate	Bivariate
First stage audit selection				
RTAX	$1.4*10^{-5}$**	$4.9*10^{-5}$***	$1.4*10^{-5}$**	$2.0*10^{-5}$**
	$(6.0*10^{-6})$	$(1.1*10^{-5})$	$(6.0*10^{-6})$	$(8.3*10^{-6})$
RWAGDUM	−0.25**	−0.38***	−0.25**	−0.16
	(0.10)	(0.10)	(0.10)	(0.11)
RDIVDUM	−0.52***	−0.99***	−0.52***	−0.39***
	(0.13)	(0.14)	(0.13)	(0.10)
RCAPDUM	0.19***	0.31***	[illegible]9***	0.23***
	(0.06)	(0.06)	(0.06)	(0.06)
ITDRES	0.06***	0.02***	0.06*	0.04**
	(0.01)	$(2.0*10^{-3})$	(0.01)	(0.02)
Constant	−2.69***	−2.64***	−2.69***	−2.94***
	(0.05)	(0.05)	(0.05)	(0.06)
Second stage noncompliance				
MTR	1.79*	1.46***	3.80***	1.11***
	(0.94)	(0.19)	(1.19)	(0.34)
INC	$3.4*10^{-5}$*	$5.6*10^{-5}$***	$9.3*10^{-5}$*	$5.5*10^{-5}$***
	$(2.9*10^{-5})$	$(1.0*10^{-7})$	$(5.2*10^{-5})$	$(1.0*10^{-7})$
WAGDUM	−0.37	−0.38***	−0.81*	−0.63***
	(0.38)	(0.09)	(0.41)	(0.09)
DIVDUM	−2.14***	−0.92***	−1.43***	−0.99***
	(0.70)	(0.15)	(0.50)	(0.10)
CAPDUM	0.33	0.56***	[illegible]	0.25***
	(0.24)	(0.06)	(0.[illegible]8)	(0.06)
BENEFIT	−7.68*	−10.75***	5.74	−1.20
	(4.58)	(1.04)	(5.69)	(1.46)
FAMSIZE	−0.08	−0.03**	−0.14**	−0.05***
	(0.05)	(0.01)	(0.06)	(0.01)
Constant	−0.04	−3.71***	−1.09*	−3.58***
	(0.40)	(0.10)	(0.56)	(0.19)
RHO	—	0.93***	—	0.93***
		(0.03)		(0.02)
−2 * ln likelihood ratio	[b]	4,845.6	[b]	4,875.0

[a]Maximum likelihood coefficient estimates are reported with asymptotic standard errors in parentheses.

[b]Minus 2 times the log-likelihood ratio is distributed χ^2. The χ^2 statistic for the univariate model of audit selection is 303.7. The χ^2 statistics for the univariate models of income and tax underreporting are 37.6 and 62.0, respectively.

*significant at 0.10 level.

**significant at 0.05 level.

***significant at 0.01 level.

(*RDIVDUM*) lowers the likelihood of audit, despite the fact that secondary income sources expand noncompliance opportunities. This result may reflect cross verification difficulties on the part of ITD auditors, or the reporting of dividend income primarily by honest taxpayers. As expected, the reported receipt of wage income (*RWAGDUM*) also lowers audit probabilities. Since wage income is subject to source withholding, auditors may not find it worth their effort to focus on this income source.

The second-stage estimation results, or those pertaining to the probability of noncompliance, are reported in the lower part of table 5. Univariate probit estimates of the likelihood of noncompliance are presented for two measures of evasion, income underreporting (*INCNON*) and tax underreporting (*TAXNON*); bivariate probit estimates are also reported as the second component of the joint estimation of audit selection and the probability of underreporting.

The second-stage results tell a consistent story regarding the determinants of the probability of noncompliance (*INCNON* and *TAXNON*). In particular, the marginal tax rate (*MTR*) significantly raises the probability of being an income or tax underreporter. This result is similar to that of Clotfelter (1983), and indicates that the highly progressive tax rates in Jamaica encourage noncompliance by raising the rewards for successful evasion. A higher level of taxpayer income (*INC*) also has an unambiguously positive effect on noncompliance propensities. The positive relationship between income and underreporting may reflect both broader opportunities for noncompliance for those with higher income and decreasing absolute risk aversion.

The measure of payroll tax benefits (*BENEFIT*), which captures the present value of future benefits derived from paying an additional dollar in payroll taxes, lowers the probability of income underreporting, but fails to exert a statistically significant influence on the probability of tax underreporting. This result indicates the limited role of an additional policy device for combatting evasion that has not been previously identified. A sound payroll tax program may induce participation in the formal sector of the economy, and at the same time enhance the compliance of those within the formal sector.

The results for the remaining variables are generally stable and consistent across equations. The accrual of wage income (*WAGDUM*) lowers underreporting propensities, which emphasizes the merits of a source withholding system. Somewhat surprisingly, the receipt of dividend income (*DIVDUM*) also lowers the probability of underreporting. One explanation is that the presence of serious problems with cross verification has led ITD auditors to largely ignore this income source. An alternative explanation is that only honest taxpayers report such income. Capital allowances and adjustments (*CAPDUM*) raise the probability of tax underreporting. This result reflects the unique opportunity for the self-employed to evade through their own business activities. Finally, taxpayers with larger families (*FAMSIZE*) are less likely to underreport than taxpayers in smaller families. Larger families may reflect, or instill, higher moral values that make compliance less attractive; larger families may also face a higher opportunity cost if identified as noncompliant.

Table 6 contains the third-stage linear regressions for the levels of underreported income and underreported taxes (*UNDERINC* and *UNDERTAX*). A total of six sets of regression results are reported, corresponding to the two alternative measures of the dependent variable and three alternative estimation techniques. In general, the third-stage results are consistent with the second-stage results in that those factors that influence underreporting probabilities tend to have a similar impact on the levels of noncompliance.

Results for the most general specification are reported in the first two columns of table 6. These results use the bivariate probit model to generate two sample selection terms, λ_A and λ_N, corresponding to the first stage (audit probability) and the second stage (noncompliance probability), respectively. Note that while the signs of all variable coefficients are consistent with the signs of those in the second stage, as well as with the other estimates of table 6, the extraordinarily large standard errors yield statistical insignificance for all variables, including the sample selection terms.

There is strong evidence that this pattern of results is attributable to a serious multicollinearity problem introduced by the two selectivity terms. As noted by Behrman and Wolfe (1984) and Tunali (1986), such collinearity can be expected by the very nature of the construction of the two selectivity bias controls. This is evident from eq. (9), where the individual components of the selection bias controls are detailed.

There are a number of other indicators of a multicollinearity problem. First, the two selection bias controls exhibit an extremely high pairwise correlation coefficient of -0.83. Second, note the dramatic increase in standard errors in columns one and two of table 6, relative to the alternative specifications of the third stage. While the point estimates are reasonably stable, the standard errors sometimes increase by more than thirty-fold, as with *BENEFIT*. Third, the adjusted R-square does not diminish when the two selection terms are omitted; in fact, the explanatory power of the underreported tax equation actually increases, indicating that more is lost through degrees of freedom than is gained through additional explanatory power when the selection terms are included. Finally, F-tests for the linear regressions in columns one and two allow rejection of the null hypothesis that the set of regressors has no impact on noncompliance, despite the fact that no individual parameters are statistically significant.

Although this specification of the model is most general and has the

Table 6

Double selection estimates of the level of income and tax underreporting.[a]

Independent variable	Bivariate selection terms included		Bivariate selection terms omitted		Independent univariate selection terms included	
	UNDERINC	*UNDERTAX*	*UNDERINC*	*UNDERTAX*	*UNDERINC*	*UNDERTAX*
MTR	1.23	2.51	1.09	2.62**	3.22*	4.61**
	(1.85)	(7.80)	(0.79)	(1.08)	(1.90)	(2.15)
INC	$4.2*10^{-5}$	$9.7*10^{-5}$	$3.8*10^{-5}$**	$9.9*10^{-5}$***	$5.6*10^{-5}$**	$1.1*10^{-4}$***
	$(7.1*10^{-5})$	$(4.0*10^{-4})$	$(1.5*10^{-5})$	$(1.7*10^{-5})$	$(2.0*10^{-5})$	$(2.3*10^{-5})$
WAGDUM	−1.01	−0.28	−1.01***	−0.37	−1.33***	−0.73*
	(1.44)	(3.06)	(0.31)	(0.34)	(0.34)	(0.40)
DIVDUM	−1.54	0.72	−1.44	0.50	−3.59**	−0.47
	(0.97)	(1.14)	(0.94)	(0.60)	(1.67)	(1.03)
CAPDUM	0.11	0.02	0.04	0.02	0.33	0.04
	(1.71)	(5.5)	(0.18)	(0.19)	(0.33)	(0.19)
BENEFIT	−14.15	−8.81	−11.87***	−10.05**	−19.35***	−8.54*
	(45.00)	(168.2)	(4.18)	(5.10)	(6.13)	(4.75)
FAMSIZE	0.04	$-2.5*10^{-3}$	0.04	$-8.5*10^{-3}$	−0.03	−0.06
	(0.17)	$(6.3*10^{-2})$	(0.04)	$(4.4*10^{-2})$	(0.07)	(0.06)
λ_A	0.13	−0.04	—	—	−0.09	−0.09
	(1.15)	(1.2)			(0.06)	(0.09)
λ_N	0.11	−0.08	—	—	2.12	1.25
	(0.46)	(0.09)			(1.55)	(1.13)
Constant	7.37	5.51	7.85***	5.30***	6.26***	4.29***
	(6.23)	(6.02)	(0.39)	(0.62)	(1.53)	(1.34)
$\bar{R}^2$	0.33	0.50	0.33	0.51	0.33	0.52
F	6.36	13.14	7.94	17.16	6.53	13.9

[a]Coefficient estimates are reported with corrected standard errors in parentheses.
*Significant at 0.10 level.
**Significant at 0.05 level.
***Significant at 0.01 level.

broadest capacity to capture the essence of the sequential equilibrium model of the tax compliance game, other models have been estimated under somewhat more restrictive assumptions. One method ignores both stages of selection, and estimates the levels of income or tax underreporting only as a function of the factors included in the second stage. These results are reported in columns three and four of table 6, and compare favorably with the results of the second stage. Higher marginal tax rates raise the rewards for successful noncompliance, and induce higher levels of tax underreporting. The levels of underreported income and taxes and also respond positively to higher levels of income. Payroll tax benefits, on the other hand, discourage higher levels of underreporting. These results, in conjunction with those of the second stage, have important policy implications for the incentive effects of tax structure, and suggest taxpayer characteristics indicative of noncompliance that may be of use to auditors. As for the other explanatory variables, family size exerts no influence on the level of underreporting, which contrasts with the second-stage results in which larger families tend to be more compliant. While family size may influence the probability of underreporting, family size exerts no influence on the level of noncompliance once one is an underreporter. Capital allowances tend to raise evasion probabilities in the second stage, but as with family size have no impact on the level of underreporting. Finally, the receipt of wage income tends to lower the level of income underreporting, providing additional support for source withholding.

Another set of estimation results is reported in the last two columns of table 6. These specifications remain quite general in that both selection hurdles are explicitly controlled for; however, the selectivity terms are now generated from univariate probit estimates of the probability of audit and the probability of noncompliance, so that independence is assumed across the probit equations. Note that neither of these selection terms is statistically significant, which means that the null hypothesis of no selection bias cannot be rejected at conventional significance levels.[25]

As with other specifications of the third-stage model, marginal tax rates and income tend to raise the levels of underreporting, while larger payroll tax benefits lower the levels of underreporting. Family size and capital allowances still exert an influence only on the probability of noncompliance, and wage income reduces the level of underreporting.

Together, the second- and third-stage results provide compelling evidence that tax incentives are a key consideration in making compliance choices. In general, higher tax rates and higher income increase noncompliance activity,

[25]This result does not necessarily imply a random audit strategy, since a number of factors was found to be statistically related to the probability of audit in the first stage. The absence of selection bias simply implies the independence of error terms across equations.

while higher payroll tax benefits decrease noncompliance. These results are found for both the probability and the level of noncompliance.[26,27]

4.2. The implications of policy reform

These estimation results provide the basis for the analysis of policy reform. Two sets of simulation results are presented. The first set examines the underreporting implications of 'minor reform' by calculating the response of underreporting to a one percent change in the various policy parameters (e.g., income, the marginal tax rate, and the marginal payroll benefit rate). The second set pertains to the underreporting implications of a 'major reform' implemented recently in Jamaica.

In both sets of simulations, the analysis is confined to those audited (the 148 observations in the audit data set) because it is only this group for which there is any information on 'true' return items and because these 'true' return items are necessary to use the results of the second- and third-stage estimations; for those not audited, 'true' return items are not available.[28] In addition, the analysis uses underreported income equations, as opposed to underreported tax equations, because underreported taxes depend upon underreported income as well as the tax structure.[29] Finally, the behavioral responses are simulated both for the third-stage model with the selectivity

[26]Tobit maximum likelihood estimation results for the combined second and third stages with and without the selectivity control λ_A from the first-stage (univariate) probit estimation yield similar results. For income noncompliance, see table Appendix A, where the dependent variable now includes those individuals with zero and positive noncompliance and corrected asymptotic standard errors are in parentheses. With some exceptions, most variables are significant at the 0.10 level or better. Similar results are found for Tobit estimation of tax noncompliance. Note that heteroscedasticity may be present in the Tobit estimation, although Arabmazar and Schmidt (1981) show that its presence need not lead to biased estimates. Note also that the inclusion of the selection term (λ_A) implies nonnormality of the regression disturbance.

[27]Estimates of the second and third stages that include the predicted probability from the first-stage (univariate) probit model give similar results. For income underreporting (*INCNON* and *UNDERINC*), see table Appendix B, where *AUDPROB* is the predicted probability of audit selection from the first-stage univariate probit model, λ_N is the selection control from the second-stage probit estimation, and corrected asymptotic standard errors are in parentheses. The results are largely unaffected by the use of tax underreporting (*TAXNON* and *UNDERTAX*) as the dependent variables. Note the negative and significant coefficients on *AUDPROB*, so that an increase in the probability of detection increases compliance. Note also that Tobit estimation could be applied here.

[28]The behavioral responses have also been confined to those audited individuals identified as noncompliant. The behavioral responses for this group are similar to (although slightly larger than) those for all audited individuals.

[29]Two examples illustrate this point. First, an individual earning J$8,000 in true income may have been identified as a tax underreporter prior to the reform; however, after the reform, this individual will be exempt from taxation and could no longer be viewed as noncompliant. Second, when tax rates change, it would be impossible to distinguish between the tax structure changes and behavioral response from the reform. Both issues can be addressed using the underreported income equation.

terms omitted (column three of table 6) and for the third-stage model with independent selectivity terms (column five of table 6). This approach is followed because these two sets of results place upper and lower bounds on the point estimates of *INC*, *MTR*, and *BENEFIT*.

The simulations are conducted by evaluating the difference between predicted underreported income in the pre- and post-reform tax regimes.[30] There are three steps involved in each simulation. The first step requires calculation of the pre-reform expected value of underreported income for each individual in the audit data set, using the pre-reform values for the explanatory variables.[31] For the underreporting equation with no selectivity terms, this calculation is a straightforward application of the estimated coefficients to the appropriate 'true' return characteristics for each individual return; for the equation with two selectivity terms, the calculation also requires evaluation of the relevant sample selectivity term (or the inverse Mill's ratio) for each stage of selection. In the second step, the post-reform value of underreported income is calculated for each individual when the appropriate policy instrument is altered. Again, this is a straightforward calculation for the model with no selectivity terms, in which each return characteristic (including those items subject to policy changes) is multiplied by its corresponding coefficient estimate. When the selectivity terms are included, the calculation reflects the fact that the inverse Mill's ratio from the second-stage probability of noncompliance equation is affected by the policy changes. For practical reasons the inverse Mill's ratio from the first-stage probability of audit estimation is assumed invariant to the policy changes, since the first stage is estimated with reported return items under a given audit strategy and it is not clear how reporting and auditing will change in response to policy. In the third step, the difference between the predicted levels of underreporting in the pre- and post-reform regimes is taken to represent the simulated behavioral response to reform.

Consider first the responses of underreporting to 'minor reform', or one percent changes in *INC*, *MTR*, and *BENEFIT*. The average underreporting-income elasticity ranges from 0.49 to 0.61 for all taxpayers, with the larger elasticity coming from the model with independent selection terms. The smallest elasticity by tax bracket (see table 1 for the brackets) is for those in the lowest tax bracket (0.01 to 0.11), and the elasticities increase monotonically with income, reaching highs of 0.73 to 0.87 for those in the top tax bracket.

[30]Although actual underreporting is observed for the noncompliant, predicted values are used throughout the analysis for the sake of consistency.

[31]For example, the expected value of underreported income for those individuals audited and found to be compliant is calculated as $\mathcal{E}(E \mid I_A^* > 0, I_N^* \leqq 0)$, while the expected value for those individuals audited and found to be noncompliant is given as $\mathcal{E}(E \mid I_A^* > 0, I_N^* > 0)$. These expectations are computed using the estimation results from eqs. (5), (7), (8) and (9).

The overall marginal tax rate elasticity ranges from 0.56 to 1.18. Again the elasticities increase for higher tax brackets. In the top bracket, where the pre-simulation marginal tax rate (inclusive of income and payroll taxes) sometimes exceeds 60 percent, the elasticity reaches 1.47, for the third-stage model with independent selection trms. These large elasticities illustrate both the importance of tax incentives in the compliance decision and the differential effects of taxes on individuals with different incomes.

The underreporting-benefits elasticities are all extremely small, amounting on average to only −0.19 to −0.20 for all taxpayers. However, unlike the effects arising from income and marginal tax rates, the responses decline as the tax bracket increases, reflecting the limitation of benefits above certain income ceilings in the Jamaican payroll programs. Payroll tax benefit programs can apparently have their largest impact on the compliance patterns of low income individuals.

In general, these results point to systematic behavioral responses on the part of individuals, and indicate the important role fiscal structure can play in influencing compliance. In particular, the responses to higher marginal tax rates adds credence to popular arguments that they are a key incentive for noncompliance, despite theoretical arguments to the contrary. The results also reveal differential responses to various policy instruments across tax brackets, which may introduce uneven equity effects and may complicate the design of programs to combat noncompliance.

Also of interest are the responses to major reform. The Government of Jamaica has recently enacted a comprehensive reform of the individual income tax. Alhough there were many justifications for the reform, foremost was the belief that the pre-existing tax regime stifled incentives and encouraged both tax avoidance and tax evasion at a rather grand scale. The reform replaces the highly progressive rate structure with a flat marginal tax rate of $33\frac{1}{3}$ percent applied to all income in excess of J$8,580; income less than J$8,580 is tax-exempt. Further, all tax credits have been abolished, and most employer provided perquisites have been brought into the tax base. In total, the reform is estimated to reduce income tax liabilities by J$60 million in 1986, so that it is not a revenue-neutral reform. In simulating the response to major reform, the income and substitution effects attributable to the change in effective marginal tax rates are examined separately from the change in net of tax income. The change in the effective marginal tax rate encompasses nominal rate changes, as well as changes in credits; the change in income captures the influence of all aspects of the reform, including rate changes, the abolition of tax credits, and the imposition of the exemption level. As with minor tax reform, behavioral responses are simulated using the third-stage model with selectivity terms omitted and the third-stage model with independent selectivity terms.

Due to the magnitude of the changes introduced by the reform, the simulated behavioral responses are quite large. The response to reduced effective marginal tax rates causes underreporting to decline by 21.2 to 43.0 percent, with the largest effects in the top brackets where rate reductions are more pronounced.

The simulated response to the change in net income has the opposite effect on compliance due to the positive underreporting-income elasticity. Underreporting here is estimated to increase by 20.9 to 35.4 percent, which is clearly an unintended aspect of the reform. The overall income response is dominated by those in the top tax bracket where the increase in net income arising from reform is most pronounced. For this group of individuals, underreporting is estimated to increase by 37.4 to 55.1 percent.

The net effect of major reform is a modest reduction in overall underreporting ranging from −0.3 percent to −7.6 percent. For those in the top tax bracket, an increase in underreporting of approximately 14 percent is projected; for all other tax brackets, the net effect is to reduce underreporting. These are important results, and suggest that auditing resources should be directed to higher income individuals. It is important to note, however, that the simulations ignore the likelihood that other taxes will be increased or that public services will be reduced in order to reduce any reform-induced deficit. To the extent that net income falls from other policy changes, the income responses reported here are overstated.

Clearly, the reform will not solve all of Jamaica's noncompliance problems. Opportunities and incentives for noncompliance will remain for the self-employed, particularly those in higher income classes. In addition, it must be remembered that underreporting is only part of the compliance problem in Jamaica. Nonfiling of tax returns appears to be a more severe problem, and the response of nonfilers to the reform is not known. Tax reform must necessarily be accompanied by a vigorous enforcement campaign to induce further taxpayer compliance with the income and payroll taxes.

5. Conclusions

It is apparent that the tax compliance game is a complicated one, in which both taxpayer and tax agency interact strategically to achieve their respective ends. This paper provides empirical evidence from Jamaica to support this view of compliance. The estimation results provide strong evidence that the tax agency systematically uses information reported by the taxpayer to select returns for audit. Consequently, it should not be assumed that the behavior of the agency is given and exogenous to the compliance process, nor can it be assumed that the behavior of the taxpayer has no effect on the probability of audit. The estimation results also suggest that economic factors play a large role in the individual's evasion decision, after controlling for audit selection. Underreporting is positively related to the marginal tax rate and to income, and is negatively affected by the benefits of payroll programs. Opportunities for evasion, as measured by sources of income, also affect evasion. These results indicate that the government can have a substantial effect on compliance through its fiscal structure. For example, it is estimated that the recent reform of the Jamaican income tax will actually decrease compliance among the self-employed by as much as 9.1 percent, due primarily to the large increases in net income resulting from the reform. It is, of course, possible to devise other policies that will increase reported income. More generally, this paper shows that understanding tax compliance – and devising policies to combat it – requires recognition of the strategic nature of the compliance game.

Appendix A

Table A.1

variable	Dependent variable: Underreported income	
MTR	19.00	9.36
	(5.07)	(3.23)
INC	$1.2*10^{-4}$	$1.5*10^{-4}$
	$(9.2*10^{-5})$	$(8.6*10^{-5})$
WAGDUM	−8.48	−4.96
	(2.21)	(2.02)
DIVDUM	−20.22	−14.97
	(4.97)	(4.46)
CAPDUM	2.43	4.48
	(1.42)	(1.62)
BENEFIT	−130.60	−30.09
	(29.52)	(17.60)
FAMSIZE	−0.01	−0.25
	(0.33)	(0.17)
λ_A	—	14.78
		(7.50)
Constant	−18.10	−39.60
	(3.10)	(15.74)

Appendix B

Table B.1

Independent variable	Dependent variable	
	INCNON	*UNDERINC*
MTR	4.01	2.57
	(1.19)	(1.27)
INC	0.56	0.44
	(0.32)	(0.19)
WAGDUM	−0.50	−1.00
	(0.40)	(0.28)
DIVDUM	−3.12	−1.77
	(0.78)	(0.81)
CAPDUM	0.44	0.11
	(0.26)	(0.22)
BENEFIT	−6.28	−13.63
	(4.91)	(3.46)
FAMSIZE	−0.18	−0.05
	(0.07)	(0.05)
AUDPROB	−1.70	−1.02
	(0.44)	(0.35)
λ_N	—	0.18
		(0.51)
Constant	0.41	8.04
	(0.43)	(0.65)

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