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A SIMULATION STUDY OF INCOME TAX EVASION*

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In a game-simulation context, tax evasion behavior of 15 subjects was observed. Large fines were found to be more effective deterrents than frequent audits. The decision to underreport income appears to be influenced by different factors than the magnitude of underreporting. Tax evasion behavior differed widely among individuals.

1. Introduction

Tax evasion is by nature an exceedingly difficult phenomenon to observe and research. Theoretical models of optimal evasion, though yielding interesting insights, are often beset by key, ambiguously-signed derivatives.[1] Questionnaire studies have also produced useful findings but respondents are understandably wary.[2] This study attempts, experimentally, a third approach – game-simulation – which faces subjects with hypothetical tax evasion decisions and observes their behavior.[3] For an admittedly small group of participants, this approach led to some sensible answers to the following questions: How sensitive is income tax evasion to changes in tax rates?

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[1]See Allingham and Sandmo (1972), Srinivasan (1973), Kolm (1973), Yitzchaki (1974) and McCaleb (1976).

[2]See Enrick (1963), Vogel (1974) and Spicer and Lundstedt (1976).

[3]Social psychologists have made wide use of games and simulation in studying compliance with rules. See Friedland, Thibaut and Walker (1973), and Thibaut, Friedland and Walker (1974).

Which socio-economic variables are related to evasion? Are the *decision* to evade tax and the *extent* of evasion separate and distinct decisions? Are large fines a more effective deterrent than frequent audits? Applied to larger, more varied groups, game-simulation of tax evasion could, we believe, help design more efficient and equitable income tax systems.

Apart from McCaleb (1976), most theoretical studies have focused on evasion behavior which maximizes an individual's utility or net income. We assume such behavior and, in the following section, suggest a parametric characterization of the tax evasion function, and outline our main hypotheses. Section three describes the simulation, estimates the evasion function's parameters and outlines the major findings. The final section summarizes and points to possible extensions of our approach.

2. Some theoretical considerations

Consider an income tax system with three main parameters: a (proportional) tax rate t, a frequency-of-audit parameter (defined as the fraction of total tax returns audited) a, and a magnitude-of-fine parameter, f, imposed as some multiple of the sum of tax evaded.[4] Let q be the fraction of taxable income reported. A reasonable specification for the relation between q, t, f and a is:

$$q=(1-t)^{b(f,a)}, \qquad 0<b<\infty. \tag{1}$$

The interpretation of (1) is that when income is not taxed, all income is reported; when taxation is confiscatory ($t=1$) no income is reported; and q declines monotonically with increases in t. For $b>1$, $q(\cdot)$ is concave with respect to the origin; for $b<1$, $q(\cdot)$ is convex.

We conjecture that $b<1$, on the grounds that for moderate rates of tax, q will decline only slowly with rises in t, but for high rates of t, q will fall rapidly; i.e. q is convex (see figure 1). We shall later test this hypothesis.

2.1. *Magnitude of fine*

Are large fines (with small probability of detection) more effective deterrents than small fines (with high probability of detection)? Tversky and Kahneman (1974, 1975) have found, in a series of ingenious experiments, that people almost invariably prefer to give up $5 rather than risk a one-in-one-thousand chance of losing $5,000, but gladly incur a one-in-four risk of losing $5,000 rather than give up a certain $1,250. This result may be applied to tax evasion. We conjecture that a one-in-fifteen chance of paying a fine of fifteen times the sum of tax evaded will be a more powerful deterrent than a

[4] This is in fact how fines are imposed in the U.S. and in Israel.

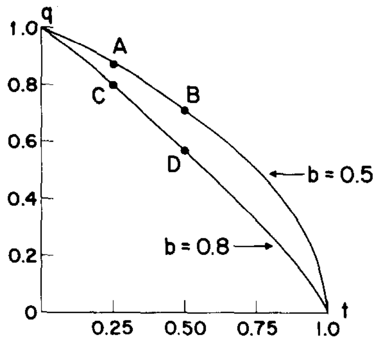

Fig. 1. Fraction of income reported, q, as function of tax rate t and elasticity b: $q=(1-t)^b$.

one-in-three chance of paying a fine of three times the sum of tax evaded. For each pair of (a, f) parameters, $(\frac{1}{15}, 15)$ and $(\frac{1}{3}, 3)$, the expected value of the net gain from tax evasion is zero.[5] Based on Tversky and Kahneman, we hypothesize that:

$$b(f_1, a_1) < b(f_0, a_0), \quad \text{for} \quad f_1 > f_0,$$
$$\text{and} \quad a_1 f_1 = a_0 f_0. \tag{2}$$

The implication of (2) is that $q(f_1, a_1)$ is everywhere greater than $q(f_0, a_0)$, for a given tax rate.

2.2. *Socio-economic factors*

Studies by Spicer and Lundstedt (1976), Vogel (1974) and Enrick (1963) strongly suggest that different groups and individuals have different $q(\cdot)$ functions, according to their attitudes and socio-economic characteristics. The specification of $q(\cdot)$ in (1) is best regarded as an aggregation of *individual* $q(\cdot)$ functions which may vary widely.

Before beginning the simulation, we ascertained by questionnaire such background information as age, sex, marital status, ethnic background (Middle East or European), whether subject is employed, whether subject owns a car,[6] and whether subject habitually buys lottery tickets (as a proxy variable for risk aversion or affinity). For most of these variables, we had no firm hypotheses about their relation to evasion (the anticipated relation between risk aversion and evasion is self-evident).

[5]The expected net gain from evading T dollars in tax is $T - a \cdot fT$, which is zero for $a \cdot f = 1$.

[6]Both capital and operating costs of cars are very high in Israel, so car ownership serves as a rough proxy variable for income.

2.3. *The decision to evade and the extent of evasion*

It is possible to separate conceptually the *decision* to underreport income and the *magnitude* of the income underreported. Let p be the probability that declared income is less than earned taxable income, and let x be the fraction of income not reported, when evasion occurs. The product of p and x is the expected value of the *overall* fraction of income not reported. It follows that:

$$q = 1 - p \cdot x. \tag{3}$$

A reasonable conjecture is that p should be related to such factors as whether the tax system is perceived as equitable, while x should be associated with risk aversion.

3. A simulation of income tax evasion

3.1. *The experiment*

Our subjects were 15 Israeli undergraduate psychology students. Their average age was 25. There were seven men and eight women. Each subject was given a folder containing tax tables and a form for reporting income and calculating tax and net income. First, questionnaires eliciting the background data previously described were filled out. Then the subjects were instructed:[7] You will receive a salary each 'month'. On the form you received, report your income and pay income tax according to the income you reported. Each month a random check will be made (according to a preannounced frequency, either one out of fifteen or five out of fifteen), and fines will be imposed, as a preannounced multiple of the sum of tax evaded. Your objective is to maximize your net income (gross income less tax less fines). At the end of each round of ten months, your net income will be calculated and posted. At the end of four rounds, a small money prize will be distributed in proportion to each person's total net income.

The following parameters were used:

Fine magnitude	Tax rate 25%	50%
15 times	round one	round three
3 times	round two	round four

The simulation lasted about 90 minutes. Monthly income was the same for all subjects, set at about the national average, and was raised by I£ 100 per

[7]See appendix for the precise instructions.

month. Subjects participated with enthusiasm and appeared to us to weigh their decisions with care.

There were 60 data points in all – 15 subjects times four rounds per subject. For each round, we calculated, for each subject, the number of months (out of 10) for which reported income was less than earned income (p), the average fraction of income *not* reported for those months where evasion occurred (x), and the overall fraction of income reported ($q=1-p\cdot x$).

3.2. Results

Values of p, x and q are reported in table 1 for each of the four sets of tax rates and fine parameters. When the rate of tax is increased from 25 per cent

Table 1

Probability of evading (p), fraction of income not declared when evading (x), and overall fraction of income declared ($q=1-p\cdot x$).*

Fine magnitude	Tax rate 25%	Tax rate 50%
15 times sum evaded	$p=0.47$ $x=26.8\%$ $q=87.4\%$	$p=0.78$ $x=43.1\%$ $q=66.4\%$
3 times sum evaded	$p=0.57$ $x=37.5\%$ $q=79.6\%$	$p=0.81$ $x=53.7\%$ $q=56.5\%$

*p, x and q are *averages* for the 15 subjects.

to 50 per cent, there is a striking increase both in the probability of underreporting income and in the extent of the underreporting, as one might expect. For $t=25$ per cent, income is underreported about half the time, while for $t=50$ per cent, underreporting occurs about eight times out of ten. For low rates of tax and high fines, about seven-eighths of earned taxable income is reported, while for high tax rates and low fines, 57 per cent of income is reported. We emphasize that audit frequency was always the inverse of fine magnitude, keeping the expected value of gains from evasion at zero.

For each of the four cells in table 1, an estimate of b can be computed, using:

$$b=\log q/\log(1-t). \tag{4}$$

Table 2

Zero order correlation coefficients for evasion variables (p, x, q) with structural and background variables.*

	Age	Self-employed?**	Owns car?**	Buys lottery tickets?**	Male (0) or female (1)	Tax rate	A_1	A_2	f
Probability of evading (p)		−0.34	0.21			0.43	0.25		
Fraction of income not declared (x)	−0.26			0.38	−0.33	0.27		0.32	
Overall fraction of income declared ($q=1-px$)	0.29			−0.31	0.28	−0.36		−0.37	

*Only coefficients significant at 0.05 listed.
**Yes = 1; no = 0.
A_1 = number of times reported income audited in previous rounds.
A_2 = 'round' number (1, 2, 3, 4).

The four values of b so obtained are:

0.47 ($t=25$ per cent, $f=15$ times),

0.59 ($t=50$ per cent, $f=15$ times),

0.79 ($t=25$ per cent, $f=3$ times),

0.82 ($t=50$ per cent, $f=3$ times).

The results confirm our hypothesis that $q(\cdot)$ is convex. They further indicate that b is about 0.5 for large fines ($f=15$) and about 0.8 for small fines ($f=3$), which in turn maintains our conjecture that large fines are more effective deterrents than small ones, even when audit frequencies are reduced proportionately. Shown graphically in figure 1, the outermost curve represents $q=(1-t)^{0.5}$, on which lie points A and B, the values of q for $f=15$. The innermost curve is $q=(1-t)^{0.8}$, on which lie C and D, the values of q for $f=3$.[8]

Does evasion behavior differ among individuals? Our data point to some interesting differences. Women are more likely to evade ($p=0.69$) than men ($p=0.61$), but underreport a much smaller fraction of their income (31 per cent, compared with 51 per cent for men). Those who habitually buy lottery tickets are no more *likely* to evade than those who do not. However, lottery ticket buyers conceal much more income when they *do* evade (59 per cent, compared with 33 per cent).

Zero order correlation coefficients for p, x and q with various background and structural variables are shown in table 2. These correlations do suggest that p and x are rather separate and distinct decisions. Only the rate of tax is significantly correlated with *both* p and x.

Table 3 presents multiple regression coefficients with p, x and q as dependent variables. These regressions tend to confirm the variability of evasion behavior over individuals whose circumstances differ, and emphasize the distinct identities of p and x. The rate of tax is the most important determinant of the probability of evading (with 'importance' measured by the size of the beta coefficient), while such variables as age, marital status and sex are the most important determinants of the extent of evasion.

[8]Assuming that earned income is independent of t, the revenue-maximizing rate of tax t^*, found by differentiating $q \cdot t$ with respect to t and equating to zero, is equal to $1/(1+b)$. For $b=0.5$, t^* is 0.67; for $b=0.8$, t^* is 0.56. For these values of t^*, the maximum effective rate of tax collectible, $q \cdot t^*$, is 0.38 and 0.29, respectively. These results are suggestive of Colin Clark's doctrine that no more than a quarter of national income can be collected in taxes. For $b=1.0$, the revenue-maximizing rate of tax is 50 per cent, and the maximum effective rate of tax is $(0.5)(0.5)=0.25$. More realistically, if earned income is a *non-increasing* function of the tax rate, then increasing t above 0.67 [or 0.56] will reduce revenue.

Table 3

Multiple regression equations with p, x and q as dependent variables: Beta coefficients. (t-values in brackets)

Explanatory variables	Dependent variable: Probability of evading (p)	Fraction of income not declared (x)	Overall fraction of income reported (q)
Tax rate	0.43*	0.27*	−0.36*
	(4.0)	(2.5)	(3.3)
Owns car?**	0.30*	−0.05	−0.16
	(2.4)	(0.4)	(1.3)
Age (years)	−0.16	−0.33*	0.41*
	(1.3)	(2.6)	(3.2)
Employed?**	0.13	0.11	−0.07
	(1.0)	(0.8)	(0.6)
Married?**	−0.35*	0.44*	−0.27*
	(2.5)	(3.2)	(1.9)
Male (0) or female (1)	0.28	−0.38*	0.24
	(1.5)	(2.1)	(1.3)
Magnitude of fine	−0.10	−0.18	0.11
	(1.0)	(1.7)	(1.0)
Buys lottery tickets?**	−0.02	0.25	−0.24
	(0.12)	(1.5)	(1.5)
Constant	0.38	0.75*	0.44*
	(1.2)	(2.6)	(2.0)
R^2	0.40	0.43	0.39

*Significant at 0.05.
**Yes = 1, no = 0.

4. Conclusion

A simple game-simulation of tax evasion has, we believe, yielded useful evidence. Our findings suggest that beyond some rate of tax, the fraction of earned income reported becomes very elastic with respect to the tax rate, and that the relation between underreporting and tax rate can be experimentally determined. We found that large fines tend to be more effective deterrents than frequent audits (even though fine magnitude did not prove statistically significant in correlations and regressions). There is evidence that the decision to underreport and the magnitude of underreporting are influenced by different factors, and that tax evasion behavior varies widely over differing individual circumstances.

Greater realism could, and should, be introduced into the simulation. Taxpayers are generally uncertain about the probability that their returns will be audited. It would be interesting to learn whether this uncertainty itself (which internal revenue officials seem understandably loath to remedy) acts as a deterrent to evasion. There is a certain amount of social stigma attached to apprehension. This may be as important a deterrent as fines to some people, and could also be simulated. In another context, it has been found that 'critically important in determining the degree of compliance (to rules) is the policy governing the allocation of resources within the group; equitable sharing heightens the tendency to comply' [Thibaut, Friedland and Walker (1974)]. An individual's perception of the tax burden placed upon him as 'fair' or 'unfair' should therefore be closely related to his evasion behavior. Finally, it is commonly believed that tax evasion in Mediterranean countries is simply more acceptable than in Anglo-Saxon countries. Replication of our experiment in several countries could prove or disprove this belief.

Appendix

The following instructions were read to participants:

'First, thank you for agreeing to take part. Please fill out this brief questionnaire (handed out). We will then explain the experiment.

'This research takes the form of an economic game. In general, each one of you will receive salary slips. You will be asked to report your income, and pay income tax on the income you reported. From time to time, audits will be conducted according to a random sample, and fines imposed on tax evaded. At the end of each "round" of 10 months, each person's net income will be added up (gross income less income tax less fines). The objective of each person in the game is to accumulate the maximum amount of net income.

'Everyone received a folder. Please open it.

'First, look at the lower table. In the first column are listed 10 months. Each month, you will receive a salary slip. Write the sum you receive in the appropriate column, headed "gross income". Then, consider carefully, and write in your declared income on which you will pay income tax. Calculate your income tax liability using the tax table provided. For instance, if you reported income of I£ 3,000, at a 25 per cent tax rate you pay income tax of I£ 750. Write in the sum of income tax in the appropriate column. Deduct this sum from your *gross* income, *not* from your reported income, and write the result in the column head "net income". After everyone completes this calculation, we will announce who was drawn in the random sample and will be audited. If, for some month, you came up in the draw, *for this month only* we will check if you underreported income, and if you did, you will be fined some multiple of the sum of tax evaded.

'At the end of a "round" of 10 months, we will compute everyone's net income (after deduction of fines, if any) and will write each person's net income on the blackboard. A small money prize will be divided up among you, at the end of the game, in proportion to each person's total net income.'

Each person received forms like the following:

Month	Gross income	Reported income	Income tax	Net income	Audited?	Fine	Net income less fines

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