Sticks and Carrots[*]

by

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Distributional Analysis Research Programme

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Abstract

The tax-payer-as-gambler (TAG) model of tax non-compliance is the classic vehicle for providing some simple insights. Under fairly general conditions this model supports the following four propositions: (1) if the rate of return to evasion is positive everyone evades tax; (2) people with higher risk-aversion tend to evade less; (3) people with higher personal income tend to evade more; (4) increasing any of the standard tax-enforcement parameters (the probability of audit, the proportional surcharge on evaded tax and the tax rate) will reduce the amount of concealed income. Not all of these TAG model predictions seem intuitively reasonable, nor are they all borne out by empirical evidence.

There are three principal intellectual routes for a more satisfactory approach:

- A re-examination of the underlying model of taxpayer motivation. This encompasses relaxation of the expected-utility assumption, introduction of time into the modeling framework and an extension of the range of arguments of the utility function.
- A revision of the model of interaction between the taxpayer and the tax authority. This allows the introduction of an explicit strategic interaction encapsulated in the auditing relationship. Neither the models with precommitment or those without precommitment fully capture the relevant features of the noncompliance problem. Both neglect the problem of "ghosts".
- The role of the modeling of firms. This route is relatively neglected in the theoretical and empirical literature. An elementary treatment of the problem suggests that it has potential as an exploratory tool and as a guide to policy makers.

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1   Introduction

This paper is about the role of economic analysis in understanding the tax-compliance problem. The title "sticks and carrots" suggests a recalcitrant beast to be beaten into unwilling compliance or to be seduced into cooperation by an elusive dangling incentive. However, the story is somewhat richer than that. The discussion will show that economic theory can play an important part in explaining the underlying mechanisms relating to the economic engagement of the citizen as taxpayer in the funding of public programmes and why this may be an endemic problem for tax administration. It will also show what the natural limitations of the stick-and-carrot analogy may be and what alternative paradigms of compliance could usefully be employed.

The standard microeconomic approach to tax compliance helps us to understand the basic schizophrenia that lies at the heart of public economics. This has little to do with the like or dislike of government and little to do with the approval or disapproval with the way in which the government raises funds or the mix of goods and services that it provides. In order to be able to appreciate how the standard approach can be useful in designing empirical investigations into tax noncompliance and in formulating policy it is important to understand what can reasonably be expected from economic models in this area and what can be expected by way of evidence.

Models   No overall modelling framework can be expected to offer an all-encompassing story of the compliance problem. However particular models can be useful in providing particular economic insights that illuminate particular aspects of the compliance problem and that can help a piecemeal appreciation of different parts of the tax-administration territory. Microeconomic models have a further role in helping us to understand what may be the consequences of the successful establishment of specific institutions or norms or, indeed, the breakdown of these institutions and norms. Predictions in these models are always conditional upon the appropriateness of the particular institutional set that is assumed.

Evidence   By definition evidence is bound to be limited and imperfect – a claim to the contrary would make any sensible researcher suspicious. However, data arising from the audit process or from activities that are collateral to noncompliance activities can be expected to reveal information about subsets of the compliance problem.

We begin by introducing the standard paradigm.

2   The TAG model

The *T*axpayer *A*s *G*ambler model[1] is perhaps the benchmark economic approach of modelling tax-noncompliance. It is important to understand the

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[1] The model was pioneered by Allingham and Sandmo (1972) and is widely discussed in the literature. For an introduction see, for example, Andreoni et al. (1998), section 3; Cowell (1990), section 2.1; Franzoni (1999) section 3.1; Slemrod and Yitzhaki (2002) Chapter 4.

ground rules of this type of approach – and thereby its limitations in helping us to see the way in which official incentives work on individual decisions to conceal taxable income and, in some cases, to generate taxable income.

The model is based on the elementary choice facing an individual in an atemporal environment. It is non-strategic in that no account is taken of possible conditioning of taxpayer behaviour on beliefs about the tax-authority's reaction to its information signals, nor vice-versa. Government or tax-authority actions may be conditioned on personal attributes, but there is not enough information in the system to build in assumptions about best response.

2.1 Foundations

The taxpayer is confronted by a classic economic problem of choice under risk. He or she knows the tax legislation, the taxes that are liable be paid and the penalty for getting caught and convicted of failing to pay one's taxes. The taxpayer also knows that the tax authority is not psychic: the authority cannot know the true liability to tax unless the person reports it or the authority spends time and trouble finding out for itself. So the taxpayer could get away with concealing part of his resources, falsifying the report made to the tax-authority, or even making no report at all. Being without moral scruples he or she is tempted to take the opportunity of evasion.

2.1.1 The individual

At the heart of the analysis there is an simple and familiar lottery: is it worth the taxpayer's taking a chance on being caught and suffering a financial penalty? To focus on this problem assume that the taxpayer's initial resources and all gains and losses can be measured in terms of a single consumption good that can be interpreted as "income". We further simplify the discussion by making two important assumptions about time and uncertainty.

1. Time is compressed into a single period within which the taxpayer has to make a decision on whether to attempt to evade paying tax and, if so, how much to evade.

2. Once the evasion decision has been taken, exactly one of two possible states-of-the-world must occur: either the taxpayer is not audited and enjoys a consumption level c', or is audited and, if he has evaded tax, is convicted and punished, in which case consumption is c''. If the taxpayer chooses to act honestly then $c'' = c'$; otherwise $c'' < c'$.

The exact nature of the lottery will be determined by the person's financial resources, the tax system and the penalty system in force. The basic model assumes that the tax system is based on income and has the following characteristics:

Axiom 1 *The person has a fixed gross income y which is liable to tax.*

Axiom 2 *There is a proportional income tax at rate t.*

Axiom 3 *(a) There is a fixed probability p of tax evasion being discovered and punished. (b) The tax on any concealed income is subject to surcharge at a rate s.*

Viewed this way noncompliance is just another risky activity with a known distribution of returns. The rate of return $\mathbf{r}$ to a dollar of evaded tax takes the value $-s$ with probability p and the value 1 with probability $1 - p$. So the expected rate of return is $\bar{r} := 1 - p - ps$. If the person behaved honestly and declared y disposable income would be $[1 - t]y$. Otherwise disposable income depends on the amount of evasion: if an amount of income e is concealed (so that the taxpayer reports an amount $y - e$) then consumption is given by the random variable:

$$\mathbf{c} = [1 - t]y + \mathbf{r}et \tag{1}$$

Let us now analyse the taxpayer's optimal evasion decision, given the above budget constraint. We may expect the exact decision that the person makes will depend on his or her personal attributes a that may include components such as willingness to take risks, innate honesty and the like. However, it is conventional to assume that all taxpayers of whatever a-type have the same general structure to their preferences over the state-contingent consumption levels c' and c''. The standard assumption is:

Axiom 4 *Each a-type taxpayer's preferences is represented by an expected utility function*

$$[1 - p]u^a(c') + pu^a(c'') \tag{2}$$

where u^a is an increasing, concave function.

What this means is that the utility derived from disposable income (consumption) is increasing, but marginal utility increases at a decreasing rate. It rules out the phenomenon of the risk-lover: everyone is assumed to be either risk-averse (in which case the indifference curves are strictly convex to the origin) or risk-neutral. Furthermore the slope of any indifference curve in the neighbourhood of perfectly honest behaviour[2] is fixed at $-[1 - p]/p$ (the betting odds on the person succeeding in his evasion), irrespective of income.

With $\mathbf{c}$ determined by the rate-of-return to evasion $\mathbf{r}$ and condition (1) it is straightforward to write down the condition for maximising utility with respect to concealed income e. If the taxpayer conceals some but not all of his income then we must have

$$\frac{1 - p}{p} \frac{u_c^a(c')}{u_c^a(c'')} = s \tag{3}$$

where $u_c^a(c')$, $u_c^a(c'')$ denote the a-type's marginal utility in the two possible cases ("not-caught", "caught") respectively. Condition (3) has the simple interpretation "Marginal rate of substitution = proportional penalty". In principle we should also consider two special cases that modify this conclusion:

1. Where the person reports completely honestly; replace "=" by "≤" in (3).

2. Where the person completely specialises in evasion; replace "=" by "≥" in (3).

Condition (3) can be used to derive optimal evasion e^* as a function of the tax-enforcement parameters (p, s, t) and the personal characteristics (y, a). The properties of this function are are inherited directly from the assumptions about the utility function and it can be used to derive a number of specific behavioural predictions, discussed in section 2.2.1 below.

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[2] This the point where $c'' = c'$, because $e = 0$.

2.1.2 The aggregate

If the economy is large then the government may take as determinate the total amount of revenue that it receives through the penalties imposed on proven tax evaders, although the amount that each individual taxpayer has to pay (tax plus surcharges) is random.

There are several ways in which the appropriate budgetary constraint upon government might be modelled. The standard version is as follows. The government has a specific net revenue target R_0 and it faces an aggregate resource cost of enforcement that is increasing in the detection probability p. Actual revenue raised R is given by total legal tax burden minus the total leakage through evasion and the resource cost of enforcement. The constraint that the government faces is simply $R \geq R_0$: tax receipts, net of any leakages to the underground economy and administration costs, must be at least as great as revenue. Given an appropriate objective function and a specification of the resource-cost function this constraint can form the basis for the design of an optimal tax-enforcement policy. But, as we will see in section 6.1 below, uncritical application of this apparently commonsense criterion in a normative model can lead to unfortunate prescriptions.

2.2 Results

Let us briefly review what can be deduced immediately from the basic assumptions of the simple TAG model and the attempts to implement it empirically.

2.2.1 Theoretical overview

Although we have mentioned three possible outcomes of individual optimisation (equation 3 and the two modifications that follow) only two are relevant. Given that the person is an expected utility maximiser and that the marginal utility of consumption is positive then case 1 drops out if $\bar{r} > 0$: the person will always conceal some of his income.[3] We can also see from the condition (3) that increasing the probability of detection p or the surcharge s will shift the equilibrium in such a way that e^* is reduced.[4]

Furthermore, there is an intuitively reasonable result to be obtained that characterises taxpayer behaviour across different attribute classes of taxpayers. An a-type's *risk aversion* is defined to be the proportion rate at which the

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[3] See Cowell (1990), page 56 for an explanation. However, this may not apply in richer models of tax-payer choice. If for example, the person is in an intertemporable problem and faces borrowing constraints, then he may evade even if the expected return is negative (Andreoni 1992). Of course if the individuals' preferences in the face of risk do not conform to that of the expected-utility model (2) then taxpayers ,may comply more than the conventional theory would suggest (Bernasconi 1998).

[4] To see this rewrite condition (3) as

$$\frac{u_c^a([1-t]y + et)}{u_c^a([1-t]y - set)} = \frac{ps}{1-p}$$

Check the left-hand side of this equation: remembering that $u_c^a(\cdot)$ is everywhere decreasing or constant we can see that an increase in e will decrease the numerator the and increase the denominator; the LHS is decreasing in e. Now ncreasing p or s obviously increases the right-hand side. So the only way the equation can still hold if p or s increases is if e falls.

a-type's marginal utility falls with consumption:

$$-\frac{u_{cc}^a(c)}{u_c^a(c)}. \tag{4}$$

where $u_{cc}^a(c)$ is the slope of the marginal utility function (negative in the case of risk aversion). If it is true that in attribute class 1 risk taxpayer risk aversion is higher than in attribute class 2, for all values of c, then taxpayers in class 1 will always conceal more income than taxpayers in class 2.[5]

To obtain other results one further restriction on preferences is usually introduced. This is expressed as:

Axiom 5 *Absolute risk aversion (4) is a decreasing function of c.*

This implies that a risk-averse individual who holds a mixed portfolio of a safe asset and a risky asset would increase the holding of the risky asset were the endowment to increase. So, for any particular a and any given set of tax-enforcement parameters (p, s, t), if the person's taxable income y increases then so too does e, the absolute amount of income concealed. However decreasing absolute risk aversion does not permit anything definite to be said about the proportion of taxable income that is being concealed.

So, the elementary analysis of behaviour in the face of risk results in four simple propositions about the incidence of tax-evasion in the community (see the Appendix page 27):

1. if the rate of return to evasion is positive everyone evades tax;

2. people with higher risk-aversion tend to evade less;

3. people with higher personal income tend to evade more;

4. increasing any of the tax-enforcement parameters p, s, t will reduce the amount of concealed income.

The TAG model is remarkably robust in that the above propositions are established for a wide class of individual preferences. However, of these only proposition 2 and two-thirds of proposition 4 seem to chime automatically with common sense. It seems strange to assert that *all* taxpayers will evade; and although the we would expect compliance to increase with the probability of audit p and with the size of the surcharge s, why should it also increase with the nominal tax rate t? Many would argue that common sense suggests the opposite. As for proposition 3, who knows? Clearly this is an area where "common sense" is not entirely adequate and we need empirical evidence.

2.2.2 Empirical model specification

The model gives aggregate evasion in the form (13) which suggests that an appropriate econometric version of the model ought to have tax and enforcement parameters, personal income and indicators of the type of income recipient as

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[5] See Cowell (1990), pages 57,8

explanatory variables; the dependent variable would be some measure of under-reported income. The model could be estimated for different categories of tax-payer or for taxpayers in general. The empirical model could be used to test the empirical validity some of the propositions on the shape of the *e*-function that were raised in section 2.2.1.

However there are a number of difficulties with appropriately specifying an empirical model. There may be underlying problems of sample-selection bias; for example even a carefully conducted review of taxpayer audits may nonetheless exclude some individuals who do not file a tax return at all. Furthermore a particularly tricky difficulty is the specification of the variable characterising the probability of audit. Usually what has been done is to rely upon some proxy for evasion opportunity (such as the presence of business income) to categorise different audit classes, and we can expect the probability of audit to differ across these classes.[6] Finally there is a "rationing" problem: individuals' opportunities for participating in evasion differ greatly as between occupations and social groups, although one might suppose that the membership of rationed and non-rationed groups is largely self-selected. The appropriate margin of choice for an individual may not be to change the amount of evasion activity undertaken within the context of a particular group, but rather to migrate between groups in response to changes in tax-enforcement parameters.

2.2.3 Taxpayer audits

Nevertheless the work that has been done on taxpayer audit data is interesting and very informative. Historically the United States has provided the empirical researcher a tremendous advantage – the Tax Compliance Measurement Program (TCMP) is a pre-eminent data source unmatched by other countries' tax systems.[7] Here I briefly summarise some of the empirical work based on taxpayer audit data, principally from the TCMP.[8]

- Tax compliance differs according to income type and socioeconomic group. For example it is lower for married people than single persons; lower for younger people (are they less risk averse?).

- It is the *source* of income rather than its level which is a significant determinant of evasion. A much higher proportion of wage and salary income is reported than is the case for self-employment income. Personal taxpayers have a rather low value of the income-elasticity of underreporting (about 0.3) compared with that for farm business income (about 0.65).

- Income level and enforcement parameters generally have the expected effects on evasion behaviour. Higher income is associated with higher

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[6] See for example the approach in Andreoni et al. (1998).

[7] The last TCMP was done in 1988, although a limited version has been reintroduced as the National Research Program in 2002.

[8] A bibliographic note. The results on taxpayer characteristics and income sources are drawn from the studies by Beron et al. (1992), Clotfelter (1983) and Feinstein (1991). The main references on the role of income and the impact of enforcement parameters are Beron et al. (1992), Landsman et al. (2002), Poterba (1987) and Witte and Woodbury (1985), For an authoritative account of the inherent econometric problems see Feinstein (1991). The Minesotta audit experiment is reported in Slemrod et al. (2001).

amounts of under-reported income. However although taxpayer compliance is usually positively associated with the probability and severity of criminal penalties the relationship is weak. This has been broadly confirmed by a recent Minnesota "audit experiment" where taxpayers were informed that they were likely to be subject to close scrutiny, although high-income taxpayers appeared to behave differently from those on low and modest incomes.

- Early studies suggested that there is less taxpayer compliance in audit classes with higher marginal tax rates. However there is an important word of caution to note here. In any sample of taxpayers taken at any particular time those persons facing different marginal tax-rates may belong to groups that have different economic opportunities, or that have significantly different preferences for risk and attitudes towards evasion. More recent work has been be able to show greater insight on the important relationship between the marginal tax rate and evasion, separate from income: while income has only a weak effect, the marginal tax rate has *negative* impact.

- Detection is imperfect: variation in detection rates is at least as important as variations in personal characteristics.

2.2.4   Indirect evidence

As we noted above, microdata on tax evasion is, perhaps understandably, limited in availability and coverage. So some researchers have attempted to get a handle on the overall noncompliance problem by an indirect route. What is usually done is to try to infer something about the amount of underground economic activity ("black" labour, concealed payments as well as undeclared income) by using some indirect indicator, including monetary variables or apparent differences between income and expenditure at the aggregate level.

Unfortunately many of the more ambitious attempts to obtain indirect evidence so are of dubious value, since they are only sketchily based on economic theory and offer suffer from severe econometric shortcomings. What is needed is a careful empirical model of the relationship between observables that appropriately takes account of the influence of unobservables in its specification and that provides a plausible basis for distinguishing between the impact of noncompliance and other unobservables.[9]

2.2.5   Laboratory experiments

The questions that either microdata or indirect evidence allow the researcher to pursue usually concern issues such as the possible role of specific personal or job

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[9] An example of the aggregative approach is Crane and Nourzad (1986) used a synthetic series of an "adjusted gross income gap" as a measure of tax evasion. Modelling this as a function of tax rates enforcement parameters, income and the inflation rate they suggest that aggregate evasion falls with the tax rate, in line with the early cross-section TCMP evidence. Thomas (1999) provides a good overview of the methodlogical pitfalls in many of these aggregative approaches.

A good example of appropriate micro-modelling of behavioural relationships is Pissarides and Weber (1989) who use the UK's Family Expenditure Survey to model the differential relationship between expenditure and income for the employed (with very low evasion opportunities) and for the self-employed who clearly have substantial opportunity for noncompliance.

characteristics as factors predisposing to tax compliance, the impact of changes in tax rates, the relationship between compliance and the tax-structure. It is not usually possible to focus clearly on taxpayer motivation, which may be of immediate concern for those who want to judge the effects of incentives – the "sticks and carrots" – on compliance. Experimental methods suggest themselves as a possible way of filling this gap, but it is not often that circumstances permit experiments with real taxpayers. So it is not surprising that several economists and psychologists have used laboratory experiments. The results are not encouraging for the TAG model: early studies concluded that subjects do not seem to act like gamblers in the tax-compliance setting and it is not even clear that they act in conformity with the basic economic model of risk-taking. Furthermore it appears that the *structure* of taxation is important, over and above the levels of tax-rates and exemptions. However, the evidence on the responses to tax-enforcement parameters is broadly in line with what gets from econometric analysis of the microdata reviewed in section 2.2.3 above: for example a higher probability of audit is associated with greater compliance, although it may have its principal impact on whether the chooses to evade at all rather than on the amount evaded conditional on noncompliant behaviour.[10]

2.3   What is wrong with the model?

Some aspects of the TAG model appear to be distinctly unsatisfactory. For example the implication that, as long as the expected rate of return to evasion is positive, everyone will conceal some income. There are several ways in which we might seek a reform of the underlying model structure: it is useful to focus on three areas:

- The nature of taxpayer motivation. The assumption is usually made that the objective function should be in the form of expected utility. What is the appropriate characterisation of risk?

- The nature of the economic interaction. Because of its inherently non-strategic nature some essential features determining compliance and the possibility of manipulation by the tax-authority may have been assumed away. Furthermore the atemporal setting arguably leaves out some of the crucial aspects of the interaction between taxpayer and tax authority – for example it completely misses the issues associated with tax amnesties.

- The nature of the economic agent. The basic TAG model assumes that we are dealing with gamblers endowed with exogenously fixed incomes. While this has been relaxed in some models to include labour supply[11] the productive economy is usually ignored. In particular focusing on the TAG model typically neglects a key feature of tax-noncompliance – the behaviour of firms. Given that the firm is constrained only by the size of

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[10] The studies by Baldry (1986) and (1987) demonstrated that tax evaders to do not seem to act like gamblers and discusses the role of the structure of taxation. Cowell (1991) demonstrates the violations of the basic risk-taking model. Spicer and Thomas (1982) focus on the role of audit probability. Some (weak) contrary evidence on responses to tax-enforcement parameters in the laboratory setting is given by Alm et al. (1990).

[11] See, for example, Baldry (1979), Cowell (1985) and Pencavel (1979).

the market and its ability to undercut the costs of competitors the consequences of successful individual successful attempts at noncompliance may be enormous.

We will deal with each of these issues in sections 3 to 5.

3 What taxpayers want – rethinking taxpayer motivation

Underlying the TAG model is the simple greed assumption that is conventionally made in economics. It is clear that this may only tell a partial story when it comes to issues that involve big issues such as the relationship between the citizens and the state. The question as to what motivates taxpayers deserves to be addressed. Clearly some people may pay taxes and refrain from evasion out of civic duty. In reviewing taxpayer motivation we may examine a number of issues that give arise to distinct modelling issues.

3.1 The expected utility model

The TAG model, rooted in rather conservative economic theory, assumes rational individuals with stable preferences who, given specific economic opportunities and probabilities, maximize their expected utility. The expected utility (EU) paradigm may be good as a device for simplified model-building but it may miss out important nuances about people's preferences in the face of uncertainty.

Indeed the use of the EU assumptions to characterise these preferences is arguably restrictive. It rules out state-dependent utility and hence any feeling of shame, or intrinsic delight at successful evasion. It also rules out regrets and misperceptions by the taxpayer of the probabilities of alternative possible states of the world – i.e. misperceptions about the probability of audit. However, there is evidence that individuals make systematic mistakes when attempting to maximize their expected utility. Would relaxing this assumption to encompass non-EU models – such as rank-dependent utility or prospect theory – result in a more promising underlying story?

Rank-dependent utility is unlikely to be a fruitful approach in the present context given the typically uncomplicated nature of the risk involved: the possible outcomes are usually taken to be the simple pair ("income-if-not-caught", "income-if-caught") rather than some richer structure of possible payoffs. However, prospect theory incorporates a number of features that may be relevant to the problem of appropriately modelling taxpayer choice, in particular:

- Individuals "edit" information about gambles before they evaluate them so as to simplify the representation of the prospect with which they are faced.

- They use a reference point from which to measure outcomes in terms of changes.

- The value function is defined over gains and losses relative to the reference point rather than absolute values of wealth or income.

- In evaluating of gambles individuals assign decision weights different from the actual probabilities.

The first three of these lead to a version of the "framing" phenomenon in which risk choices are evaluated differently according to the way in which they are presented to the decision maker – in particular gains may be evaluated quite differently from losses relative to a particular reference point.

Several studies examine tax evasion in the light of prospect theory and suggest support for the framing hypothesis whereby the response to a particular economic incentive (stick or carrot) would differ according to the context in which it was perceived. But direct tests of conformity of behaviour with prospect theory have been inconclusive.[12] It is not clear that prospect theory receives overwhelming support in comparison with EU, although the framing issue remains important for the issue of the effectiveness of incentives and sanctions.

3.2 The range of goods

The range of goods in the utility function is also simplified within the specification of the TAG problem. Individuals are concerned only with their own private consumption and so of course care nothing for the goods and services that are produced by the resources raised through the tax system. This issue is relevant to economies with a small public sector as well as those that supply a lot of goods publicly. One would expect to see a positive relationship between marginal tax rates and the overall size of the underground economy if, on average, public goods were perceived to be under-provided, with the reverse effect if there is overprovision of public goods.[13]

3.3 The temporal model

The TAG model ignores time: one can imagine that each year essentially the same gamble takes place, without there being any "memory" in the system. Some contributions to the literature have attempted to correct this by allowing the tax-authority to use information from multiple time periods. Even if the tax-authority uses just information from the current period for an audit, the outcome of the audit may be used to trigger retrospective investigation.[14] This

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[12] On the general issues of prospect theory see Kahneman and Tversky (1979), Tversky and Kahneman (1981)and Schepanski and Shearer (1995), and for a review of experimental evidence on the EU model and other paradigms of individual decision making see Camerer (1995). Support for the framing hypothesis is found in the studies by Chang et al. (1987), Robben et al. (1990) and Schepanski and Shearer (1995). King and Sheffrin (2002) designed an investigation to identify whether individual behaviour conforms to the standard results of prospect theory, given a scenario that incorporates a perception of inequity. Using student respondents they adopt a questionnaire approach designed to reveal how the individual responds when filing taxes. The responses to the control questions are consistent with prospect theory. However the responses to the questions depicting inequity are more consistent with expected utility theory in that they did not display the phenomenon of "loss aversion" (risk-taking when faced with losses and risk-averse when face with gains) that is characteristic of prospect theory.

[13] Note that this phenomenon is, nonetheless, fully consistent with the well-known "free-rider" problem associated with public good provision; it follows from the impact of income levels on risk-taking behaviour associated with noncompliance – see Cowell and Gordon (1988).

[14] This is the argument in Engel and Hines (1999). See also Greenberg (1984) and Landsberger and Meilijson (1982) for a detailed analysis of the role of time in the audit sequence.

clearly weights the "stick" of the punishment wielded by the tax authority. A rational taxpayer's current tax evasion is a decreasing function of evasion in previous periods: the reason for this is that if the taxpayer is audited and caught evading this year penalties for earlier noncompliance may be incurred.

3.4 Interdependence

There are a number important of aspects of taxpayer interdependence that can impact on the overall compliance problem including aspects of trust and the concept of a "climate of behaviour." This climate can be represented by an externality in the individual utility function – people may care about their own behaviour *relative* to those of their peers; the "stigma" or non-monetary penalty associated with discovered evasion may be endogenously determined by the behaviour of others.[15] This consumption externality may be supplemented by a production externality; the growth in individual noncompliance may facilitate the development of a kind of infrastructure of noncompliance – finding a corrupt accountant to for one's own tax-cheating will lower the search costs of other potential non-compliers.

The endogeneity of the interdependence within the economic model is crucial. One of the significant contributions of the type of economic model that incorporates such interdependence is to explain why there may be epidemics of noncompliance. The maintenance of a culture of compliance is one good example of where a government or a tax administration may be able to create a "carrot" or positive incentive for taxpayers to act in their broader social interests rather than just according to narrow selfishness.

4 Donkeys, mice and ghosts

Are taxpayers donkeys? The stick-and-carrot approach to modelling the interaction between taxpayer-tax and authority assumes that the tax authority views the issue of economic incentives in a fairly simplistic fashion. The reason for this is the simple nature of the economic interaction in the basic TAG model: the tax-authority lays down a set of ground rules of the mass of taxpayers; each taxpayer assumes that the probabilities in the fundamental gamble are uninfluenced by his or her own actions.

4.1 Strategic models

An alternative view of economic interaction between the two parties sees them as cat and mouse, or cat and dog. Each party is aware of the other's motivations and interests – the taxpayer wants to maximise utility, the tax authority to maximise net tax revenue – and takes these into account in selecting its own strategy. The outcome is an equilibrium in which each party makes the best response to the other's strategy in the light of the available information.

This type of approach resolves into two basic classes of model according as whether one assumes that it is reasonable for the tax authority to precommit

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[15] On trust see Scholz and Lubell (1998). The stigma model is attributable to Benjamini and Maital (1985). Note that it only requires an aggregate level of externality to be generated by the taxpayers as distinct from the near-neighbour model of Glaeser et al. (1996) in which the position of other economents is important.

to an audit strategy – to set the agenda for the interaction.[16] Which model is the more appropriate depends on issues such as the type of institutions and laws present in the economy and the nature of the information available to the parties.

4.1.1 Precommitment

In a model characterised by a simplified distribution of income (just "rich" and "poor" in known proportions) and where the tax authority "moves first" strategically the optimal policy of the authority is stark. It should audit all low income reports and ignore all the high income reports. However, under such circumstances no high-income person would ever dare to report a low income; so in fact the only people who ever get audited are those who are genuinely low-income! The statement of the model may seem extreme but it contains an inner truth about the regressive nature of such carefully tailored audit schemes.

4.1.2 No precommitment

By contrast consider a model where precommitment to such an extreme policy is not credible. Again there are two income levels, but also the personal characteristics of the population are such that some will always report truthfully, others would cheat on the tax authority if they get the opportunity and find it profitable to do so. Let the probability that the tax-authority decides to audit a particular low-income report be p and the probability of a potentially dishonest taxpayer not complying be q. Each party takes fully into account the other's strategy in this game of noncompliance and investigation. The outcome will be a Nash equilibrium characterised by a pair (p^*, q^*) representing the "best response" of each party (the tax-authority, the taxpayer) to the other's strategy in this game. Each of these equilibrium values depends on, among other things, the tax rate t, the penalty surcharge s and the cost of an individual audit. In general we find that:

- Decreasing the marginal cost of audit – i.e. making the investigation and enforcement system more efficient – will reduce the probability of noncompliance q^*; but it will leave the optimal probability of audit p^* unchanged.

- Increasing the surcharge s will reduce both the optimal probability of audit and the optimal probability of noncompliance. The first of these is attributable to the usual marginal deterrent effect of higher punishment;[17] the second emerges because the the tax-authority does not need to put in so much effort to achieve a given result in terms of net revenue raised.

- Increasing the tax rate reduces the probability of noncompliance q^* and will either increase or leave unchanged the optimal probability of audit.

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[16] See Reinganum and Wilde (1985) for the model with precommitment and Graetz et al. (1986), Reinganum and Wilde (1986) for the no-commitment case. The specific no-commitment model discussed here is briefly outlined in Appendix A.2.

[17] A word of caution. This argument about the marginal deterrent effect in this and other models cannot be pressed too far – see page 18 below.

It is interesting to note that, despite the very different premises of this type of model, the impact of the key parameters s and t on compliance is in the same direction as in the TAG model.

4.2 Ghosts

Ghosts are individuals who fail to comply with their income tax filing requirements in an extreme form – they "disappear" from the system. From the point of view of the economic modelling there is an essential difference between those who make a zero-income report and those who make no report at all. What do we know, or what could be known, about ghosts and the way they can be expected to respond to economic incentives designed by a tax agency?

Unfortunately information about behaviour and characteristics of ghosts is sparse, although enough is known to suggest that they are quantitatively important: the US ghost population in 1988 has been estimated to be 7.9 million (compared with 110 million who filed tax returns); the tax shortfall for the ghosts is estimated as $11 billion – some 15 percent of the known tax shortfall of those who filed returns.[18] However, ghosts play a role in the overall tax-enforcement story that may be more important than a snapshot picture of their numbers may suggest.

4.3 Hybrid model

The reason for this last remark is that typically both ghosts and strategic players are present in the same population. The margin between the two types of behaviour may be crucial from the point of view of policy design: an over-zealous approach to implementation of enforcement in the sector populated by strategic players may mean that they migrate to the "ghost" sector that is, in essence non-strategic and where the costs of detection and enforcement are typically much higher.[19]

5 Firms

Why consider corporations or businesses separately in economic models of tax compliance? Some have adopted an essentially pragmatic approach: it has been argued that to distinguish corporate and personal sectors is an important way to understand the overall distortionary impact of tax evasion.[20] However, this is distinct from the issue of whether the underlying economic analysis of tax evasion is, or should be, different according to the sector considered.

Let us briefly examine the state of the economics literature on the issue of compliance and tax enforcement as it relates to the behaviour of firms and attempting to unpick the key issues that could characterise a specific theory of compliance by firms. This theoretical approach could then form the basis of appropriate empirical models for the corporate sector and enable policy makers

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[18] The results come from Erard and Ho (2001) who extend the standard TAG model to account for non-filers and use a special subset of the TCMP data containing detailed tax and audit information for both filers and nonfilers of US federal income tax returns.

[19] See Cowell and Gordon (1995).

[20] See Fullerton and Karayannis (1994).

to develop a quantitative model for analysing the effectiveness of tax-compliance regimes.

In principle firms can evade by misreporting or making false declaration about profits, sales or input use and other costs. Does the assumed market environment of the firm make a difference to its compliance behaviour?

5.1 Model

Let us take a simplified model [21] of a firm with constant average and marginal cost producing a single output subject to tax at a uniform rate. The tax is enforced in the same way as described on page 2 and so again there is an implied expected rate-of-return to noncompliance $\bar{r}$. Checking through the formal specification of this model in Appendix A.3 it can be seen that this could be reinterpreted as a model where profit is the tax base.

The firm has two types of decision to make:

- The quantity of output.

- The extent to which it conceals output or hides profit.

In analysing the solution to this double problem it is useful to introduce two new concepts. The first is the *expected tax rate* on output $\bar{t}$: this is given by the nominal tax rate t multiplied by a factor of one minus the proportion of output concealed times $\bar{r}$. The expected tax rate is under the control of the individual firm (through the choice it makes on concealment) as well as the tax authority. The second concept we need is the *average concealment cost* per unit of output g: this will itself be a function of the amount of concealment – the amount of evasion – undertaken.

Let us assume that the firm chooses the output and level of evasion to maximise expected profits. Because the model is so simple expected profits can be written as

$$(P - m - g - \bar{t}) \times \text{ output}$$

where P is price and m is marginal cost and the components g and $\bar{t}$ (but no others) depend on the amount of concealment. A number of conclusions immediately follow:

- If the firm conceals output it will do so up to the point where the marginal cost of concealment equals the marginal reduction of expected tax rate.

- The firm will always conceal some output if $\bar{t} < t$. This is equivalent to the requirement that the expected rate-of-return $\bar{r}$ be positive.

- There is a fundamental separability property between the concealment decision and the output decision. Here the concealment decision is independent of the output decision.

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[21] This is based on the standard approach in the literature. The key references are Cremer and Gahvari (1993) and Virmani (1989) who focus on a competitive industry, Marrelli (1984) and Marrelli and Martina (1988) dealing with noncompetitive firms that are assumed to be risk averse and Myles (1995) who assumes risk neutrality. For a detailed treatment see Bayer et al. (2003).

- Output decisions for the competitive firm are determined by a modified "price = marginal cost" rule.

The solution to the maximisation problem can be used to derive comparative statics results in the usual way. In the case of the competitive model we then find:

- Reported sales decrease as the tax rate increases.

- An increase in tax increases the price but by less than the amount of the tax since some of the tax increase is absorbed in increased evasion.

- An increased probability of detection p or an an increased surcharge s will raise the proportion of sales declared, expected tax and the market price.

So, as in the TAG model, enhanced deterrence will have the appropriate effect on evasion; in addition it moves expected taxes in the direction that we might have anticipated. But, by contrast to the TAG model, we have an unambiguous prediction of a rise in tax evasion with a rise in the tax rate.

Moreover the results are not special to the competitive model. Under risk-neutrality the separability property holds and so it is not surprising to find that basically same conclusions apply to the monopolistic case as those for the case of perfect competition. The only real difference in the equilibrium is that "price = adjusted marginal cost" rule is replaced by a condition involving the elasticity of demand.

However, the separability issue is potentially more problematic once one drops the assumption of risk neutrality. This matters both because it clarifies the factors that determine equilibrium compliance by firms in a variety of market environments and because it enables us to draw clear-cut conclusions about the impact of policy parameters.[22]

5.2   Empirical analysis

Unfortunately the empirical analysis of corporate tax evasion is extremely limited. In the main it consists of either a compilation of rather obvious results (e.g. tax evasion depends on the preferences of the person who has the power over declaration), or of procedures that could be considered as methodologically weak. The main reasons are:

1. The lack of theoretical models, since theory mainly focused on personal income tax evasion;

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[22] Wang and Conant (1988) study the expected utility function when a monopolist overstates production costs in order to reduce taxable profits. The uncertain monopolist's optimal rate of output is not affected by either the profit tax or the penalty rate. Yaniv (1995)'s model of tax evasion covers different types of taxes that can be evaded by the firm showing that the different types of taxes do not alter the separability conclusion. Yaniv (1996) extends the analysis of separability to cases in which both the probability of detection and the penalty rate vary with the amount of cost overstatement. Lee (1998) shows that the separability property and the neutrality of profit taxes depend on the audit probability and penalty rate are formulated– see also Wang (1990).

2. The lack of corporate income tax compliance microdata;

3. The lack of confidence in microdata on tax compliance and relevance of measurement error.

However, some evidence is available, again drawn from the TCMP.[23] Of special interest are two main results that have no counterpart in the literature on personal income tax compliance:

- A firm's compliance is positively associated with being publicly traded and with belonging to a highly regulated industry;

- Having low profits relative to the industry median is correlated with higher corporate tax evasion.

Clearly both of these findings have potentially important implications for the design of policy.

5.3   An assessment

Let us briefly compare the situation of the personal and the corporate sector as they are commonly represented within microeconomic analysis. What makes the simple microeconomic model of the firm in section 5.1 essentially different from the TAG model applied to the individual? Three features stand out: (1) the nature of the taxpayer, (2) the assumption about risk preferences, (3) the determinants of responsiveness to economic incentives.

The taxpayer   It is reasonable to argue that individuals – and perhaps even families and households – exist as exogenously given entities; the set of potential taxpayers could be imagined as exogenously given. This is not the case with firms: firms are born and dissolved; they merge and change their shape; they do all this in response to economic incentives. The tax system and its enforcement mechanism are essential components of those economic incentives and so we have to have a reasonable model of firm behaviour before we can say anything intelligible about the impact of tax and enforcement policy. Of course the contrast is with the household sector is somewhat overstated,[24] but this contrast may contains an important component of the problem.

Risk preferences   A major feature of the model of personal noncompliance is the role of risk aversion in the equilibrium. Although several papers in the "cat-and-mouse" tradition of strategic models assume risk neutrality, reasonable amount of risk aversion is required in the TAG model in order to get interesting answers. If you had risk neutrality or extremely high risk aversion you would always end up at corner solution of the equilibrium. By contrast in

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[23]Rice (1992) used a corporate subset of TCMP based on an examination of the tax and financial records of a stratified random sample of about 30,000 US corporations out of a total of 1.5 million corporation with assets less than $10 million.

[24]In particular one would expect to find a rlationship between the individual personal motivations of those running firms and firm behaviour: an interesting example of this is Joulfaian (2000) who finds a positive and significative correlation between managers' preferences and firm compliance using US data.

modelling firms it is common to assume risk-neutrality: the neutrality assumption is often important the separation result that enables clear predictions to be established from the theory..

Responsiveness to incentives Following on from the difference in conventional assumption about risk preference is the question of what drives the responsiveness (or lack of it) of the taxpayer to sticks and carrots. In the case of personal taxpayers differences in risk preference are one important way of characterising the differential; responsiveness of different groups to penalties or the probability of detection. In the case of the firm modelled in section 5.1 it is quite different. The equilibrium is determined by a first-order condition involving the marginal concealment cost and the rate-of-return to tax evasion – see equation (27). It is this essential difference in the model that gives rise, amongst other things, to the different relationship between compliance and the tax rate in the models of the personal and the corporate sector.

Understanding the nature and the determinants of the cost-of-concealment function g is essential to understanding what is going on in firms' noncompliance and in to understanding the economic incentives that may usefully be applied to a tax-enforcement agency. The academic literature on this point is rather sparse, but one could conjecture that this will depend on such things as the following:

- *The nature of the product.* The output or sale of highly visible physical goods is going to be harder to conceal than some services, for example. Just as the opportunities for evasion in the personal sector differ strongly across occupational categories (employment versus self employment), so also one would expect to find systematic differences across industry categories.

- *The size and organisational structure of the firm.* Firms with a more complex organisation are likely to have higher concealment costs: the more people you bring into the plot the greater the security problem you face and the greater the risk of discovery.

- *The role of reputation.* Clearly firms for which a respected brand name is considered as an assurance of quality have more to lose in the case of exposure of illegal activity and therefore higher concealment costs.

- *The degree of concentration of the industry.* There are two counteracting effects. Firstly, an industry with a large number of similar firms may be easier to police by an external agency: those deviating from the norm in terms of reporting will be easier to spot; this would lead to higher concealment costs for each firm. On the other hand the presence of a large number of similar type firms will encourage the spread of concealment technology appropriate to a particular type of firm.

6 Guidance for policy-makers

Unsurprisingly, the appropriate guidance for policy-makers depends on the specific model in which we decide to put our trust. To consider alternative models

is not just a preoccupation with theoretical nicety but can help us draw useful policy lessons.

6.1 The TAG model

If noncompliant taxpayers are, in economic terms, indistinguishable from gamblers then they should be responsive to the same kind of economic incentives as are gamblers. There may be enough information about individual types a to tailor an audit policy that is conditioned on personal characteristics – of course this would have to use proxies for the true values of the components of a which are unobservable, but reasonable proxies may well be available. Obviously this approach rests on the assumptions that the TAG model is appropriate, that individuals' perceptions of the gambles involved are accurate and that they are rationally pursuing a policy of ex-ante utility maximisation. But, as we have seen, the evidence on this is not particularly convincing.

However, let us take the TAG model at face value for a moment: what recommendations would it suggest? Suppose the objective of the tax authority is simply to raise revenue then intuition would suggest (and formal analysis confirms – see Appendix A.1.2) that enforcement should be intensified until the probability of audit satisfies:

$$\boxed{\text{Marginal Revenue Raised}} \quad = \quad \boxed{\text{Marginal Resource Cost}}$$

where the item on the left-hand side includes both the direct revenue (tax uncovered plus surcharge) and the indirect revenue yielded by the effect on compliance of a higher audit probability. Allowing for the problem that the marginal revenue computation relies on taxpayer perceptions of probabilities that may be inappropriate the above condition seems to have a common-sense appeal; moreover this marginalist rule can be adapted and extended to other versions of the objective function.

There is a snag, though: this is a partial result that focuses on just the audit probability as a policy variable. If we allow the parameter s to be chosen too then it appears as though the tax-authority can do better – that is to say it can always achieve its objective at lower resource cost by raising s and cutting p (as long as p remains positive, albeit very small). Indeed, given this greater flexibility, there is an obvious method of guaranteeing total compliance – choosing s and p to ensure that the expected rate of return to compliance is not positive (Cf proposition 1 in section 2.2.1). If we press the simple logic of the TAG approach then it is clear that the tax authority should save resources by using a (very) "big-stick" version of deterrence.[25]

But uncritical application of the "big stick" approach to forcing compliance can lead to ridiculous outcomes. Let us not assume that such ridiculous outcomes would automatically be prevented by the common sense of legislators or administrators: one could perhaps reach the extraordinary situation of 18th Century London, described by Charles Dickens:

> "But indeed, at that time, putting to death was much in vogue
> with all trades and professions and not least of all with Tellson's

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[25] On the welfare consequences of the simple TAG approach see Cowell (1989), Kolm (1973).

[Bank]. Death is Nature's remedy for all things and why not Legislation's? Accordingly the forger was put to Death; the utterer of a bad note was put to Death; the unlawful opener of a letter was put to Death; the purloiner of forty shillings and sixpence was put to Death; the holder of a horse at Tellson's door, who made off with it, was put to Death; the coiner of a bad shilling was put to Death; ... not that it did the least good in the way of prevention – it might almost have been worth remarking that the fact was almost exactly the reverse – but it cleared off (as to this world) the trouble of each particular case and left nothing else connected with it to be looked after." – *A Tale of Two Cities*, Book II, Chapter 1.

Of course it is a cheap shot to pillory the outcome of simplified economic model as ridiculous. What is more useful is to identify the economic reasons why the high-s-low-p outcome is ridiculous and, perhaps, the way a more reasonable policy recommendation might be derived. We will do this under four headings.

Unreasonableness   At a first glance the obvious objection to the big-stick approach is that it is just not reasonable. Do we really want to see extreme penalties for perhaps minor cases of infringement of tax law? At the very least legislators and those implementing the law need to have a sense of proportion as to what is appropriate in the context of taxation relative to, say, fraud and theft elsewhere in society.

Ineffectiveness   Appeals to reasonableness may seem like the lament of a woolly-minded reformer who refuses to accept economic logic. However the outcome of this application of the TAG model also defies economic logic in that it ignores the issue of appropriately structured incentives in punishment. If, for a terrible moment, we imagine huge penalties for tax noncompliance we might well also comment "not that it did the least good in the way of prevention." Taxpayers would, with impeccable economic logic, conclude that they might as well be hung for a sheep as for a lamb.

Inequity   Ex-post inequities are almost bound to occur but it should be the job of a sensible tax administration to make sure that the consequences are not grotesquely magnified. An obvious source of potential inequity in this case are errors by taxpayers and by auditors. Although the standard model assumes that noncompliance is a result of optimisation amoral by taxpayers who desire the public benefits of the state without paying the private cost a substantial amount of noncompliance could be attributable to mistakes or the outcome of inertia or lazy habits. A more sensible approach to the normative analysis of compliance is to allow that errors are entirely possible – indeed this seems reasonable in the light of the evidence from the psychological literature. Taxpayers can be encouraged by appropriate incentives to take care in reporting, while the design and implementation of the penalty structure can distinguish between minor infractions and serious violations, even if this were to be at the apparent cost of some expected revenue.[26]

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[26] On the role of intertia see Smith and Kinsey (1987). Boadway and Sato (2000) examine the effects of unintentional errors on the design of tax enforcement and tax policy. Maximal

Misspecification It is possible that, although the TAG model has the advantage of conformity with mainstream economic analysis, and although it may be useful as a useful starting point for discussion amongst those raised in a neoclassical tradition of applied welfare economics, it is just taking us in the wrong direction because it is built of the wrong components. Let us consider what might be learned from some of the alternatives that have been mentioned in previous sections.

6.2   Modified motivation

The review of the representation of taxpayer preferences in section 3 is not just a matter of theoretical nicety. A better understanding of how individuals reach decisions under uncertainty can help in the effective design or modification of a policy to enhance tax compliance.

Non EU models of risk It is clear that one of the main reasons for the failure of TAG is a popular misperception of the probability of audit. The use of decision weights that differ from the actual audit probabilities may give the tax authority an opportunity to induce greater compliance by exploiting this misperception. It is clearly in its interest that taxpayers act as though they overestimate the chance that they will be caught.

However the non-EU risk model also suggests that there could be fruitful and low-cost possibilities for administrative innovation. If we take the framing phenomenon seriously there may be considerable scope for imaginative redesign of conditional payments associated with tax-enforcement. Even though two different payment schemes may be formally equivalent in terms of the individual's conditional budget constraint (1) they may be viewed quite differently by the person making the choice under uncertainty. For example should the tax authority consider prizes for promptness instead of penalties for late payments? One might go further and suggest that bonuses for an excellent compliance record may be more effective in some cases than surcharges for under-reporting.

Finally, since there is some evidence that, contrary to the TAG assumptions, taxpayer perceptions are important, it is clear that the structure of taxation as well as the magnitude of the incentives should be taken into account in good policy design.

Interaction The interaction models of section 3.4 pick up on an important externality present in the economic problem of compliance. The clear message of the "epidemic" model is that the impact of a modification in tax-enforcement policy should *not* be judged just in terms of its marginal impact on the compliance of a representative taxpayer. The tax authority can also have an important role to play – if not a duty – in fostering a climate of compliance.

Unfortunately the message is mainly a negative one: it is probably much easier to lose the right climate through careless implementation than to build up the right group effects and socially responsible behaviour from scratch. However, there are some positive steps that should be considered in response to

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sanctions are not applied, unlike the Dickensian model. Although intentional evasion can be deterred by introducing "carrots" for honest reporting, innocent tax evaders may be penalised whether they have unintentionally evaded or have been mistakenly convicted.

this externality. Insofar as the externality is generated by an infrastructure of noncompliance it makes sense to regulate the activities and institutions associated with this infrastructure. Other forms of regulation in the economy may be crucial for effective regulation of tax compliance.

6.3 Strategic models and hybrids

The strategic or "cat-and-mouse" type of model is informative for the design of enforcement strategy in a reporting context. However it assumes a well-defined and rather limited set of possible outcomes and a highly simplified distribution of unknowns (for example, in the implementable versions of such models there is usually a very simple representation of the income distribution from which the taxpayer is assumed to be drawn). This type of model of the compliance problem seems to be more appropriate to the one-on-one negotiation that may take place between the tax authority and large individual taxpayers, personal or corporate rather than to control of the masses.

Even in the context where the simple cat–and-mouse model is applicable it can lead to some uncomfortable conclusions. Typically the kind of tailored policy that emerges from the model generates a regressive application of the tax law – reports from the poor are audited much more intensively than those from the rich, but for good economic reasons. These good economic reasons may not be sufficient to recommend the active pursuit of a strategy that could be perceived as socially divisive.

Furthermore, if one takes on board the lesson of the hybrid model, a particularly difficult economic problem arises from the possibility of spillover. This spillover is an induced migration from the reporting sector that permits sophisticated strategic interaction to a genuine "underground economy" where time-consuming hunting of noncompliant citizens (ghosts) would have to be carried out. Over-zealous enforcement in the areas with relatively low-cost information may exacerbate the problems in high-cost areas (where the ghosts are).

6.4 The firm

Using the kind of structure outlined in section 5.1 optimal tax-enforcement rules for the firm-noncompliance can be derived;[27] but the more interesting question is the way to use the model to provide working guidelines for those who design tax-compliance schemes. Here the nature of concealment costs and their relationship to firms' characteristics seem to be crucial. As we have noted this will determine the responsiveness to incentives of all firms for which the expected rate of return to noncompliance is positive. It suggests that the right approach to the empirical modelling of compliance and to the practical enforcement of tax payments by corporations should be piecemeal. The appropriate piecemeal approach will depend on the type of market in which the firm operates, the nature of its products and the size of the firm itself.

It is useful to consider a number of points arising from the analysis of the personal sector that can be expected to have an important part to play in tax-enforcement policy toward firms.

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[27] See the derivations in Cremer and Gahvari (1993) and Etro (1998)

- The time component is, possibly, more important for firms than for individuals. We can expect reputation to be relevant for corporate tax evasion and for the effectiveness of enforcement mechanisms.

- As with individuals, audit data on firms are bound to be limited in that they have relatively little to say on "ghosts." For many developed economies an important contribution to the understanding of firms' noncompliance is a suitable model of the underground economy.

- Sometimes practical economic enquiry has to proceed by stealth, as in the indirect method to acquiring evidence of noncompliance that was considered in relation to personal incomes (see page 7). An important role for a tax authority is to identify observables that are likely to be correlated with profit (as consumption is with income) and that firms have an incentive to reveal more truthfully.

- This suggests that, as with the control of the infrastructure of personal noncompliance, an appropriate compliance policy will go hand-in-hand with effective regulation of industry.

7   A final word

Although the standard economic model of the stick-and-carrot approach to tax enforcement is flawed in many ways, it is a useful starting point for understanding the mechanics of individual decision-making. But it can be seriously misleading as a guide to policy advice. However, this should not make one sceptical of the contribution that theory can make to tax administration: careful microeconomic analysis of the role of incentives can tell us quite a lot. We may just have to be a little more selective about our modelling.

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A   Mathematical Appendix

This appendix presents the core elements of the theoretical models that underlie some of the principal assertions in the main text.

A.1   The TAG model

Given the model in Axioms 1-4 the first-order condition for maximising (2) with respect to e is given by

$$\mathcal{E}\left(\mathbf{r}u_c^a(\mathbf{c})\right) \leq 0 \text{ if } e^* = 0 \tag{5}$$

$$\mathcal{E}\left(\mathbf{r}u_c^a(\mathbf{c})\right) \geq 0 \text{ if } e^* = y \tag{6}$$

$$\mathcal{E}\left(\mathbf{r}u_c^a(\mathbf{c})\right) = 0 \text{ otherwise.} \tag{7}$$

where $u_c^a(\mathbf{c})$ denotes the first derivative of u^a and $\mathcal{E}$ denotes the expectations operator. Inequalities (5) and (6) represent, respectively, the cases where the person reports truthfully (conceals no income) and where the person conceals everything. Equation (7) gives the case where the person conceals just a part of his income from the authorities. first-order conditions (5)-(7) can be solved to yield the taxpayer-response function:

$$e^* = e(\tau, y, a) \tag{8}$$

where $\tau := (p, s, t)$ is the collection of tax-and-enforcement parameters.

A.1.1   Comparative statics

If the person is risk-averse and at an interior equilibrium then (7) characterises the optimum and differentiation can be used to obtain the way e changes in response to policy parameters. For example, differentiating (7) with respect to p and using (1)we get

$$\mathcal{E}\left(\mathbf{r}^2 u_{cc}^a(\mathbf{c})\right)\frac{\partial e(\tau, y, a)}{\partial p} - u_c^a(c') - s u_c^a(c'') = 0 \tag{9}$$

The expectation term on the left-hand side must be negative, in view of the concavity of u^a and so

$$\frac{\partial e(\tau, y, a)}{\partial p} = \frac{u_c^a(c') + s u_c^a(c'')}{\mathcal{E}\left(\mathbf{r}^2 u_{cc}^a(\mathbf{c})\right)} < 0 \tag{10}$$

Likewise we can derive

$$\frac{\partial e(\tau, y, a)}{\partial s} < 0 \tag{11}$$

and, if axiom 5 holds and s is a constant independent of t and y:

$$\frac{\partial e(\tau, y, a)}{\partial t} < 0 \tag{12}$$

Note that (12) holds if the penalty is proportional to the tax evaded (as in our interpretation of the TAG model) rather than to the income concealed (Yitzhaki 1974).

A.1.2 The aggregate

If the numbers of taxpayers is effectively infinite and the distribution of individuals in the community by (y, a)-type is given by a continuous distribution function $F(y, a)$ then aggregate income is $Y := \int y \, dF(y, a)$ (the tax base), aggregate evasion is

$$E := \int e(\tau, y, a) \, dF(y, a) \tag{13}$$

and revenue raised is

$$R := tY - \overline{rE}t - \Phi(p), \tag{14}$$

where $\overline{rE}t$ is the expected aggregate loss through tax evasion and $\Phi(p)$ is the dollar cost to the government of enforcing the probability of detection p everywhere.

We can use this to derive a rule for public policy. Differentiating (14) with respect to p we find

$$\frac{\partial R}{\partial p} = -\frac{\partial \left(\overline{rE}\right)}{\partial p} t - \frac{\partial \Phi(p)}{\partial p}. \tag{15}$$

So, if the objective were simply to maximise revenue R, setting (15) to zero would yield:

$$\underbrace{[1+s] \, et}_{\text{direct effect}} \quad \underbrace{-\bar{r}t\frac{\partial e}{\partial p}}_{\text{indirect effect}} \quad = \quad \frac{\partial \Phi(p)}{\partial p} \tag{16}$$

A.2 Cat and mouse

Consider a world in which there are exactly two levels of income y_0 and $y_0 + \Delta y$ and three groups of taxpayers with characteristics known to be as in the following table:

Group	Income	Personal attribute	proportion of population
0	y_0	—	f_0
1	$y_0 + \Delta y$	always honest	f_1
2	$y_0 + \Delta y$	potentially dishonest	f_2

Consider first the taxpayers' position. The behaviour of those in groups 0 and 1 segments is fixed; and those in the group 2 get expected utility

$$pu^a \left([1-t] \, y_0 + [1-t-st] \, \Delta y\right) + [1-p]u^a \left([1-t] \, y_0 + \Delta y\right) \tag{17}$$

if they cheat and

$$u^a \left([1-t] \, [y_0 + \Delta y]\right) \tag{18}$$

if they do not, where p is the assumed probability that a low-income report will be audited. The value of p that equates (17) and (18) is given by

$$p^* := \frac{u^a \left([1-t] \, y_0 + \Delta y\right) - u^a \left([1-t] \, [y_0 + \Delta y]\right)}{u^a \left([1-t] \, y_0 + \Delta y\right) - u^a \left([1-t] \, y_0 + [1-t-st] \, \Delta y\right)} \tag{19}$$

If the person were risk-neutral then (19) becomes $p^* = \frac{1}{1+s}$. Let q be the proportion of group 2 who cheat on taxes: if they believe that $p < p^*$ then all will cheat $(q = 1)$; if $p > p^*$ then none will cheat $(q = 0)$.

Now consider the tax authority. It knows that group 0 has to report y_0, that the group-1 people feel bound to report $y_0 + \Delta y$ and that each person in group 2 could report low (y_0) or high ($y_0 + \Delta y$); it assumes that a proportion q of this group will report low. If the authority aims to maximise net revenue and audits a proportion p of the low-income reports then the probability of catching an evader is

$$\frac{f_2 q}{f_0 + f_2 q} p.$$

So, if the cost of an individual audit is φ, the expected net revenue from the policy is

$$[f_1 + [1 - q] f_2] t \Delta y + \frac{f_2 q}{f_0 + f_2 q} p[1 + s] t \Delta y - \varphi p \tag{20}$$

which may be rewritten as

$$\text{const} + p \frac{\varphi f_0}{f_0 + f_2 q} \left[\frac{q}{q^*} - 1 \right] \tag{21}$$

where

$$q^* := \frac{\varphi f_0}{f_2 [1 + s] t \Delta y - \varphi} \tag{22}$$

From (21) If $q > q^*$ expected net revenue increases everywhere with p, in which case the authority would investigate all low-income reports ($p = 1$); if $q < q^*$ then expected revenue decreases with p and it will choose $p = 0$.

The Nash equilibrium is given by the point where the beliefs of the tax authority and taxpayers are consistent. This is where $p = p^*$ and $q = q^*$. To see how this equilibrium is affected by public policy we just need to differentiate (19) and (22) with respect to the parameters φ, s, t. Doing so we get:

$$\frac{\partial p^*}{\partial \varphi} = 0, \frac{\partial q^*}{\partial \varphi} > 0 \tag{23}$$

$$\frac{\partial p^*}{\partial t} \geq 0, \frac{\partial q^*}{\partial t} < 0 \tag{24}$$

$$\frac{\partial p^*}{\partial s} < 0, \frac{\partial q^*}{\partial s} < 0. \tag{25}$$

A.3   The firm

The simplified model uses the following assumptions

- *Proportional cost function*: average and marginal cost are a constant m.

- *Proportional tax*: Output x is taxed uniformly at rate t

- *Determinate demand*: The firm faces a demand function $x(P)$ or, equivalently, can command a known price $P = P(x)$ for its product, where $P(\cdot)$ is the inverse demand function. This includes as a special case the situation of perfect competition where $P = \text{constant}$.

- *Costly concealment*: A proportion β of sales are concealed by the firm – i.e. a proportion $1 - \beta$ of sales are declared to the tax authority – where $0 \leq \beta \leq 1$. The unit cost of concealing is given by $G(\beta)$ where $G(\cdot)$ is an increasing convex function.

- *Fixed detection probability*. The probability of discovery and by the tax authority and subsequent conviction is fixed at a level p.

- *Fixed proportional penalty*. The penalty rate on evaded tax is s.

Hence the expected tax rate per unit of output is

$$\bar{t} := [1 - \beta + \beta p[1 + s]]\, t$$

$$= [1 - \beta \bar{r}]\, t$$

where $\bar{r} := 1 - p - ps$, as before. Expected profits are

$$\left[P - m - \beta G(\beta) - \left[\underbrace{[1 - p]\,[1 - \beta]\,t}_{\text{``not caught''}} + \underbrace{p\,[1 + s\beta]\,t}_{\text{``caught''}} \right] \right] x(P)$$

$$= \quad [P - m - g(\beta) - \bar{t}]\; x(P) \tag{26}$$

where $g(\beta) := \beta G(\beta)$ is the average concealment costs per unit of output. For any given output level $x > 0$ (26) implies that the firm chooses β to minimise concealment costs (as a proportion of total output) plus the expected tax rate:

$$g(\beta) + \bar{t}$$

The first-order condition for a maximum is

$$\frac{dg(\beta)}{d\beta} + \frac{\partial \bar{t}}{\partial \beta} = 0$$

which simplifies to

$$\frac{dg(\beta)}{d\beta} \quad = \quad [1 - p\,[1 + s]]\, t \tag{27}$$

$$= \quad \frac{t - \bar{t}}{\beta} \tag{28}$$

From (27) a necessary condition for an interior solution for β is that

$$1 - p[1 + s] > 0 \tag{29}$$

or, equivalently,

$$\bar{t} < t \text{ for } 0 < \beta \leq 1$$

Note that (29) is exactly the same as the requirement that the expected rate of return to evasion be positive in the simple TAG model – see page 3. If (29) is violated then clearly no evasion issue will arise and the firm will report honestly.

Market equilibrium for a competitive firm occurs at

$$P = m + g + \bar{t}$$

implying that expected profits are zero; actual profits are positive if the firm is not audited, negative if audited.

A.3.1 Comparative statics

Differentiating (27) with respect to t we find

$$\frac{d^2 g(\beta)}{d\beta^2} \frac{\partial \beta}{\partial t} = [1 - p[1 + s]]$$

so

$$\frac{\partial \beta}{\partial t} > 0$$

Clearly the same method give us

$$\frac{\partial \beta}{\partial p} < 0, \ \frac{\partial \beta}{\partial s} < 0$$