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Nahum D. Melumad; Dilip Mookherjee

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# Delegation as commitment: the case of income tax audits

Nahum D. Melumad\*

and

Dilip Mookherjee\*

*In this article we study the value of delegating authority over income tax audit policy, arising from the incompleteness of contracts. Consider a utilitarian government whose ability to commit is limited to aggregate dimensions of its audit policy, as publicly verifiable information about detailed allocations of audit budgets is not available. We show that the welfare level associated with the full-commitment solution can be attained by delegating authority over audit policy to a manager. The latter is offered a simple incentive scheme based only on the aggregate variables which are publicly observable. In contrast, if the government retains authority, direct commitment to these same variables does not allow the full-commitment welfare level to be achieved. Thus, despite sharing a common informational basis, delegation may perform better than centralized arrangements in the presence of incomplete contracts.*

## 1. Introduction

■ Delegation of authority to subordinates is an essential feature of a hierarchically decentralized organization. Delegated decision making may be valuable for a variety of reasons. Constraints on the ability to process information and limited communication flows may cause “control-loss” or limited “spans of control,” necessitating delegation. Alternatively, a principal may be a collective (for example, shareholders of a firm) that, incapable of readily arriving at consensus decisions, chooses to delegate decision-making authority to a single agent. Other reasons for delegation include a principal’s lack of skills or information necessary for efficient decision making. In the public sector, elected representatives may seek to shift responsibility for controversial policies by delegating authority to the heads of regulatory bodies.<sup>1</sup>

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\* Graduate School of Business, Stanford University.

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<sup>1</sup> For specific discussions of the rationale behind delegation in various contexts, see for example Arrow (1974), Fiorina (1985), Geanakoplos and Milgrom (1984), Holmström (1978, 1984), Simon (1976), and Williamson (1967).

Delegation, however, may not be necessary in many instances. The revelation principle implies that, absent incompleteness of contracts, bounded rationality, or communication costs, an organization involving delegation cannot perform better than a centralized one in which subordinates communicate their information to the principal, who subsequently makes the relevant decisions and transmits instructions back to the subordinates (see Myerson (1982)). This gives rise to the question whether delegation may be valuable in the presence of incomplete contracts. In this article we explore that potential value. To focus on this issue exclusively, we assume away any features of bounded rationality, limitations on communication capacities, and informational asymmetries between the principal and the agent to whom authority may be delegated.<sup>2</sup>

The simplest form of delegation concerns the assignment of decision-making authority by a principal to agents in a two-layer organization. Such settings have been studied by Green and Stokey (1981) and Holmström (1984), among others. In contrast, we are concerned with multilayer organizations, where a principal assigns authority over agents in the bottom layer to managers in an intermediate layer. Examples of such hierarchical arrangements are as follows: governments delegate authority over the auditing of taxpayers to revenue collection agencies; city governments delegate law enforcement to their police force; firm owners delegate contracting with input suppliers to managers; and the Securities and Exchange Commission delegates the setting of accounting standards to the Financial Accounting Standards Board. An interesting feature of such hierarchies is that the principal often designs incentives for managers in the intermediate layer which diverge substantially from its own preferences. For instance, revenue collection authorities often appear to pursue objectives such as revenue maximization that are narrower than the governments' concern for social welfare.

In this article we explore the value of introducing an intermediate manager who is delegated authority over a set of agents, relative to a setting where the principal deals directly with the agents. The principal is assumed to be unable to commit to all relevant policy variables. This may strain the credibility of promises to execute certain policies that are desirable *ex ante*, owing to the principal's opportunistic propensity to deviate from them *ex post*. Such lack of credibility—often referred to as the time-consistency problem—may lead to significant welfare losses, a point that has received much attention in recent literature.<sup>3</sup> We argue that the credibility problem may be overcome if the principal delegates policy-making authority to an intermediate agent. By choosing a suitable incentive scheme for the agent, the principal may be able to manipulate the agent's preferences in the "proper" direction. Consequently, delegation may help achieve performance superior to that obtained when the principal retains authority over decision making. It also necessitates designing incentives for managers which induce objectives different from the principal's own objectives.

A careful argument along these lines requires us to specify exactly why commitment to an incentive contract for an agent may be credible in a setting where direct commitment to relevant policies is not. We also need to carefully derive the welfare benefits of delegation. Our analysis focuses on the problems a government faces in designing audit strategies to deter income-tax evasion.

Section 2 of this article provides an introductory discussion of the nature of the commitment problem in income tax auditing, as well as the nature of delegation schemes that may conceivably overcome this problem.

<sup>2</sup> As Holmström (1984) and Melumad and Reichelstein (1987) point out, delegation may be preferred to communication-based centralization, if the former reduces the complexity of contracts or reduces communication costs without impairing organizational performance. Melumad, Mookherjee, and Reichelstein (1989) analyze the value of delegation in the presence of limitations on communication.

<sup>3</sup> See, for example, Kydland and Prescott (1977) for the context of governmental monetary and fiscal policies, and Klein, Crawford and Alchian (1978), Williamson (1985), Baron and Besanko (1987), and Laffont and Tirole (1988) for the context of bilateral contracting and regulation.

Section 3 introduces the formal model underlying our analysis. In Section 4, we derive the nature of optimal mechanisms in the presence of full commitment (hereafter denoted FC). In that context, we show that the revelation principle holds, despite the presence of horizontal equity constraints; in other words, the government can confine attention to mechanisms where taxpayers are asked to report their realized income levels and are induced to report truthfully. This section subsequently characterizes the nature of optimal FC policies. This characterization provides a natural benchmark for the rest of the analysis, and isolates properties employed in later sections to study the feasibility of implementing optimal FC policies in the absence of full commitment.

In order to sharply highlight the nature of the commitment problem, Section 5 considers the case where the government is unable to commit to any dimension whatsoever of its audit policy (this is referred to as the no-commitment (NC) case). We show that, except in the degenerate case where the optimal FC policy involves no auditing, it is impossible for the full-commitment welfare level to be achieved in the no-commitment case. Section 6 then considers the more realistic case of limited commitment (denoted LC), where the government can commit to aggregate dimensions of its audit policy (such as aggregate audit costs, and total collections), but not detailed allocations across taxpayers of different characteristics. We first demonstrate that in the absence of delegation, the full-commitment welfare level cannot be achieved with limited commitment in a large variety of cases. In other words, the government is generally tempted *ex post* to distort the allocation of auditing across different types of taxpayers away from the *ex ante* optimal allocation. We then consider the case where the government delegates authority over audit decisions to an independent manager. It is shown that by choosing a suitable incentive scheme for the manager based only on (publicly observable) aggregate dimensions of audit policy, the full-commitment welfare level can always be achieved as a unique equilibrium outcome in the game between the audit manager and taxpayers. This holds both for managers motivated by salary-based incentive schemes, as well as for bureaucrats motivated by budgetary schemes. Roughly speaking, these incentive schemes work by inducing preferences over allocations (of a given budget) across different types of taxpayers that differ from the government's own *ex post* preferences. The interesting feature of these delegation schemes is that they permit achievement of a higher welfare level despite, being conditioned on aggregate variables to which the government could directly commit to itself had authority not been delegated.

Section 7 concludes the article and there we discuss the shortcomings and possible extensions of our analysis.

Before we proceed, we would like to contrast our work to previous literature on delegation. In the context of monetary policy, Rogoff (1985) has advanced an analogous suggestion; i.e., the government can commit to anti-inflationary policies by delegating authority over money supply decisions to an independent Federal Reserve Board with a conservative chairperson. In a similar vein, Sappington (1986) has studied a regulation model in which the *ex ante* optimal policy involves less auditing than the regulator can commit to. Introducing a bureaucracy—which is represented as an inefficient monitoring device—is then argued to result in a welfare gain. In these analyses, the preferences of the intermediate authority are exogenously specified rather than being subject to manipulation by the principal via the choice of an incentive scheme. To the extent that these exogenous preferences are more closely aligned with the principal's *ex ante* preferences, the commitment benefit of delegation is readily apparent. This benefit is less obvious when preferences of the intermediate manager can be designed by the principal via the choice of a suitable incentive scheme. Such a setting has been the focus of Fershtman and Judd (1986) and Vickers (1987), who argue that precommitment to managerial incentive contracts may enable the owners of two rival firms to collude with one another. What remains an open question in these articles however, is whether delegation is essential. Specifically, would direct commitment by the principal (to the variables over which incentive contracts are written) lead

to inferior performance? As we have argued previously, it is important to ensure that the benefits of delegation schemes do not stem from an implicit assumption of greater commitment ability.

Our analysis also constitutes a new approach to the formulation of tax evasion models. Recent analyses of a government's choice of audit strategies have been split between two distinct approaches. One approach assumes, in the usual principal-agent tradition, that the revenue authority or the government is a Stackelberg leader in its choice of tax-audit schemes, which taxpayers subsequently take as given in deciding what income levels to report (see Reinganum and Wilde (1985a), Border and Sobel (1987), and Mookherjee and P'ng (1989)). The alternative approach assumes that the revenue authority cannot credibly commit to an announced audit strategy, though it can commit to a tax scheme. Rather, it chooses myopically optimal responses to reporting strategies of taxpayers (see Greenberg (1984), Reinganum and Wilde (1985b), and Graetz, Reinganum, and Wilde (1986)). These sequential equilibrium models usually postulate an exogenous objective for the revenue authority, such as net revenue collected. Not surprisingly, the two approaches generate qualitatively distinct conclusions. We depart from the principal-agent approach by assuming that the revenue authority cannot commit to a prespecified audit strategy. Unlike the sequential equilibrium approach, however, we do not take the authority's objective as given. Instead, we allow the government flexibility in manipulating the objective of the revenue authority by choosing a suitable incentive scheme, thus raising the question: what *should* the objective of revenue authorities be? Our results suggest that the maximization of gross collections rather than of collections net of total auditing costs—modified perhaps with penalties for exceeding prespecified budgets—may be a more appropriate objective for revenue collection authorities. From a normative standpoint, our approach suggests a potentially useful symbiosis between principal-agent models and sequential equilibrium models of auditing: the former are useful in describing the *structure* of optimal policies while the latter can be useful in discussing their *implementation*.

## 2. The setting

■ Suppose initially that a government can commit to all relevant policy variables, e.g., tax schedules, audit policies, and penalties for those detected misreporting. The structure of optimal policies in this context has been studied by Border and Sobel (1987) and Mookherjee and P'ng (1989). The following two properties of the optimal solution, in particular, give rise to a severe credibility problem. First, in light of the revelation principle, it suffices for the government to confine its attention to policies inducing truthful reporting. Second, it is optimal for the government to decide whom to audit only *after* observing reports sent by taxpayers. However, because the reports are commonly known to be truthful and because audits impose costs on the government as well as on the taxpayers, both parties have an *ex post* preference for these audits *not* to be carried out. But if taxpayers rationally anticipate that the government will not audit, they will have an incentive to misreport, with consequent welfare losses.

The commitment problem is heightened insofar as optimal policies generally involve random audits, which make it difficult for any taxpayer to monitor deviations of the government from a specified (mixed) strategy. Consequently, commitments cannot be easily enforced through either explicit regulations or reputational forces. This particular problem might be argued to be less severe when the taxpayer population is large: in light of the law of large numbers, taxpayers need only monitor the fraction of reports in different categories audited by the government. In this case, if such information is available in the public domain, audit regulations or reputational phenomena may enable the government to credibly commit to execute *ex ante* optimal audits. If the set of alternative report categories is sufficiently

numerous and complex, however, the public would need access to reliable information about extremely detailed aspects of the government's audit performance. Such information would have the characteristic of a public good, which no single taxpayer would have the incentive to expend resources to acquire. The government may volunteer this information to the public, but it would then have a problem in credibly committing to not overstating audit frequencies.

A more realistic scenario is one where some *aggregate* measures of the government's audit performance are available in the public domain at relatively low cost. For instance, aggregate audit costs incurred, as well as aggregate taxes and fines collected, are variables made publicly available as part of the process of budgetary appropriations and reviews of tax-collection agencies. More detailed information about the *allocation* of these aggregates across different categories of reports are typically not available.

We therefore analyze the situation where the government has the ability to make commitments based on the aggregate audit costs, and on the manner in which they should relate to aggregate revenues or fines subsequently collected. What the government cannot commit to are allocations of these aggregates across different categories of taxpayers and their reports. The government can either retain discretionary authority over detailed allocative decisions, or delegate this authority to an independent agent, hereafter labelled the *manager*. Note that delegation here does not refer to the physical task of executing audits. Rather, it requires the government to abdicate decision-making authority to the manager, who then allocates resources for the auditing of different kinds of income reports.

To demonstrate that delegation may be superior to centralized decision making, we compare the following two organizational forms. In the absence of delegation, the government initially announces the policies to which it can credibly commit: tax schedules, penalties for misreporting, as well as policies involving (or based on) aggregate audit costs and aggregate fines and taxes collected. Then, at the second stage, individual taxpayers decide what income level to report. Finally, the government decides which reports to audit. At this stage it attempts to maximize social welfare *ex post*, subject to its previously stated commitments. In contrast, if authority is delegated to a manager, the government must restrict itself to an incentive or budgetary scheme for the manager. We assume that this scheme can only be based on the *same* aggregates that the government could directly commit to in the absence of delegation, rendering plausible the assumption that the government can commit to this incentive scheme.<sup>4</sup> Both organizational forms are based on the same structure of publicly verifiable information, thereby allowing meaningful comparisons between them. To assert the essentiality of delegation, one must show that the welfare level achievable in a delegation setting dominates the highest possible welfare level in a setting where the principal *directly* commits to the variables on which delegation schemes are based.

For these reasons, we model delegation in the following manner. The government initially announces both tax-fine schedules and the incentive scheme for the manager. At the second stage taxpayers report, and finally the manager chooses an audit policy to maximize his own utility (induced by the chosen incentive scheme).

We demonstrate that in the absence of delegation the government will generally be unable to obtain the welfare level associated with full-commitment to audit policies. That is, for many parameter values there cannot be an equilibrium in the game played between

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<sup>4</sup> This of course requires the assumption that the manager's salary paid by the government is publicly observable. One might argue that this leaves open the possibility of unobserved side-payments between the government and the manager that can "undo" the announced incentive scheme. We feel, however, that there would be difficulties in enforcing any such side-contract, since potential third-party enforcers such as courts cannot monitor such side-payments. Note also that in the no-delegation setting we allow the government's payments to a third party to be publicly observable. Thus, the delegation and no-delegation settings are characterized by exactly the same structure of publicly observable variables on which the corresponding mechanisms are based.

taxpayers and the government that achieves the optimal full-commitment welfare level. In contrast, with delegation the government can always design simple incentive or budgetary schemes for its manager such that the ensuing subgame (between taxpayers and the manager) has a *unique* equilibrium which achieves the full-commitment optimal welfare level.

Two aspects of the latter result deserve special emphasis. First, one could trivially meet the requirement that the delegation scheme should have *at least* one equilibrium which achieves the full-commitment optimal welfare level. For instance, the government could offer the manager a fixed salary contract. Consequent upon truthful reporting by taxpayers, this agent would have no incentive to deviate *ex post* from the *ex ante* optimal audit policy, and the full-commitment solution could be obtained as one possible equilibrium. But the government could hardly rest assured that this equilibrium would result: the game between the taxpayers and manager has many alternative equilibria. Because the manager is completely indifferent between alternative audit policies, *any* audit policy (combined with corresponding best responses of taxpayers) would constitute an equilibrium. As a result, ensuring *unique* implementation of the full-commitment optimal policy is an important criterion which renders our problem nontrivial.

The other interesting feature is that the incentive schemes which suffice are of an extremely simple form. They typically involve a linear bonus for the aggregate fines collected and a quadratic penalty for deviations from budget targets. Alternatively, the budgetary scheme is one where overruns can be approved only if a proportionate amount of aggregate fines are collected. The simplicity of such schemes makes it more plausible that the public should be able to monitor the government's commitment to them.

### 3. The model

■ The population consists of a continuum of taxpayers. Each taxpayer has one of  $n$  possible income levels  $Y_1, Y_2, \dots, Y_n$ , where  $0 < Y_i < Y_{i+1}$  for all  $i$ . The measure of individuals with income  $Y_i$  is  $\lambda_i > 0$ , which is common knowledge among taxpayers and also known to the government.<sup>5</sup> The income of any specific taxpayer, however, is known only to that individual. There are two goods available—one private and the other public. All taxpayers share the same von Neumann-Morgenstern utility function  $U(x) + G(R)$  where  $x$  denotes the consumption of the private good (or post-tax income of the taxpayer), and  $R$  denotes the level of public good. Throughout the analysis we adopt the following assumptions about preferences and feasible consumptions.<sup>6</sup>

#### *Assumption A*

- (i)  $x \geq 0$  and  $R \geq 0$ .
- (ii)  $U$  is twice differentiable with  $U' > 0$ ,  $U'' < 0$ , and  $U'(0) = \infty$ . We normalize  $U$  such that  $U(0) = 0$ .
- (iii)  $G$  is differentiable with  $G' > 0$  and  $G'(0) = \infty$ .

<sup>5</sup> In practice, the distribution of income could change from year to year, and the government may not have perfect knowledge of  $\lambda_i$ . We abstract from this problem, as well as many other important practical considerations, in order to retain a tractable analysis.

<sup>6</sup> Since the income of every taxpayer is positive, the assumption that  $Y_1 > 0$  ensures the existence of an allocation with a positive public good level and positive consumption for every taxpayer. For example, the government could choose a public good level financed by a lump-sum tax scheme where all taxpayers of all income levels are required to pay in taxes a constant positive level less than  $Y_1$ . Since no taxpayer would have incentives to misreport his income, such a scheme would necessitate no auditing. Consequently, a positive level of the public good could be provided. It should be noted that our analysis does not depend on the assumption that individuals can survive with any positive level of consumption, no matter how small. If there exists a minimum income level  $Y_{min}$  necessary for survival, we can replace 0 as the lower bound for consumption by  $Y_{min}$  and renormalize utility so that  $U(Y_{min}) = 0$ .

The government's objective is to maximize a utilitarian welfare function which, owing to the concavity of  $U$ , reflects a concern for both equity and efficiency. Specifically, the government adopts an income tax policy in order to raise revenues for the public good, as well as to redistribute income. Equity considerations require taxes to increase with income, creating an incentive for taxpayers to understate their income. Therefore, the government needs to enforce a tax-fine scheme with a suitable audit policy. Higher tax rates generate stronger incentives for wealthy taxpayers to underreport, thereby necessitating higher audit frequencies. The government's problem is to trade off the welfare benefits from higher levels of public good provision and redistribution on the one hand, and the concomitant increase in audit expenditures on the other.

The government can design a mechanism as follows. Each taxpayer is required to submit a report  $m$  (from a set  $M$  of allowed messages) to the government regarding his income  $Y_i$ , as well as pay an amount  $T_m$  corresponding to the report. The government may subsequently audit the income report at a cost  $C_i$  to this taxpayer and  $A_i$  to the government. When a report is audited, the true income of the taxpayer is discovered.<sup>7</sup> Subsequent to the audit, an additional transfer (depending upon the reported message and the true income of the taxpayer) between the taxpayer and the government may take place.

A *mechanism* is therefore a combination  $\{M, p_m, T_m, F_{im}, R\}$ , where  $M$  is the set of allowed reports,  $p_m$  the probability that report  $m$  will be audited,  $T_m$  the amount paid by the taxpayer corresponding to report  $m$ ,  $F_{im}$  the additional amount paid by a taxpayer who was audited and discovered to have a true income of  $Y_i$ , and  $R$  is the level of public good chosen by the government.<sup>8</sup> We assume that horizontal equity requirements constrain the government to choose deterministic functions  $T_m$  and  $F_{im}$ ; i.e., in the interest of fairness, taxpayers with identical characteristics must be required to transfer identical amounts of resources to the government.<sup>9</sup>

We now discuss the requirements that a mechanism must satisfy in order to be feasible. To begin with, a taxpayer of any given income level must be able to send a report that ensures feasible consumptions for himself. Define  $M_i = \{m \in M \mid Y_i - T_m \geq 0 \text{ if } p_m < 1, \text{ and } Y_i - T_m - C_i - F_{im} \geq 0 \text{ if } p_m > 0\}$  to be the set of feasible messages for income- $Y_i$  taxpayers. Then the first feasibility requirement on a mechanism is that

$$\text{For all } i, M_i \neq \phi. \tag{1}$$

Further, given a mechanism, taxpayers choose a reporting strategy  $q_{im}$ , where  $q_{im}$  denotes the probability that a taxpayer of income  $Y_i$  reports  $m$ . The consequent level of social welfare is:

$$W \equiv \sum_{i=1}^n \lambda_i \sum_{m \in M} q_{im} [p_m U(Y_i - T_m - C_i - F_{im}) + (1 - p_m) U(Y_i - T_m) + G(R)].$$

A mechanism  $\{M, p_m, T_m, F_{im}, R\}$ , combined with a Nash equilibrium reporting

<sup>7</sup> We thus assume that an audit reveals true income with perfect accuracy. See Section 7 for discussion of this assumption.

<sup>8</sup> In general,  $p_m, T_m, F_{im}$  could depend not only on the report of the given taxpayer, but also on the reports of other taxpayers. Our analysis extends straightforwardly to this case as well, provided we restrict the government (on equity grounds) to symmetric mechanisms (in the sense of Hammond (1979)). In a symmetric mechanism,  $p_m$  and  $T_m$  can depend also on  $\mu_m$ , while  $F_{im}$  and  $R$  can depend on  $\mu_m$  and  $\nu_{my}$ , where  $\mu_m$  denotes the frequency distribution of reported messages, and  $\nu_{my}$  denotes the joint frequency distribution of messages and true income for those audited. In order to simplify our notation, we hereafter do not include  $\mu_m$  and  $\nu_{my}$  as arguments of different elements of a mechanism.

<sup>9</sup> See Stiglitz (1982) for a discussion of horizontal equity in the context of taxation, and Ortuno-Ortin and Roemer (1988) in the context of income-tax audits. We note, however, that many of our results extend to randomized mechanisms; see Section 7.

strategy  $q_{im}$ , must satisfy the additional constraints (besides  $0 \leq p_m \leq 1$ ,  $0 \leq q_{im} \leq 1$ , and  $\sum_{m \in M} q_{im} = 1$  for all  $i$  and  $m$ ):

$$R \leq \sum_{i=1}^n \lambda_i \sum_{m \in M} q_{im}(T_m - p_m(A_i - F_{im})). \tag{2a}$$

$q_{im} > 0$

implies  $k = m$  maximizes  $\{p_k U(Y_i - T_k - C_i - F_{ik}) + (1 - p_k)U(Y_i - T_k)\}$ ,  
 subject to  $k \in M_i$ .  $(3)$

Requirement (2a) represents the government’s budget balance constraint that public good expenditure  $R$  cannot exceed net revenues. Requirement (3) is the set of incentive constraints for taxpayers. Given the reporting strategies of other taxpayers, each taxpayer is powerless to affect the net revenue of the government and thus has no impact on the level of public good expenditure. Therefore, the taxpayer’s report maximizes his expected utility from consumption of the private good.

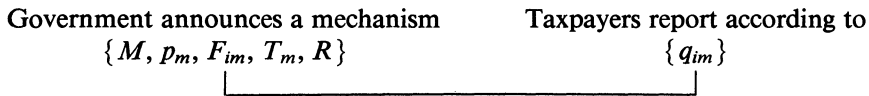
We also assume the legal structure is such that no resources can be transferred to a taxpayer following an audit (i.e., fines can be imposed, but no rewards granted):

$$F_{im} \geq 0. \tag{4}$$

Constraint (4) seems fairly realistic. It also simplifies our analysis considerably. It should be noted, however, that it may be optimal for the government to violate this constraint in some instances, i.e., to transfer resources back to taxpayers consequent upon an audit.<sup>10</sup> Our main results extend to the more general case as well, though the arguments are more complicated. We shall discuss this in the concluding section.

#### 4. Full commitment to audit policies

■ We initially consider the benchmark case where the government moves first and commits to all its policy variables, as in a standard principal-agent model. In this setting the sequence of moves is as follows.



We refer to the combination of a mechanism and an associated reporting strategy,  $\{M, T_m, p_m, F_{im}, R, q_{im}\}$ , as a *policy*. We say that a policy is *FC-feasible* if it satisfies feasibility constraints (1)–(4). Two policies are *equivalent* if they generate identical expected utility from private good consumption for each taxpayer, as well as identical public good levels. The government’s problem is to choose the optimal FC-feasible policy, i.e., maximize  $W$  subject to constraints (1)–(4).

□ **The revelation principle.** Most analyses of the principal-agent problem invoke the revelation principle (see Myerson (1979) or Harris and Townsend (1981)). This states that without loss of generality the government can confine its attention to FC-feasible policies where taxpayers are asked to report their incomes (i.e.,  $M = \{Y_1, \dots, Y_n\}$ ), and are provided incentives to report truthfully (i.e.,  $q_{im} = 1$  if and only if  $m = Y_i$ ). We shall refer to such policies as incentive-compatible revelation policies. Since feasible message sets are type-dependent in our model, we shall add the requirement that the truth is always a feasible

<sup>10</sup> See Mookherjee and P’ng (1989) for an elaboration of this point.

message (i.e.,  $Y_i \in M_i$  for all  $i$ ). The revelation principle is usually established by showing that, corresponding to any FC-feasible policy, there exists an equivalent incentive-compatible revelation policy.

In our context, however, it is not immediately clear that this principle continues to hold. Horizontal equity constraints cause the government to restrict attention to deterministic taxes and fines. Therefore the nonconvexity associated with the incentive constraints (3) may conceivably make randomized reporting strategies for taxpayers optimal, i.e., where  $q_{im}$  lies strictly between 0 and 1 for some taxpayers.<sup>11</sup> An equivalent incentive-compatible revelation policy will then be associated with a randomized tax-fine policy, which would violate horizontal equity constraints. As the following proposition shows however, there is no welfare benefit resulting from taxpayers randomizing their reporting strategies in our model. The government can thus confine its attention to the relatively simple class of incentive-compatible revelation policies.<sup>12</sup>

*Proposition 1. (Revelation principle).* In the full-commitment game, the government can confine its attention to incentive-compatible revelation policies with the additional property that  $F_{ij} \equiv Y_i - T_j - C_i$ , for  $j \in M_i, j \neq i$ . Consequently, the government's problem can be formulated as follows:

Choose  $\{T_i, p_i, F_i, R\}$ , where  $F_i$  denotes  $F_{ii}$ , to maximize:

$$\sum_{i=1}^n \lambda_i [p_i U(Y_i - T_i - C_i - F_i) + (1 - p_i) U(Y_i - T_i)] + G(R)$$

subject to:

(i)  $p_i U(Y_i - T_i - C_i - F_i) + (1 - p_i) U(Y_i - T_i) \geq (1 - p_j) U(Y_i - T_j)$  if  $j \in M_i, j \neq i$ .

(ii)  $R \leq \sum_{i=1}^n \lambda_i (T_i - p_i (A_i - F_i))$ .

(iii)  $Y_i - T_i \geq 0, Y_i - T_i - F_i - C_i \geq 0, F_i \geq 0, 1 \geq p_i \geq 0$ .

*Proof.* We first show that given any FC-feasible policy  $\{M, T_m, p_m, F_{im}, R, q_{im}\}$ , there exists an equivalent FC-feasible policy  $\{M, \tilde{T}_m, \tilde{p}_m, \tilde{F}_{im}, \tilde{R}, \tilde{q}_{im}\}$  with nonrandomized reporting strategies (i.e.,  $\tilde{q}_{im} \in \{0, 1\}$ ). Let  $r(i) \in \underset{\{m \in M_i, q_{im} > 0\}}{\operatorname{argmax}} \{T_m - p_m (A_i - F_{im})\}$ . Choose

$\tilde{T}_m, \tilde{p}_m, \tilde{F}_{im}, \tilde{R}$  equal to  $T_m, p_m, F_{im}, R$ , respectively.<sup>13</sup> Finally, choose  $\tilde{q}_{im}$  such that  $\tilde{q}_{im} = 1$  if and only if  $m = r(i)$ . Then it is easy to check that: (i) the new reporting strategy is an equilibrium under  $\{\tilde{T}_m, \tilde{p}_m, \tilde{F}_{im}, \tilde{R}\}$ , because each agent is atomless; (ii) the new policy is feasible, since feasible message sets  $M_i$  for each type  $Y_i$  of taxpayer remain unchanged, and also because the amount of revenue raised cannot have fallen; (iii) each taxpayer has identical expected utility from consumption of the private good, while public good expenditure is unchanged.

<sup>11</sup> See Stiglitz (1982) for a formal illustration of this point.

<sup>12</sup> Note also that the set of feasible messages for any taxpayer depends on his true income (i.e., a taxpayer with income  $Y_i$  can choose messages only from  $M_i$ ). The standard revelation principle requires all types of taxpayers to have the same set of feasible messages, as shown by Green and Laffont (1986). As Border and Sobel (1987) point out, however, the results of Green and Laffont do not apply because the message spaces in our model are endogenous (as they depend on the tax-fine schedule chosen by the government). In addition, it should be noted that Proposition 1 depends upon the assumption that audit costs ( $A_i$  and  $C_i$ ) are independent of messages reported.

<sup>13</sup> In case  $T_m, p_m, F_{im}, R$  depend on the distributions  $\mu_m$  and  $\nu_{my}$  of reports and audited income levels, choose  $\tilde{T}_m, \tilde{p}_m, \tilde{F}_{im}, \tilde{R}$  to be independent of these distributions, and equal to  $T_m, p_m, F_{im}, R$  evaluated at the distributions  $\mu_m$  and  $\nu_{my}$  induced by the original equilibrium reporting strategy  $q_{im}$ .

Standard arguments then imply that there exists an incentive-compatible revelation policy equivalent to this nonrandomized policy.

Finally, because an incentive-compatible policy has  $q_{ij} = 0$  for all  $j \neq i$  in  $M_i$ , we can set, without loss of generality,  $F_{ij}$  equal to its maximal feasible level, i.e.,

$$F_{ij} = Y_i - T_j - C_i,$$

as this keeps welfare unchanged and continues to preserve the incentive constraints for taxpayers.<sup>14</sup> *Q.E.D.*

□ **Characterization of an optimal incentive-compatible policy.** We can check that an optimal FC-feasible solution exists.<sup>15</sup> We shall now describe some properties of an optimal solution which will be useful for our analysis in the following sections. In the following, the incentive-compatibility constraint corresponding to the incentive of a taxpayer with true income  $Y_i$  not to report  $Y_j$  is denoted by  $IC(i, j)$ .

*Proposition 2.* An optimal full-commitment policy has the following properties.

- (i)  $F_i^* = 0$  for all  $i$ . Taxpayers with identical incomes transfer identical resources to the government, irrespective of whether or not they are audited.
- (ii) All audits are random, i.e.,  $p_i^* < 1$  for all  $i$ .
- (iii) If income report  $Y_i$  is audited, there must exist an income level  $Y_j$  such that  $IC(j, i)$  binds.
- (iv) If income  $Y_i$  is not associated with the highest tax obligation (i.e.,  $T_i^* < \text{Max}_j T_j^*$ ), then  $Y_i$  reports must be audited (i.e.,  $p_i^* > 0$ ).

*Proof.* (i) If  $p_i^*$  equals 0 or 1, we can set  $F_i^* = 0$  with no loss of generality and adjust  $T_i$  accordingly. Suppose  $F_i^* > 0$  for some  $i$  with  $0 < p_i^* < 1$ . We can then reduce  $F_i^*$  to 0 and increase  $T_i^*$  to  $T_i = T_i^* + p_i^* F_i^*$ . Revenues are then unchanged, while the expected utility of a taxpayer with income  $Y_i$ , upon reporting truthfully, is increased (as it corresponds to a mean-preserving reduction in risk). Since  $T_i > T_i^*$ , it is clear that the incentive constraints are preserved because taxpayers at different income levels will derive even lower expected utility from reporting  $Y_i$ . Therefore the new policy is feasible and generates higher expected utility for taxpayers with income  $Y_i$ . The original scheme therefore could not have been optimal.

(ii) Given  $U'(0) = \infty$  and the fact that there exist feasible solutions with positive consumption of the private good for every taxpayer, an optimal solution must be associated with positive levels of consumption, i.e.,  $0 < Y_j - T_j - C_j < Y_j - T_j$  for all  $j$ . Thus, if  $p_i^* = 1$  for some  $i$ ,  $IC(j, i)$  could not bind for any  $j \neq i$ . This allows us to increase revenues and consequently social welfare by reducing  $p_i^*$  slightly without violating incentive constraints.

(iii) This is established by an argument similar to that in (ii) above.

(iv) Suppose that  $p_i^* = 0$  and  $T_i^* < \text{Max}_j T_j^*$ . Take any  $k$  with  $T_k^* = \text{Max}_j T_j^*$ . Because  $k \in M_k$  and  $Y_k - T_i^* > Y_k - T_k^*$ , with  $p_i^* = 0$ , it follows that  $i \in M_k$ . But  $IC(k, i)$  is violated since  $p_k^* U(Y_k - T_k^* - C_k) + (1 - p_k^*) U(Y_k - T_k^*) \leq U(Y_k - T_k^*) < U(Y_k - T_i^*)$ . Consequently, the given policy cannot be feasible. *Q.E.D.*

<sup>14</sup> If the minimum level  $Y_{min}$  of private good consumption necessary for individuals to survive is positive, the maximal feasible level of penalties  $F_{ij}$  for misreporting will be such that taxpayers are left with a post-tax income of  $Y_{min}$  rather than 0.

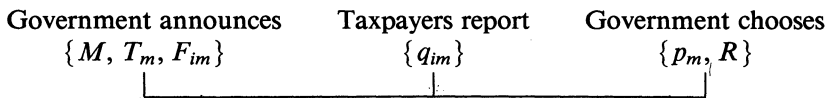
<sup>15</sup> The argument is as follows. Using the reasoning in part (i) of Proposition 2 below, the government can restrict attention to policies where  $F_i = 0$  for all  $i$ . The revenue constraint then implies that tax levels must be bounded from below. On the other hand, the nonnegativity of post-tax consumption requires taxes to be bounded above. Therefore the government can confine attention, with no loss of generality, to a compact subset of the feasible set.

This proposition establishes the following feature of an optimal full-commitment solution. After verification of truthful income reporting, there are no additional transfers between the government and taxpayers because such transfers would imply that the latter bear risk (unnecessary for incentive reasons) associated with the audit decision. The government can preserve net revenues as well as the incentive constraints, while reducing this risk, by eliminating the transfers and increasing taxes.

Proposition 2 highlights the severity of the government's commitment problem with respect to audit policy. Taxpayers prefer not to be audited subsequent to a truthful report because of their personal audit cost  $C_i$ . *Ex post* the government also prefers not to carry out an audit, as it can use the savings in audit cost to increase expenditure on the public good. The ability of the government is further strained insofar as (using (iv) above) every non-lump-sum tax scheme will necessitate some auditing, and (using (ii)) all such auditing must be random. The latter results follow from the fact that the sole purpose of auditing is to deter strategic misreporting by taxpayers: non-lump-sum taxes create such incentives, and thereby necessitate audits. On the other hand, nonrandom audits (i.e.,  $p_i = 1$ ) create excessively strong incentives to report truthfully and therefore waste audit expenditures.

### 5. No commitment to audit policy

■ Before proceeding to the case of limited commitment, in this section we shall consider the other polar benchmark whereby the government is completely unable to commit to its audit policy. We continue to assume that the government can commit to a message space  $M$  as well as a tax-fine scheme  $\{T_m, F_{im}\}$ . The sequence of moves is depicted below.<sup>16</sup>



Given a choice of  $\{M, F_{im}, T_m\}$ , taxpayers and government choose strategies that are best responses to one another. We describe the outcome of this game by a subgame-perfect equilibrium, hereafter referred to simply as an equilibrium. Because the government maximizes social welfare *ex post*, it will not throw away any resources, i.e., it must choose the public good expenditure level according to

$$R = \sum_{i=1}^n \lambda_i \sum_{m \in M_i} q_{im}(T_m - p_m(A_i - F_{im})). \tag{2b}$$

The problem for the government at the last stage, therefore, is to choose audit probabilities  $\{p_m\}$ . Given a reporting strategy  $\{q_{im}\}$  of taxpayers, the government will choose its audit policy to maximize *ex post* welfare. At the same time, given audit policy  $\{p_m\}$ , each taxpayer's reporting strategy must maximize his expected utility, as represented by constraint (3). A policy  $\{M, T_m, p_m, F_{im}, R, q_{im}\}$  is consequently feasible in this setting if it satisfies constraints (1), (2b), (3), and (4), as well as the government's *ex post* incentive constraint:

$\{p_m\}$  maximizes

$$\sum_{i=1}^n \lambda_i \sum_{m \in M_i} q_{im} \{ p_m U(Y_i - T_m - C_i - F_{im}) + (1 - p_m) U(Y_i - T_m) \} + G \left( \sum_{i=1}^n \lambda_i \sum_{m \in M_i} q_{im} \{ T_m - p_m(A_i - F_{im}) \} \right). \tag{5}$$

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<sup>16</sup> In this context, we must amend our formulation of feasible message sets  $M_i$ , as these should be defined independently of the audit policy  $p_m$  (because taxpayers choose reports prior to knowing the government audit policy). Since without loss of generality we may set  $F_{im} = 0$  if  $p_m = 0$  or 1, and since  $C_i + F_{im} \geq 0$ , we can define  $M_i = \{m \in M | Y_i - T_m - C_i - F_{im} \geq 0\}$ .

We refer to such a policy as an *NC-feasible* policy. Because (5) is an additional constraint, it is evident that an optimal NC-feasible policy cannot do better than an optimal FC-feasible policy. The obvious question that arises then is: does there exist an NC-feasible policy that achieves the welfare level associated with the full-commitment solution? One situation where the answer is clearly yes is when the full-commitment solution involves lump-sum taxes (and thus no auditing). The next proposition shows that in all other situations the full-commitment welfare level cannot be achieved.

*Proposition 3.* Assume that an optimal full-commitment solution necessarily involves non-lump-sum taxes. Then there does not exist any policy feasible in the no-commitment setting which achieves the same welfare level as the optimal full-commitment policy.

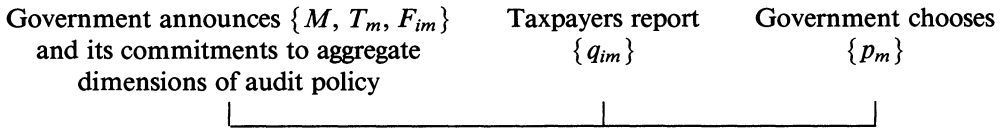
*Proof.* Suppose to the contrary that there exists an NC-feasible policy  $\{M, T_m, p_m, F_{im}, R, q_{im}\}$  which achieves the full-commitment welfare level. Using the argument in the first step of the proof of Proposition 1, it follows that  $q_{ik} > 0$  and  $q_{im} > 0$  imply that  $T_k - p_k(A_i - F_{ik}) = T_m - p_m(A_i - F_{im})$ . Further, given any  $r(i) \in M$  such that  $q_{i,r(i)} > 0$ , the policy  $\{M, T_m, p_m, F_{im}, R, \tilde{q}_{im}\}$  where  $\tilde{q}_{im} = 1$  if and only if  $m = r(i)$  is an optimal FC-feasible policy. Thus, by Proposition 2(i),  $q_{im} > 0$  implies  $F_{im} = 0$ . It then follows from (5) that  $p_m = 0$  whenever  $q_{im} > 0$  for some  $i$ . Therefore we have an optimal full-commitment solution which involves no auditing. As we show in Proposition 2(iv), this contradicts the hypothesis that every optimal full-commitment solution has non-lump-sum taxes. *Q.E.D.*

The intuition behind this result is straightforward: in any policy achieving the full-commitment welfare level, no fines are collected in equilibrium (by virtue of Proposition 2(i)). Consequently, audits do not generate any revenues, while they reduce taxpayers' utilities. Their only benefit is that they deter misreporting. But if taxpayers have already reported their incomes, audits would represent *ex post* deadweight losses. The government would thus not audit any taxpayer at all, and anticipating this, taxpayers would misreport. This leaves open the question of what equilibrium outcomes would result in this setting. We do not pursue this any further because the assumption that the government can commit to aggregate dimensions of its audit policy seems more realistic.

## 6. Limited commitment

■ We now assume that information on the aggregate values of audit expenditures, taxes filed, and fines collected is publicly available. Therefore, the government can commit not only to  $\{M, T_m, F_{im}\}$  but also to the magnitude of the aggregate audit budget, as well as other conceivable actions (in particular, transfers to taxpayers or other third parties) conditioned on these variables. The government cannot, however, commit to the *allocation* of its aggregate audit budget across audits of different kinds of reports. Thus, it may retain discretionary authority over detailed allocation decisions; alternatively, it can delegate this authority to a manager. We shall argue that given such limited capacity for commitment, delegation may prove essential in order to achieve the welfare level associated with the full-commitment solution.

□ **Limited commitment without delegation.** In the absence of delegation, the government retains discretion over the allocation of its audit budget. The government may be able to commit to aggregate levels of its audit expenditures, fines collected, and aggregate taxes collected, denoted  $A$ ,  $F$ , and  $T$  respectively. It could conceivably commit to prespecified functional relations between those aggregates by promising to enact welfare-reducing policies if it fails to meet these commitments. This includes the possibility that the government is able to write contracts with third parties, promising to transfer large amounts of resources to them in the event that it cannot fulfill its stated commitments. The sequence of moves is as follows.



For the government to be able to achieve the full-commitment welfare level in this context, it should be able to design commitments (i.e., choices at the first stage) such that there exists an equilibrium in the ensuing subgame that achieves this welfare level. We do not formulate the precise commitments the government can make in this context: instead, we concentrate on some minimal conditions that any equilibrium in any such game form must satisfy. Let  $\bar{A}$ ,  $\bar{F}$ , and  $\bar{T}$  denote the resulting equilibrium aggregate levels of audit costs, fines collected, and taxes paid. A *necessary* condition for  $\{q_{im}, p_m\}$  to constitute an equilibrium in the subgame is that the government should not have an incentive to deviate from the audit allocation defined by  $p_m$ , given the distribution of reports  $q_{im}$ , and that the levels of  $A$ ,  $F$ , and  $T$  resulting from the new policy equal  $\bar{A}$ ,  $\bar{F}$ , and  $\bar{T}$ , respectively. Since the precise allocation  $\{p_m\}$  is not publicly verifiable, while the aggregate levels  $A$ ,  $F$ , and  $T$  are, any such deviation would not conflict with the government's previously mentioned commitments to relevant aggregates.

Thus, necessary conditions for  $\{p_m, q_{im}\}$  to be an equilibrium are that,

$q_{im} > 0$  implies

$$m \in \operatorname{argmax}_{k \in M_i} \{p_k U(Y_i - T_k - C_i - F_{ik}) + (1 - p_k)U(Y_i - T_k)\}, \quad (3)$$

and

$\{p_m\}$  maximizes (6)

$$\begin{aligned} & \sum_{i=1}^n \lambda_i \sum_{m \in M} q_{im} \{p_m U(Y_i - T_m - C_i - F_{im}) + (1 - p_m)U(Y_i - T_m)\} \\ & + G(\sum_{i=1}^n \lambda_i \sum_{m \in M} q_{im} \{T_m - p_m(A_i - F_{im})\}), \end{aligned}$$

subject to

$$\sum_{i=1}^n \lambda_i \sum_{m \in M} q_{im} p_m A_i = \bar{A}, \quad \text{and} \quad \sum_{i=1}^n \lambda_i \sum_{m \in M} q_{im} p_m F_{im} = \bar{F}.$$

Note that no constraint is imposed by the government's commitment to achieve a given level of total tax collections  $\sum_{i=1}^n \lambda_i \sum_{m \in M} q_{im} T_m$ , as this is independent of the audit policy  $\{p_m\}$ . The outcomes achievable in this regime must obviously constitute FC-feasible policies satisfying (1), (2a), (3) and (4). In addition, the incentive constraint (6) is imposed on the government. We shall call any such policy an *LC-feasible* policy.<sup>17</sup> Clearly, the set of LC-feasible policies is a subset of the set of FC-feasible policies. Consequently, the optimal LC-feasible policy may or may not achieve the full-commitment welfare level. We now investigate conditions under which the full-commitment welfare level can be achieved by an LC-feasible policy. In the following proposition, given a full-commitment solution  $\{T_i^*, F_{ij}^*, p_i^*, R^*\}$ ,

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<sup>17</sup> Note that if the government is able to write arbitrary contracts with passive third parties, contingent on aggregate levels of audit expenditures and revenues collected, the necessary condition (6) is also sufficient for the corresponding policy to be implementable. Therefore the problem of choosing an optimal LC-feasible policy is precisely what the government faces with limited commitment in the absence of delegation.

we refer to the partition of the set of income levels  $I = \{Y_1, \dots, Y_n\}$  into subsets  $I_1, \dots, I_r$ , defined by the property that each subset contains a set of income levels that are pooled, i.e.,  $i, j \in I_h$  if and only if  $p_i^* = p_j^*$  and  $T_i^* = T_j^*$ .

*Proposition 4.* If the full-commitment welfare level can be achieved with limited commitment without delegation, there must exist an optimal solution  $\{T_i^*, F_{ij}^*, p_i^*, R^*\}$  to the full-commitment problem with the following property. There exists a scalar  $K$ , independent of income level, such that for all subsets  $I_h$  of income levels that are audited (i.e.,  $p_i^* > 0$  if  $i \in I_h$ ):

$$\sum_{i \in I_h} \lambda_i [U(Y_i - T_i^*) - U(Y_i - T_i^* - C_i) - KA_i] = 0. \quad (7)$$

The equality in (7) is replaced by  $\geq$  for the set of income levels that are not audited.

*Proof.* See Appendix.

Proposition 4 imposes a condition on the structure of optimal solutions to the full-commitment problem which enables the government to achieve, without delegation, full-commitment welfare levels in this setting of limited commitment. This condition is rather special, and is likely to hold only in exceptional situations. The condition may be interpreted as follows. *Ex post*, the government wishes to minimize the costs imposed on taxpayers by auditing, subject to the constraint of achieving the target aggregate audit cost  $\bar{A}$ . The utility benefit to a taxpayer of income  $Y_i$  from an infinitesimal reduction in the audit probability  $p_i$  is  $U(Y_i - T_i^*) - U(Y_i - T_i^* - C_i)$ , while the effect of this reduction on the aggregate audit budget is proportional to  $A_i$ . These two quantities should thus be proportional to one another in equilibrium (except that we must aggregate over income levels that are pooled).

To demonstrate that condition (7) is unlikely to hold in general, we consider the case where every solution to the full-commitment problem is *fully separating*, i.e., taxpayers of different income levels pay different taxes. Then an LC-feasible policy achieves the full-commitment welfare level only if there exists an optimal full-commitment policy satisfying

$\frac{1}{A_i} [(U(Y_i - T_i^*) - U(Y_i - T_i^* - C_i))] = K$ , for all  $i$ , with equality replaced by  $\geq$  for the income level paying the highest tax. For example, in the case where audit costs  $A_i$  and  $C_i$  are independent of the income level, this condition requires taxpayers belonging to all but one income level to have identical post-tax incomes. That is, the marginal tax rate must equal 100% for most of the range of the optimal tax function. We now show that if audit costs incurred by taxpayers are small, this condition cannot be satisfied by an optimal commitment solution.

*Proposition 5.* Suppose that audit costs are independent of income level (i.e.,  $C_i = C$  and  $A_i = A$ , for all  $i$ ), that the audit cost  $C$  imposed on taxpayers is sufficiently small, and over this range every optimal solution to the full-commitment problem is fully separating (i.e., taxpayers of different income levels pay different taxes). Then, the full-commitment welfare level cannot be achieved by limited commitment without delegation.

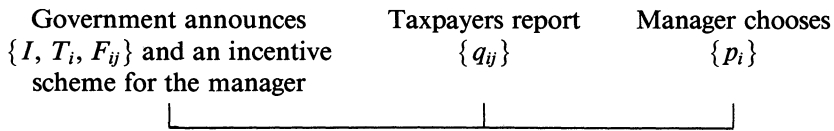
*Proof.* See Appendix.

The reasoning in Proposition 5 can be explained as follows. As we argue above, condition (7) requires that all audited taxpayers must obtain equal post-tax income levels if the optimal commitment solution involves no pooling. This will necessitate excessive auditing, because such steeply progressive tax schemes generate strong incentives for misreporting. In fact, the scheme is excessively egalitarian in the following sense. Tax schemes that are slightly less progressive will lead to small (second-order) reductions in welfare owing to the consequent increase in (post-tax) income inequality, provided  $C$  is small. However, they si-

multaneously permit significant (first-order) reductions in the government's audit costs. Such schemes cannot therefore be optimal in the full-commitment setting.

□ **Limited commitment with delegation.**

*Salary-maximizing managers.* We shall now examine the alternative for the government to delegate discretionary authority over audit policy to an independent manager who is motivated to maximize his salary. To facilitate comparability with the no-delegation case, we assume that information about aggregate audit costs ( $A$ ), aggregate fines collected ( $F$ ), and taxes paid ( $T$ ) is publicly available; therefore that the government can commit to incentive or budgetary schemes for the manager which are based on these aggregates. In order to focus on the commitment value of delegation, we assume there is no moral hazard in the relationship between the government and the manager. In other words, alternative audit policies inflict no personal unobservable costs on the manager. Further, the government chooses a revelation mechanism, so that the set of allowed messages is  $I = \{Y_1, \dots, Y_n\}$ . The sequence of moves is as follows.



Consider the following incentive scheme determining the manager's salary  $S$ :

$$S = \begin{cases} \alpha - \beta(A - A^*)^2 & \text{if } F = 0 \\ \alpha + \beta F & \text{if } F > 0, \end{cases} \quad (8)$$

where  $\alpha$  and  $\beta$  are positive constants,  $A^*$  denotes aggregate audit costs in an optimal-commitment solution (i.e.,  $A^* = \sum_i \lambda_i p_i^* A_i$ ), and  $A$  and  $F$  denote realized aggregate audit costs and aggregate fines, respectively (i.e.,  $A = \sum_i \lambda_i \sum_j q_{ij} p_j A_i$ ,  $F = \sum_i \lambda_i \sum_j q_{ij} p_j F_{ij}$ ). This incentive scheme has a simple interpretation. The manager is induced to maximize fines collected. If he is successful in collecting some fines, then the audit expenditure is disregarded. On the other hand, if no fines are collected, the manager is induced to minimize the deviation from a target budget. Given the reporting policies of taxpayers, the values of  $A$ ,  $T$ , and  $F$  will be deterministic functions of the audit policy  $\{p_i\}$ , since the population of taxpayers is large. Consequently, the manager's salary  $S$  will be a deterministic function of the chosen audit policy;  $\{p_i\}$  will thus be chosen to maximize  $S$ . Note that the government does not need to know the precise utility function of the manager, only that it is strictly increasing in his salary.

Any given choice of tax-fine schemes, combined with an incentive scheme for the manager, induces a subgame between the taxpayers and the manager. The outcome of this game is represented by an equilibrium in which  $\{q_{ij}\}$  satisfies (3), and the manager chooses  $\{p_i\}$  to maximize  $S$ , given  $\{q_{ij}\}$ .

Before we proceed, we shall introduce a regularity condition which rules out exceptional cases where the optimal FC solution takes a particular form.

*Regularity condition (RC).* The optimal FC solution has the property that there exist no income levels  $Y_i, Y_j$  such that  $T_j^* = Y_i - C_i$ .

One would expect that RC is generically satisfied. It implies that fines can be collected from any taxpayer detected cheating (i.e.,  $F_{ij} > 0$  whenever  $q_{ij} > 0$  and  $Y_i - C_i - T_j^* > 0$ ). Correspondingly, the manager can be provided with appropriate incentives by basing his reward on fines collected as in scheme (8). The assumption thus simplifies our analysis considerably and allows the use of delegation schemes of a particularly appealing form. We

stress however, that RC is not essential to our result that delegation schemes based on aggregates can always achieve the FC welfare level. Later in this section we explain how delegation schemes of the form (8) can be amended in case RC is not satisfied.

*Proposition 6.* Assume that RC is satisfied. Suppose the government asks taxpayers to report their income, adopts a tax-fine scheme  $\{T_i^*, F_{ij}^*\}$  corresponding to some optimal full-commitment policy, and chooses the incentive scheme (8) for the manager. Then the ensuing subgame between the taxpayers and the manager has a unique equilibrium where each taxpayer reports truthfully ( $q_{ii} = 1$ , for all  $i$ ) and the manager chooses an audit strategy  $\{p_i^*\}$  corresponding to the optimal commitment policy. Consequently, the full-commitment welfare level can be achieved via limited commitment with delegation.

*Proof.* The proof proceeds through a series of three claims.

*Claim 1. Truthful reporting and  $\{p_i^*\}$  form an equilibrium.*

Given  $\{p_i^*\}$ , which together with  $\{T_i^*, F_{ij}^*\}$  constitutes an FC-feasible policy, no taxpayer has an incentive to deviate from truth-telling. Conversely, given truth-telling, the manager has no incentive to deviate from  $\{p_i^*\}$ , because by Proposition 2,  $F_{ii}^* = 0$ , implying that no audit policy can generate fines. Consequently, the manager must attain a budget level equal to  $A^*$ , and  $\{p_i^*\}$  is a best response.

*Claim 2. There cannot be an equilibrium where taxpayers report truthfully and the manager deviates from  $\{p_i^*\}$ .*

Clearly, if taxpayers report truthfully, the auditor must choose  $\{p_i\}$  such that the target budget level is achieved. Suppose there exists an equilibrium with truthful reporting where the manager chooses an allocation of the audit budget that differs from  $\{p_i^*\}$ , while achieving the same aggregate expenditure  $A^*$ . This implies that if there exists an  $i$  with  $p_i > p_i^*$ , there must also exist a  $j$  such that  $p_j < p_j^*$ . Let  $J = \{j | p_j < p_j^*\}$ . Consider the audit policy  $\{\tilde{p}_k\}$  defined by  $\tilde{p}_j = p_j < p_j^*$  if  $j \in J$ , and  $\tilde{p}_i = p_i^* \leq p_i$  if  $i \notin J$ . By assumption it is optimal for taxpayers to report truthfully given either audit policy  $\{p_i\}$  or  $\{p_i^*\}$ . Therefore

$$\begin{aligned} p_i^* U(Y_i - T_i^* - C_i) + (1 - p_i^*) U(Y_i - T_i^*) \\ \geq (1 - p_i^*) U(Y_i - T_i^*) \quad \text{for all } i \text{ and all } t \in M_i, \text{ and} \quad (\text{a}) \end{aligned}$$

$$\begin{aligned} p_i U(Y_i - T_i^* - C_i) + (1 - p_i) U(Y_i - T_i^*) \\ \geq (1 - p_i) U(Y_i - T_i^*) \quad \text{for all } i \text{ and all } t \in M_i. \quad (\text{b}) \end{aligned}$$

We now claim it is also optimal for every taxpayer to report truthfully under  $\{\tilde{p}_k\}$ . That a taxpayer of income  $Y_i$  will not prefer to report  $Y_i$  is implied in the case that  $i, t \in J$  by condition (b), and in the case that both  $i, t \notin J$  by condition (a). When  $i \notin J$  and  $t \in J$ , we have  $\tilde{p}_i = p_i^*$ , and  $\tilde{p}_t = p_t$ . Thus (a), along with the fact that  $p_t \geq p_t^*$ , implies the optimality of reporting truthfully. Finally, in the case that  $i \in J, t \notin J$  we have  $\tilde{p}_i = p_i$ , and  $\tilde{p}_t = p_t^*$ . Then (a), along with the fact that  $p_i < p_i^*$ , implies the same result. Thus the revelation mechanism defined by  $\{T_i^*, F_{ij}^*, \tilde{p}_i\}$  is FC-feasible. It generates a level of welfare higher than the one corresponding to  $\{T_i^*, F_{ij}^*, p_i\}$ , because  $\tilde{p}_i \leq p_i^*$  for all  $i$ , with strict inequality for some  $i$ . This contradicts the assumed optimality of  $\{T_i^*, F_{ij}^*, p_i^*\}$  in the full-commitment problem.

*Claim 3. There cannot be an equilibrium where a positive measure of taxpayers report untruthfully.*

Suppose to the contrary that there exists an equilibrium with  $q_{ij} > 0$  for some  $i \neq j$ . RC implies that it must be the case that  $Y_i - T_j^* - C_i > 0$ , and thus, by Proposition 1,  $F_{ij}^* = Y_i - T_j^* - C_i > 0$ . Then the manager can collect fines by auditing  $Y_j$  reports. His

optimal response is to choose  $p_j = 1$ , in order to maximize the total fine collected. But  $p_j = 1$  implies that it cannot be optimal for any taxpayer with an income  $Y_i (\neq Y_j)$  to report  $Y_j$ , which is a contradiction. *Q.E.D.*

Delegation works because discretionary authority over audit policy rests with a manager who is concerned only with measures of aggregate audit performance, thus inducing preferences over *allocations* of aggregate audit costs across audits of different income reports that diverge from the government's *ex post* preferences (which include a concern for social welfare). As a result, subsequent to truthful reporting, the manager lacks the incentive to deviate from the *ex ante* optimal audit policy  $\{p_i^*\}$ . Care has to be taken, however, to insure that alternative unwanted equilibria do not arise: the incentive scheme must induce the manager to respond to any misreporting with an increase in auditing so severe that it makes such misreporting unrewarding for taxpayers. This is achieved by imposing no penalty for exceeding budget targets when lies are detected, and allowing the auditor to keep a fraction of the fines he collects.

We now discuss how Proposition 6 extends to the case where the regularity condition RC is violated. In this case, we cannot rule out the possibility of an equilibrium where some taxpayers misreport their income, and yet no fines can be collected from them when they are audited. Consequently, the prospect of raising fine collections cannot induce the audit manager to increase audit frequencies for such taxpayers. The following extension of the scheme (8), however, does ensure that the optimal FC outcome is uniquely implemented:

$$\begin{cases} \alpha - \beta(A - A^*)^2 & \text{if } GC \leq GC^* \\ \alpha + \beta F + \eta A & \text{if } GC > GC^*, \end{cases} \quad (8a)$$

where  $GC$  denotes gross collections, which are equal to total taxes paid plus fines collected (i.e.,  $GC = \sum_i \lambda_i \sum_j q_{ij}(T_j^* + p_j F_{ij}^*)$ ),  $GC^*$  equals the gross collection at the optimal FC solution (i.e.,  $GC^* = \sum_i \lambda_i T_i^*$ ), and  $\beta, \eta$  are positive coefficients. When all taxpayers report truthfully,  $GC$  equals  $GC^*$ , and the manager is then induced to achieve the audit budget  $A^*$ . When taxpayers do not report truthfully and fines cannot be collected from them ( $q_{ij} > 0, j \neq i$ , implies that  $F_{ij}^* = 0 = Y_i - T_j^* - C_i$ ), it must be the case that they voluntarily file higher taxes than if they had reported truthfully (i.e.,  $T_j^* > T_i^*$ , since  $T_i^* < Y_i - C_i$ ). Therefore, in this case, there exist audit strategies which ensure that gross collections will exceed the first-best level  $GC^*$ . Consequently, it will be optimal for the audit manager to increase his audit budget  $A$  as far as possible, deterring all forms of misreporting. Therefore, untruthful equilibria cannot arise.

These incentive schemes however, are sharply discontinuous and therefore may be vulnerable to small mistakes by taxpayers or auditors. For instance, a small fraction of taxpayers who misreport by mistake will induce the manager to significantly over-audit. Before proceeding to discuss how such discontinuities can be avoided, we briefly digress to the case of managers with an alternative set of personal objectives.

*Budget-maximizing managers.* It is often argued that salary maximization does not realistically depict the motivation of public sector managers. Part of the reason is that salary levels, as well as the hiring, firing and promoting of bureaucrats, are structured by a formal career system (such as Civil Service), and are not easy to manipulate (see Moe (1985)). Further, some economists and political scientists (Niskanen (1971, 1975), Miller and Moe (1983), and Stiglitz (1986) among others) argue that bureaucrats are primarily motivated by considerations of personal power and prestige—both of which are closely related to the size of budgets they are empowered to administer—rather than monetary income. This suggests that bureaucratic incentives can be more fruitfully structured via the budgetary process. It is interesting to note, therefore, that a result similar to that of Proposition 6 can

be established for a budget-maximizing bureaucrat. Consider the following flexible budgetary scheme:

$$\bar{A}(F) = A^* + \beta F \quad (9)$$

where  $\beta$  is positive and  $\bar{A}(F)$  denotes the maximum budget allowed as a function of the aggregate fine collected,  $F$ . Implicit in this scheme is the assumption that strong penalties deter the bureaucrat from spending more than the authorized budget, if the resulting level of fines collected is not expected to exceed  $F$ . The bureaucrat is thus induced to choose  $\{p_i\}$  to maximize  $A = \sum_i \lambda_i \sum_j q_{ij} p_j A_i$  subject to  $A \leq \bar{A}(\sum_i \lambda_i \sum_j q_{ij} p_j F_{ij}^*)$ , given  $\{q_{ij}\}$ . An argument analogous to that in Proposition 6 ensures that, under RC, this scheme will also uniquely attain the full-commitment welfare level.<sup>18</sup> A very simple, flexible budgetary scheme thus suffices: the bureaucrat is allowed to exceed his mandated budget  $A^*$  by an amount which depends on the total fines collected. In other words, the bureaucrat has to justify excess audit costs in terms of a certain targeted success rate  $\beta$  of fines collected per unit dollar overspent. It should be noted that this flexibility is essential to avoid multiple equilibria: any misreporting must be responded to with enough auditing to make misreporting an inferior strategy for taxpayers.<sup>19</sup>

*Continuous incentive schemes.* A practical difficulty with incentive schemes of the form (8) or (9) is that they are too draconian. If taxpayers sometimes misreport "by mistake," the manager will respond by auditing *all* such taxpayers (see the argument in the proof of Claim 3 in Proposition 6) and welfare will drop substantially below the full-commitment level. Alternatively, if auditing is not perfect, there is some chance that a taxpayer could end up being charged with misreporting, even if he had actually reported truthfully. The schemes are thus vulnerable to small "mistakes" in reporting and may provide the manager with significant incentives to exploit taxpayers in the presence of auditing errors.

We now show how this "knife-edge" property can be avoided by incentive schemes of comparable simplicity. The "knife-edge" property of (8) is a consequence of its discontinuity at  $F = 0$ , which leads the manager to choose vastly different audit policies in response to small audit errors or changes in reporting strategies. Consider the following continuous incentive scheme for a salary-maximizing manager:

$$S = \alpha + \beta F - \frac{1}{2} \gamma (A - A^*)^2 \quad (10)$$

where  $\alpha$ ,  $\beta$ , and  $\gamma$  are positive constants. Such a scheme has the property that small changes in  $q_{ij}$  will result in the manager modifying his optimal audit strategy only slightly. Alternatively, if taxpayers report truthfully, and auditing is subject to small errors, the manager will not be motivated to strategically over-audit by a significant margin.

We now show that there exist continuous incentive schemes of the form (10) which ensure that the optimal commitment outcome is achieved as the unique equilibrium with the property that taxpayers report truthfully whenever they are indifferent between the truth and some alternative report. Further, the only untruthful equilibria that may exist must involve infinitesimally small fractions of the population reporting untruthfully. Welfare levels achieved in such equilibria are thus arbitrarily close to the full-commitment welfare level.<sup>20</sup>

<sup>18</sup> If RC is violated, then (9) can be suitably amended in an analogous manner.

<sup>19</sup> Graetz, Reinganum, and Wilde (1986) show that lack of budget flexibility leads to the presence of equilibria in the game between taxpayers and the IRS with underreporting.

<sup>20</sup> This is the notion of "virtual implementation" explored recently by Abreu and Sen (1987). The behavioral assumption that agents report truthfully whenever indifferent between the truth and some alternative report is a standard assumption in the principal-agent literature.

*Proposition 7.* Assume that RC is satisfied. Then:

(1) There exists an incentive scheme of the form (10), in combination with taxes and fines  $\{T_i^*, F_{ij}^*\}$  corresponding to a full-commitment solution, which induces a subgame between the taxpayers and the manager with the following properties:

- (a) There is an equilibrium achieving the full-commitment welfare level where the manager chooses  $\{p_i^*\}$  corresponding to the optimal-commitment policy, and taxpayers report truthfully.
- (b) The equilibrium in (a) is the only equilibrium consistent with the assumption that taxpayers report truthfully whenever they are indifferent between reporting truthfully and sending some other report.

(2) For any arbitrarily chosen  $\epsilon > 0$  there exists an incentive scheme of the form (10) satisfying (a) above, with the additional property that all equilibria involve no more than  $\epsilon$  fraction of any category of taxpayers misreporting (i.e.,  $q_{ij} > 0$  implies  $q_{ij} < \epsilon$  if  $i \neq j$ ).

*Proof.* See Appendix.

The idea behind the reasoning in Proposition 7 is that if taxpayers report truthfully then no fines can be collected; consequently the manager will want to achieve the FC budget level  $A^*$ . On the other hand, if the total number of taxpayers misreporting is bounded away from zero, the manager is given sufficient incentive to exceed the audit budget  $A^*$ , provided the bonus rate  $\beta$  associated with fine collection is set large enough.

If RC is not satisfied, the following alternative class of continuous incentive schemes can be used instead of (11):

$$S = \alpha + \beta F - \frac{1}{2}\gamma \cdot (A - A^*)^2 + \eta \cdot A \cdot h(GC - GC^*),$$

where  $h(\cdot)$  is a nondecreasing, continuous real-valued function satisfying  $h(x) = 0$  for  $x \leq 0$ ,  $h(x) > 0$  for  $x > 0$ , and  $\beta, \gamma$  and  $\eta$  are positive coefficients.<sup>21</sup>

## 7. Discussion and extensions.

■ One difficulty in using delegation as a commitment device is that it provides *ex post* incentives to the principal to renegotiate with the manager to whom authority is delegated. This is certainly true of the delegation schemes studied in our article. For instance in (8), the government may attempt to influence the audit manager’s policy choices with the offer of suitable side-payments.<sup>22</sup> If such renegotiations cannot be prevented, then delegation

<sup>21</sup> The proof of Proposition 7 can be extended as follows. Let  $\underline{t}$  denote  $\text{Max}_{ij} |T_i - T_j|$ ,  $\bar{t}$  denote

$$\text{Min}_{\{i,j|T_i \neq T_j\}} |T_i - T_j|$$

and  $\lambda$  denote  $\text{Min}_i \lambda_i$ . Given  $\epsilon > 0$ , choose  $\xi$  satisfying:  $0 < \xi < \frac{1}{2}\lambda\epsilon\bar{t}/[n(n-1) - 1]\bar{t} < \epsilon$ . Then we can set

$\beta$  and  $\gamma$  such that there cannot be an equilibrium with  $q_{ij} > \xi$  for  $i \neq j$  satisfying  $F_{ij}^* > 0$ , as in the proof of Proposition 7. It then follows that if there exist  $i \neq j$  with  $q_{ij} > \epsilon$  and  $F_{ij}^* = 0$ , then  $GC - GC^* \geq \frac{1}{2}\lambda\epsilon\bar{t}$ . By choosing  $\eta$  large enough we can ensure that under the salary scheme

$$S = \alpha + \beta F - \frac{1}{2}\gamma \cdot (A - A^*)^2 + \eta\bar{\theta}A,$$

where  $\bar{\theta} \equiv h(\frac{1}{2}\lambda\epsilon\bar{t})$ , it is optimal for the auditor to audit any report  $Y_k$  with a probability sufficiently close to one, provided that a measure of at least  $\lambda\epsilon$  of the taxpayers report  $Y_k$ .

<sup>22</sup> This is less of a problem for delegation via budgetary schemes of the form represented by (9). The size of the actual budget of the revenue authority is routinely verified by the General Accounting Office, and these figures are released to the public. If the government seeks to reduce the size of the budget *ex post*, such attempts will meet strenuous objections from bureaucrats (provided the budget-maximizing hypothesis has some validity).

may lose its role as a commitment device (see Katz (1987) for an analysis along these lines). The “organization designer,” however, might attempt to set up certain institutions that render more difficult such attempts to renegotiate delegation schemes. For instance, public sector organizations are often instituted in ways that make it more difficult for legislators to manipulate bureaucratic incentives outside the formal budgetary process. Our analysis may thus provide some rationale for the constraints politicians often impose on their own relationships with bureaucrats. Note the following passage from Moe (1985):

“Politicians operate under heavy constraints in their efforts to exercise control over bureaucrats . . . aspects of organization that politicians might wish to manipulate—formal goals, structure, decision procedures—are constrained by legal statutes, and, in the absence of costly and time-consuming new legislative efforts, are effectively beyond their reach in many respects. What is most interesting about these constraints, however, is not simply that they are so confining, but that they are imposed by the politicians upon themselves. Clearly politicians have chosen—presumably in the rational pursuit of their own goals—to structure the formal context of their agency relationship with bureaucrats in such a way that the prospects for control are actually reduced. A simple principal-agent model can only find this kind of behavior paradoxical indeed. . .” (page 768).

An important research task for the future is to extend the approach of this article to the understanding of delegation within large private firms. For example, recent literature on the “ratcheting” phenomenon in contracting and regulation (e.g., see Baron and Besanko (1987) and Laffont and Tirole (1988)) is based on the problem that principals face in setting standards for agents on the basis of past performance. It would be interesting to investigate the extent to which delegation schemes help to ameliorate this problem and the institutional framework necessary to accomplish this.

We have abstracted away from a large number of realistic features of the tax-auditing process. To start with, we assumed that the tax law is unambiguous and each taxpayer knows the true level of his taxable income. Taxpayers are distinguished solely by one characteristic—their income levels—and all taxpayers with the same income incur the same pecuniary cost of being audited. The government knows the audit costs incurred by taxpayers, as well as the distribution of true income in the population. Furthermore, taxpayers do not make mistakes when they file their income tax reports, and neither does the revenue authority while auditing.<sup>23</sup> Taxpayers detected misreporting can be costlessly inflicted with arbitrarily large penalties subject to the constraint of enabling enough consumption for survival. Thus, there is no notion of legal constraints on the size of penalties or ethical notions of letting the “punishment fit the crime.” We abstract from these considerations in order to focus sharply on the commitment aspect of audit policies, as well as to explore the general conceptual issues underlying the value of delegation as a commitment device. More realistic analyses of tax evasion will obviously have to attend to these important considerations.

Our analysis has focused primarily on the potential benefits of delegation. Clearly, evaluating the desirability of a delegation scheme will require consideration of a variety of ancillary costs, such as the salary that the manager has to be paid.<sup>24</sup> A more important shortcoming of our model is that we have abstracted away from costs associated with moral hazard problems. Also, as mentioned above, we have unrealistically assumed that there are no errors in auditing. Our analysis can, however, easily accommodate errors resulting from the government’s failing to recognize an evader when audited. A more serious problem arises when truthful taxpayers may be mistakenly believed by the auditor to have misreported. This may lead taxpayers to expend resources on monitoring the correctness of auditing decisions, and if necessary, challenging them in court. Providing auditors with incentives

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<sup>23</sup> The implications of dropping the latter assumption are discussed in the following paragraph.

<sup>24</sup> To the extent that the manager’s salary represents pure rents, the government could auction off the right to become a manager and thereby reduce these costs.

to maximize gross collections may also generate incentives to exploit taxpayers, increasing the volume of costly legal disputes. Such concerns about the possible abuse of taxpayers by tax auditors are quite common, especially in connection with recent proposals to grant the IRS more autonomy. These concerns are obviously relevant to the assessment of delegation schemes in any realistic setting.

We now describe the consequences of dropping some of the restrictions imposed on the government's choice of feasible schemes. Condition (4) embodied the assumption that the government cannot transfer rewards to taxpayers following an audit. It can be shown, however, that it would always be optimal for the government in a full-commitment framework to reward taxpayers for truthful reporting (see Mookherjee and P'ng (1989)). In fact, after reporting truthfully, taxpayers should strictly prefer to be audited. Allowing the government this additional flexibility would make the analysis of our problem more complicated. Nevertheless, most of our main results still apply. For example, the revelation principle and the optimality of random auditing in the full-commitment solution continue to hold. Further, in the no-commitment setting, the negative result of Proposition 3 also holds. Given limited commitment without delegation, the result of Proposition 4 extends in the following manner. Provided we restrict attention to nonrandomized reporting strategies, the government can achieve the full-commitment welfare level only if there exists a full-commitment optimal solution with the property that there exist scalars  $K, \theta$  (independent of income) such that,  $U(Y_i - T_i^*) - U(Y_i - T_i^* - C_i - F_i^*) = KA_i + \theta F_i^*$  for all income levels  $Y_i$  that are audited. Clearly, the optimal-commitment solution will satisfy this property only in exceptional situations. Furthermore, delegation schemes with limited commitment do implement the full-commitment solution in the following sense. The truthful equilibrium corresponding to the full-commitment outcome is an equilibrium under incentive schemes of the form (8), (9) and (10), and untruthful equilibria do not exist.<sup>25</sup>

If we allow the government to choose randomized tax-fine schedules, the revelation principle and the optimality of random audits also continue to hold. Given assumption (4), it is again optimal for the government not to impose fines on audited taxpayers in equilibrium with any probability. The result of Proposition 3 also extends straightforwardly. Finally, the results on the ability to implement the full-commitment solution by delegation schemes (Propositions 6 and 7) continue to apply. We have not, however, attempted the generalization of condition (7) that characterizes the set of cases where limited commitment can achieve the full-commitment welfare level.

**Appendix**

■ The proofs of Propositions 4, 5 and 7 follow.

*Proof of Proposition 4.* Suppose there exists an LC-feasible policy  $\{M, T_m, \bar{p}_m, F_{im}, R, q_{im}\}$  that achieves the full-commitment welfare level. It then follows (as in Proposition 3) that given any  $r(i) \in M$  such that  $q_{i,r(i)} > 0$ , the policy  $\{M, T_m, \bar{p}_m, F_{im}, R, \tilde{q}_{im}\}$  where  $\tilde{q}_{im} = 1$  if and only if  $m = r(i)$ , is an optimal FC-feasible policy. By Proposition 2(i),  $q_{im} > 0$  implies  $F_{im} = 0$ . It then follows that  $\{\bar{p}_m\}$  maximizes

$$\sum_{i=1}^n \lambda_i \sum_{m \in M} q_{im} \{p_m U(Y_i - T_m - C_i) + (1 - p_m) U(Y_i - T_m)\} + G(\sum_{i=1}^n \lambda_i \sum_{m \in M} q_{im} \{T_m - p_m A_i\})$$

subject to

$$\sum_{i=1}^n \lambda_i \sum_{m \in M} q_{im} p_m A_i = \bar{A}.$$

<sup>25</sup> This leaves open the possibility of a truthful equilibrium which nevertheless does not achieve the full-commitment welfare level, i.e., if the manager deviates from the optimal audit policy (still spending exactly the same budget, and continuing to make truthful reporting an optimal response for the taxpayer), despite deriving no benefit from this deviation. Such an equilibrium would exist only in exceptional cases, though isolating these cases is a difficult task.

That is,  $\{\bar{p}_m\}$  minimizes

$$\sum_{m \in M} p_m \sum_{i=1}^n \lambda_i q_{im} \{U(Y_i - T_m) - U(Y_i - T_m - C_i)\}$$

subject to

$$\sum_{m \in M} p_m \sum_{i=1}^n q_{im} \lambda_i A_i = \bar{A}.$$

Therefore there exists a multiplier  $K$  independent of  $i$  such that

$$\sum_{i=1}^n \lambda_i q_{im} (U(Y_i - T_m) - U(Y_i - T_m - C_i) - KA_i) = 0 \quad \text{for any } m \in M \text{ with } \bar{p}_m > 0, \quad (\text{A1a})$$

with the equality replaced by  $\geq$  for  $m \in M$  with  $\bar{p}_m = 0$  (since  $\bar{p}_m < 1$  by Proposition 2(ii)).

We now show that if  $q_{im} > 0$  and  $q_{ik} > 0$  then  $\bar{p}_m = \bar{p}_k$  and  $T_m = T_k$ . By the argument in Proposition 1, we have  $T_m - \bar{p}_m A_i = T_k - \bar{p}_k A_i$ . Suppose  $\bar{p}_m > \bar{p}_k$ ; then  $T_m > T_k$ . This implies

$$\bar{p}_m U(Y_i - T_m - C_i) + (1 - \bar{p}_m)U(Y_i - T_m) < \bar{p}_k U(Y_i - T_k - C_i) + (1 - \bar{p}_k)U(Y_i - T_k),$$

which contradicts the hypothesis that  $q_{im} > 0$ , given (3).

Partition  $M$  into subsets  $M_1, M_2, \dots, M_S$  such that two messages  $m_1, m_2 \in M_j$  if and only if  $\bar{p}_{m_1} = \bar{p}_{m_2}$  and  $T_{m_1} = T_{m_2}$ . By the reasoning found above, it follows that for each  $i$ , there exists a unique element  $M_{j(i)}$  of this partition such that  $\sum_{m \in M_{j(i)}} q_{im} = 1$ . Thus, for any subset  $M_j$  with  $\bar{p}_m > 0$  for any  $m \in M_j$ , (A1a) implies that

$$\begin{aligned} & \sum_{m \in M_j} \sum_{\{i: q_{im} > 0\}} q_{im} \lambda_i \{U(Y_i - T_m) - U(Y_i - T_m - C_i) - KA_i\} \\ &= 0 \\ &= \sum_{\{i: M_j = M_{j(i)}\}} \lambda_i \{U(Y_i - T_m) - U(Y_i - T_m - C_i) - KA_i\} \sum_{m \in M_{j(i)}} q_{im} \\ &= \sum_{\{i: M_j = M_{j(i)}\}} \lambda_i \{U(Y_i - T_m) - U(Y_i - T_m - C_i) - KA_i\}. \end{aligned} \quad (\text{A1b})$$

Further, corresponding to the partition  $M_1, M_2, \dots, M_S$  of  $M$ , there exists a partition  $I_1, \dots, I_t$  of the set of income levels  $I$  such that, for any  $I_h$ , there is an element  $M_j$  of the partition of  $M$  such that  $I_h = \{i: M_j = M_{j(i)}\}$ , i.e.,  $I_h$  is the set of income levels choosing messages from  $M_j$ . By the argument in Proposition 1, the incentive-compatible revelation mechanism defined by  $T_i^* = T_m$ ,  $F_{ih}^* = F_{im}$ , and  $p_i^* = \bar{p}_m$ , where  $m \in M_{j(i)}$ , is equivalent to the given LC-feasible policy  $\{M, T_m, \bar{p}_m, F_{im}, R, q_{im}\}$  and therefore is a solution to the full-commitment problem. Further, (A1b) equals

$$\sum_{i \in I_h} \lambda_i \{U(Y_i - T_i^*) - U(Y_i - T_i^* - C_i) - KA_i\} \text{ and (7) then follows. } \quad Q.E.D.$$

*Proof of Proposition 5.* Using the result of Proposition 4 and the strict concavity of  $U$ , it follows that in any FC-optimal mechanism there exists a post-tax income  $x > 0$  such that for small values of  $C$ ,  $Y_i - T_i^* = x$  for all  $i$  with  $p_i^* > 0$ , and  $Y_k - T_k^* \leq x$  for any  $k$  with  $p_k^* = 0$ . By hypothesis, there exist income levels  $i$  with  $p_i^* > 0$ , for any small value of  $C$ . Choose  $t$  such that  $p_t^* > 0$  and  $Y_t > Y_i$  for all  $i \neq t$  with  $p_i^* > 0$ . We claim that if  $C < \text{Min}_{i,j} |Y_i - Y_j|$ , then for any  $i$  with

$$p_i^* > 0: (1 - p_i^*)U(Y_i - T_i^*) + p_i^*U(Y_i - T_i^* - C) > (1 - p_i^*)U(Y_i - T_i^*).$$

The reason is that  $Y_i - T_i^* = x$  for all  $i$  with  $p_i^* > 0$ , so the left-hand side is at least  $U(x - C)$ , while the right-hand side is less than  $U(x - Y_i + Y_i)$ , which in turn is less than  $U(x - C)$  if  $C < Y_i - Y_i$ . Using Proposition 2(iii), it follows that there exists a  $k$  with  $p_k^* = 0$  and  $U(Y_k - T_k^*) = (1 - p_i^*)U(Y_k - T_i^*)$ , implying that  $1 - p_i^* = U(Y_k - T_k^*)/U(Y_k - T_i^*)$ . We can now reduce  $T_k^*$  and increase  $T_i^*$  slightly, so as to leave revenues unchanged ( $dT_k^* < 0$  and  $\lambda_k dT_k^* + \lambda_i dT_i^* = 0$ ). This will allow a variation  $dp_t < 0$  in  $p_t$  without violating the incentive constraints for taxpayers. In fact

$$-dp_t = \frac{(1 - p_i^*)U'(Y_k - T_k^*)dT_k^* - U'(Y_k - T_k^*)dT_k^*}{U(Y_k - T_i^*)} > \frac{U'(Y_k - T_k^*)}{U(Y_k - T_i^*)} (-dT_k^*).$$

Given that  $(Y_k - T_k^*)$  and  $(Y_i - T_i^*)$  are bounded (see footnote 15 above), it follows that  $\frac{dp_i}{dT_k^*}$  is bounded away from zero. Hence the effect on welfare is:

$$\begin{aligned} \frac{dW}{dT_k^*} = & -\lambda_k U'(Y_k - T_k^*) + \lambda_i [(1 - p_i^*) U'(Y_i - T_i^*) + p_i^* U'(Y_i - T_i^* - C)] \left( -\frac{dT_i^*}{dT_k^*} \right) \\ & + \lambda_i [U(Y_i - T_i^* - C) - U(Y_i - T_i^*)] \frac{dp_i}{dT_k^*} - \lambda_i G'(R^*) A \frac{dp_i}{dT_k^*}. \end{aligned}$$

Because  $Y_k - T_k^* \leq Y_i - T_i^* = x$ , it follows that  $\frac{dW}{dT_k^*} \leq \lambda_k [U'(x - C) - U'(x)] p_i^* - \lambda_i G'(R^*) A \frac{dp_i}{dT_k^*}$ , and the right-hand side is negative and bounded away from zero as  $C$  approaches zero. Therefore the variation is welfare-improving for  $C$  sufficiently small. *Q.E.D.*

*Proof of Proposition 7.* The argument in Claim 1 in the proof of Proposition 6 establishes Part 1(a) of the proposition. Claim 2 in that proof also establishes that there cannot be any truthful equilibrium where the auditor deviates from  $\{p_i^*\}$ . So what remains is to consider the possibility of untruthful equilibria.

Note first that Part (2) of the proposition implies Part 1(b) because the behavioral postulate in the latter rules out equilibria where taxpayers randomize between truthful and untruthful reporting. Specifically, given the assumption in 1(b), if taxpayers with  $Y_i$  are untruthful, it must be the case that  $\sum_{j \neq i} q_{ij} = 1$ ; so there must exist some

$j \neq i$  such that  $q_{ij} \geq \frac{1}{n-1}$ . Using  $\epsilon = \frac{1}{n-1}$ , 1(b) follows from Part (2). Therefore we need only establish Part (2).

Suppose we are given an  $\epsilon > 0$ . Then we can choose  $\gamma$  and  $\beta$  so that

$$0 < \frac{\gamma}{\beta} < \frac{\epsilon \cdot \lambda \cdot \underline{F}}{(n \sum_h \lambda_h A_h - A^*) \sum_h \lambda_h A_h}, \quad (\text{A2})$$

where  $\lambda = \text{Min}_i \lambda_i$  and  $\underline{F} = \text{Min} \{F_{ji}^* \mid i \neq j, F_{ji}^* > 0\}$ . We claim that there cannot be an equilibrium where  $q_{kj} \geq \epsilon$  for some  $j \neq k$ . Suppose otherwise. The manager then chooses  $\{p_i\}$  to maximize

$$S = \alpha + \beta \sum_i p_i \sum_{j \neq i} q_{ij} \lambda_j F_{ji}^* - \frac{1}{2} \gamma (\sum_i p_i \sum_j q_{ij} \lambda_j A_j - A^*)^2.$$

Let  $A = \sum_i p_i \sum_j q_{ij} \lambda_j A_j$ . Clearly, it is optimal for the manager to choose  $\{p_i\}$  so that  $A \geq A^*$ , because  $\sum_j q_{ij} \lambda_j F_{ji}^* \geq 0$  for all  $i$ . Hence  $\text{Max}_i p_i > 0$ .

We now claim that  $\text{Max}_i p_i < 1$ . Otherwise there exists an  $i$  such that  $p_i = 1$ , which implies from equation

(3) that  $q_{ji} = 0$  for all  $j \neq i$ . Thus  $\sum_j q_{ji} \lambda_j F_{ji}^* = 0$ . Hence  $\frac{\partial S}{\partial p_i} < 0$ , unless  $A = A^*$ . Now we know  $q_{ji} \geq \epsilon$  for some

$j \neq i$ , implying  $\sum_h q_{h1} \lambda_h F_{h1}^* > 0$ . If  $A = A^*$ , then  $\frac{\partial S}{\partial p_1} > 0$ , and it must be the case that  $p_1 = 1$ . But  $p_1 = 1$  implies that it cannot be optimal for type- $j$  taxpayers to report 1, contradicting  $q_{ji} > 0$ . Hence  $p_k = \text{Max}_i p_i \in (0, 1)$ . Thus,

$\frac{\partial S}{\partial p_k} = \beta (\sum_j q_{jk} \lambda_j F_{jk}^*) - \gamma (A - A^*) \sum_j q_{jk} \lambda_j A_j = 0$ , and the manager's optimal response is as follows. Let  $D = \{\text{argmax}_j \sum_{h \neq j} q_{hj} \lambda_h F_{hj}^* / \sum_h q_{hj} \lambda_h A_h\}$ . Then  $p_i = 0$  if  $i \notin D$ , and any choice of  $\{p_i : i \in D\}$  is optimal as long as it satisfies,

$$\sum_{i \in D} p_i \sum_j q_{ij} \lambda_j A_j - A^* = \frac{\beta a}{\gamma}, \quad (\text{A3})$$

where  $a$  denotes  $\text{Max}_j \sum_{h \neq j} q_{hj} \lambda_h F_{hj}^* / \sum_h q_{hj} \lambda_h A_h$ . Note that  $a = \sum_{h \neq k} q_{hk} \lambda_h F_{hk}^* / \sum_h q_{hk} \lambda_h A_h$ . If  $q_{hk} \geq \epsilon$  for some  $h \neq k$ , this implies

$$a \geq \frac{\epsilon \cdot \lambda \cdot \underline{F}}{\sum_h \lambda_h A_h}. \quad (\text{A4})$$

Define  $\tilde{p}_i \equiv 1 - \min_{(j: Y_j - T_j^* > 0)} \frac{U(Y_j - T_j^* - C_j)}{U(Y_j - T_j^*)}$ . Then  $p_i > \tilde{p}_i$  implies that  $q_{ji} = 0$  for any  $j \neq i$ , since for any  $p_j \in [0, 1]$ :

$$p_j U(Y_j - T_j^* - C_j) + (1 - p_j) U(Y_j - T_j^*) \geq U(Y_j - T_j^* - C_j) \geq (1 - \tilde{p}_i) U(Y_j - T_j^*) > (1 - p_i) U(Y_j - T_j^*).$$

We claim there must exist  $i \in D$  such that  $p_i > \tilde{p}_i$ , and thus  $q_{hi} = 0$  for all  $h \neq i$  (contradicting the hypothesis that  $i \in D$ ). If this were not the case, the left-hand side of (A3) would not exceed  $\sum_{i \in D} \tilde{p}_i \sum_j q_{ji} \lambda_j A_j - A^* \leq n \sum_j \lambda_j A_j - A^*$ .

This, together with (A3) and (A4), contradicts (A2). *Q.E.D.*

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