Managerial incentives for compliance with environmental information disclosure programs

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INTRODUCTION

Publicly reported information on the environmental behavior of firms can increase the efficacy of private markets as a mechanism to control environmental malfeasance through liability for harm, consumer demand response, and shareholder reaction. Within the realm of environmental policy, examples exist of both mandatory information disclosure programs such as the EPA's Toxics Release Inventory (TRI), and voluntary programs such as Energy Star (see U.S. EPA, 2001). In the case of mandatory information disclosure programs, firms are required to report information that is potentially damaging to them. Thus, an understanding of firm incentives under such programs is essential to evaluating their performance, improving their design, and motivating the emergence of new programs.

A number of factors have the potential to alter the effectiveness of environmental information disclosure programs in encouraging firms to adopt desirable behaviors. These factors include features related to program design such as the timing of information release, firm characteristics such as size, and the existence of complementary policies such as liability rules. These factors may affect the quantity of firm emissions, the firm's decision of whether to comply with reporting requirements, and the accuracy of reported emissions. Some of the factors that may affect the firm's pollution and/or reporting decision such as financial status, compliance costs, and history of detected violations for example, have received limited attention in the literature (see Shavell, 1984; Beard, 1990; Larson, 1996; Harrington, 1988; Helland, 1998). To date, the

literature has primarily focused on pollution and/or reporting decisions at the firm level. We seek to build on this literature by examining the pollution/reporting decision of individuals within the firm. We argue that a firm's internal organizational structure alters the incentives faced by decision-makers and therefore has the potential to affect their compliance decisions. We adapt a model developed by Gilpatric (2005) to examine these incentives and test the resulting hypotheses using experimental data.

The next section motivates our work with an overview of the information disclosure and tournament literatures. In the third section, we first examine opportunities for malfeasance in the context of information disclosure programs. Then, we turn to the firm's organizational structure and present a model where incentives of lower-level or division managers, who report to an owner-manager, are determined by a rank-order tournament. From this model, we derive testable hypotheses of behavior that vary with the payoffs received by division managers (based on rank and whether a manager is found to have engaged in malfeasance), the probability that malfeasance is detected, and the penalty imposed on a manager caught engaging in malfeasance. We test these predictions using laboratory experiments and report results in the fourth section. In the final section, we offer some conclusions and discuss the next steps in this line of research.

MOTIVATION

Previous studies of information disclosure programs have focused primarily on investigating two empirical questions. First, what is the reaction of investors to the release of information regarding a firm's environmental performance (Hamilton, 1995; Khanna et al., 1998; Konar and Cohen, 2001)? Khanna et al. (1998) list several motivations for this line of research. For

example, investors may expect firms with poor environmental performance to face increased future compliance costs and greater risk of liabilities. In addition, investors may perceive poor environmental performance as an indication of inefficient input use. Regardless of the reason, investors react to information concerning the firm's financial health such that the value of the firm (share prices) tends to fall when adverse environmental information (such as TRI reports) is made publicly available.[1]

The second question relates to the effect of public information disclosure on subsequent firm environmental performance. Using data from the TRI, Konar and Cohen (1997) find that future emissions were lower among firms with the largest stock price decreases on the day of the information release.

Empirical analyses of compliance with information disclosure programs are less common due to the lack of detailed compliance data and the difficulties associated with detecting noncompliance through misreporting rather than through failing to report at all. Estimates from the Government Accountability Office (GAO) suggest that approximately a third of facilities subject to reporting under the TRI during its initial years failed to report (GAO, 1991). However, an analysis of TRI compliance of facilities in Minnesota by Brehm and Hamilton (1996) suggests that ignorance of the requirements of the regulation may better explain violations (measured as failure to report) than evasion. Their analysis suggests that facility size may be an important factor in compliance. They find that both the smallest hazardous waste generators in their sample, who they argue have lower compliance costs, and the firms with the largest sales volumes, who they maintain are more likely to employ a dedicated environmental staff, are less likely to violate. Brehm and

Hamilton also find that subsidiaries of larger companies are less likely to violate, perhaps because the larger company provides environmental and legal staff to the subsidiaries. They maintain that this finding supports the argument that firms with more information (less ignorance) are more likely to comply. However, it seems reasonable that access to parent company environmental and legal staff may also reduce compliance costs thus increasing the likelihood of compliance.

While a potentially important consideration, to our knowledge the literature has overlooked the possible role of a firm's internal organizational structure in creating a divergence between manager incentives and the objectives of an information disclosure program. Consider that many internal reward structures (including promotion ladders) imply that division managers are playing a rank-order tournament game. Lazear and Rosen (1981) show that such mechanisms can induce efficient behavior when all managerial actions directed toward winning the game are in the form of productive effort. However, if purported performance is improved via fraudulent reporting or other malfeasance such as cost savings through higher and unreported toxics releases, compensation mechanisms based on tournament structures can induce managers to engage in such malfeasance. A substantial literature has compared the efficiency of tournaments with alternative incentive schemes, such as piece rates, with regard to such factors as the risk-aversion of workers and the flexibility of the incentive framework to environmental uncertainty (e.g. Nalebuff and Stiglitz, 1983). However, little work has explored incentives in a tournament setting when workers choose not solely how much work effort to exert, but some other aspect of the work that is undertaken. Managers may be able to influence the mean output through choices other than work effort, such as through choice of production process or regulatory compliance.

When monitoring is imperfect it is likely that manager incentives are not perfectly aligned with those of the firm because there are opportunities to increase the probability of winning the tournament by engaging in activities that do not serve the firm's interest. In general, this type of malfeasance may take the form of a manager increasing division profits by illegally dumping waste, failing to adequately maintain equipment, or manipulating accounts to show larger current revenues at the expense of future revenues. All such activities may increase the manager's output as observed by his employer, while imposing potentially large future liabilities on the firm.[2]

In the context of compliance with information disclosure programs (and other regulatory mandates), the program may have sufficient sanctions for non-compliance such that compliance is optimal at firm level assuming the firm can costlessly monitor manager behavior. However, to achieve full compliance it may be very costly to monitor the behavior of division managers.[3] To the extent that non-compliance may improve managers' apparent output or productivity and such behavior is costly to observe, firms face a trade-off as compensation schemes that encourage greater managerial effort also generate an incentive for non-compliance.

The most significant line of research regarding malfeasance in tournament settings involves the exploration of "influence activities": behavior that arises when workers can influence the choice of superiors regarding who is promoted or otherwise rewarded in an organization through actions which are non-productive, ranging from ingratiation to bribery and sabotage of competitors (Milgrom and Roberts, 1988; Prendergast and Topel, 1996; Kim et al., 2002; and Chen, 2003). Such behavior is costly to the firm because it dulls a worker's incentives to exert productive

effort to win the tournament. The malfeasance we discuss here differs from influence activities because it does not derive from an agency conflict (i.e., the fact that the individual making decisions about whom to promote or otherwise reward benefits from the behavior at the expense of the firm). Malfeasance in the form of non-compliance with regulatory mandates, including failing to accurately disclose information, imposes direct costs on the firm that may significantly exceed those resulting from dulled incentives. Environmental malfeasance of course also entails important social costs which do not arise from influence activities within a firm and which are clearly of significant concern to regulators.

FIRM ORGANIZATIONAL STRUCTURE AND INFORMATION DISCLOSURE

Non-compliance and Malfeasance in the Context of Information Disclosure

While the compliance literature has relied primarily on a framework that focuses on firm-level decision-making, the firm may be an inappropriate unit of account. The firm may wish to limit emissions to avoid associated penalties and potential liability. However, any internal organizational structure that includes incentive-based compensation, in which managers' payments depend on their output, may provide managers with incentives to engage in malfeasance. Gilpatric (2005) constructs such a model of the firm to examine the general case of corporate governance. Here, we define malfeasance as a behavior that is inconsistent with the firm's objectives. If managers can increase their *apparent* output (such as the profits from their division) by increasing emissions or reducing care (and thus increasing the probability of accidental emissions) and if this behavior is sufficiently costly for the firm to monitor and prevent such that monitoring is imperfect, then any compensation that rewards managers for

higher output will generate both the intended incentive for them to exert greater work effort, but also an incentive to engage in malfeasance.

We focus on the incentives generated by a rank order tournament compensation scheme (such as promotion ladders) for two reasons: 1) competing for promotion, bonuses, or other rewards is perhaps the most ubiquitous incentive mechanism within firms, and 2) tournaments have the characteristic that players' incentives to "cheat" depends not on the absolute gain from doing so (as would be true for piece-rate compensation, for example) but on the advantage cheating provides relative to competitors. Therefore, in an evenly matched tournament individuals can face a strong incentive to cheat even if doing so achieves only a small output gain if this is sufficient to significantly increase their probability of winning. The opportunities for malfeasance that arise when we extend the model to include internal organization may result in higher levels of overall emissions and/or more frequent misreporting as divisions compete to reduce current production costs.

Let x represent the firm's (owner-manager's) optimal total emissions level. Let z represent the level of emissions that is optimal (at the firm-level) to report to the environmental authority with $z \leq x$. Assume that the firm is composed of N divisions, each of which has a designated manager with the responsibility of reporting emissions for his division to the owner-manger. Let $\hat{z}_i$ represent emissions reported by the ith division manager. $\hat{x}_i$ represents the optimal level of emissions for division i from the perspective of the division manager. The owner-manager reports firm-level emissions to the environmental authority as required by the information

disclosure program. In order to focus on the effect of division manager-level decision-making,

we assume that the owner-manager reports $\hat{z} = \sum_{i=1}^{N} \hat{z}_i$ to the environmental authority.[4]

By considering the emissions and reporting decisions of lower-level managers, we introduce

several opportunities for non-compliance. First, as shown above, non-compliance may result

from behavior on the part of the owner-manager. We do not explicitly model this form of non-

compliance here. Second, even if the owner-manager wishes to report the level of emissions

truthfully, malfeasance on the part of division managers may prevent him from doing so.

Managers are said to be engaging in malfeasance or cheating if they 1) emit more than optimal

from the firm's perspective and/or 2) fail to report their actual emissions. Table 1 illustrates the

possible cheating and non-compliance cases where $\hat{z} = \sum_{i=1}^{N} \hat{z}_i$ represents the level of reported

emissions based on the division manager reports and $\hat{x} = \sum_{i=1}^{N} \hat{x}_i$ is actual emissions of the firm. In

the first three cases, division managers are cheating or engaging in malfeasance. In cases 2 and 3

the firm is misreporting its emissions and therefore is noncompliant with the information

disclosure program. Note that even in cases 1 and 4 where the firm is compliant with the

reporting requirements, the level of emissions need not equal the socially optimal level.

TABLE 1 ABOUT HERE

By adapting the model of Gilpatric (2005), we derive hypotheses regarding the likelihood of

cheating on the part of managers who are playing a rank-order tournament game in terms of their

financial compensation. We make the following assumptions. Division managers are directed to

emit no more than x_i, where x_i represents the optimal level of emissions for division i from the perspective of the owner-manager. They are able to improve their output by increasing emissions up to a level of $\hat{x}_i$. It is costly for the firm to audit the behavior of division managers and it does so with probability η. If managers are found to have "cheated" by emitting more than x_i or by misreporting they are disqualified from winning the tournament (e.g., being promoted) and may also face additional sanction (e.g., being fined or fired). Because managers face the same penalty if found to have cheated regardless of the magnitude of cheating there is no marginal deterrent and the manager's decision reduces to choosing x_i as directed by the firm or cheating by choosing $\hat{x}_i$. In this setting malfeasance always consists of both emitting more than is optimal for the firm and failing to truthfully report emissions (Case 2 above). In what follows, we focus exclusively on the second case in Table 1 above, leaving additional discussion and experimental testing of the remaining cases to future research.

Malfeasance with Managerial Compensation Based on Tournament Payoffs

Gilpatric (2005) develops a model of cheating in a tournament in which identical contestants first choose effort then, after observing their opponents' effort, choose whether to cheat. Cheating is modeled as simply increasing output by a constant. The model developed in that paper shows how the likelihood of cheating depends on the payoffs at stake in the tournament, the variance of output, probability of cheating being detected, number of contestants, and the penalty associated with being found to have cheated. The direction of these effects is generally quite intuitive. The probability of cheating decreases as the probability of detection grows, the gain from cheating decreases, or the cost of being caught cheating increases. However it remains an important question whether these effects are observed empirically and how well the model captures

behavior. One expects that a greater likelihood of cheating being detected or stiffer penalties if caught will deter cheating to some degree, but increasing our understanding of exactly how behavior responds to changes in the competitive framework is quite valuable for understanding how competitive incentive systems can elicit effort while minimizing malfeasance and monitoring costs.

In this paper we consider a special case of the model in which three contestants compete in a rank-order tournament. Contestants play only the second stage of the game in which they choose whether or not to "cheat".[5] Players choose a distribution of output, denoted y, among two distributions, a "high" distribution and a "low" distribution. Cheating entails choosing the high distribution. Here we illustrate this application of the model and show how the predicted probability of cheating is derived conditional on the underlying parameters of the model.

We first develop some notation. An "audit" of contest behavior occurs with probability η, and if an audit occurs all contestants who cheated are discovered to have done so. This parameter represents the intensity of monitoring activity undertaken by the tournament sponsor.[6] If a player is found to have cheated he faces two possible types of sanctions: 1) a cheating player is disqualified from winning the tournament and receives the payoff associated with finishing last; 2) the player may face additional "outside" penalty in excess of any compensation at stake in the tournament. Outside penalties represent such factors as a negative reputation arising from being found to have cheated. Let r represent the outside penalty imposed on a player caught cheating. The contestant with the highest output who is eligible to win (i.e., not caught cheating) receives

payoff w_1, those who do not win but are not caught cheating receive w_2, and a player caught

cheating receives w_2-r. Let s represent the payoff spread, w_1-w_2.

To solve for strategies as a function of the tournament parameters we first identify the minimum

probability of audit that will fully deter cheating. This is found by deriving the audit probability

such that, if a contestant believes his opponents will *not* cheat then he is indifferent between

cheating and not (i.e., his expected payoffs are identical). If the audit probability is greater than

this value, which we will denote η_a, not cheating is a dominant strategy. Let $P(\cdot,\cdot)$ represent

player i's probability of finishing first (but not necessarily receiving w_1 since this probability

does not account for the possibility of disqualification if cheating). The first argument of P

denotes the action of player i and the second argument gives the action of his opponents. Then

player i's expected payoff if he cheats when his opponents do not is $(1-\eta)P(C,NC)S + w_2 - \eta r$

whereas player i's expected payoff if he does not cheat when his opponents do not is

$P(NC,NC)S + w_2$. In this symmetric contest, $P(NC,NC)=1/N$. Finding $P(C,NC)$ is rather more

complicated. In general player i's probability of having the highest draw when he receives a

draw from density function $f(y)$ and faces $N\text{-}1$ opponents k of whom cheat and who each receive

a draw from a distribution $G(y)$ if they do not cheat or $H(y)$ if they do cheat is

$$P_i = \int f(y)(G(y))^{N-1-k}(H(y))^k \, dy. \tag{1}$$

We can now set the expected payoff from cheating equal to that from not cheating to solve for

η_a. The model predicts that cheating will be fully deterred (i.e., a player's dominant strategy is to

not cheat) if the probability of detection is at least

$$\eta_a = \frac{P(C,NC) - 1/N}{P(C,NC) + r/s}. \tag{2}$$

We can employ similar calculations to find the audit probability below which cheating is a

dominant strategy, which we denote η_b. This is the value where player i is indifferent between

cheating and not cheating if he believes all his opponents *will* cheat. Cheating will be a dominant

strategy if the probability of audit is less than

$$\eta_b = \frac{[P(C,C) - P(NC,C)]}{[P(C,C) - P(NC,C)] + (S+r)/S}. \tag{3}$$

Note that $\eta_b < \eta_a$.

For audit probabilities between η_a and η_b there is a unique symmetric equilibrium where each

player cheats with probability ρ such that players' expected payoffs for cheating and non-

cheating are equal. In other words, players are indifferent between cheating and not cheating for

audit probabilities in this range. Note that the more a contestant believes his opponents will cheat

the lower the payoff he receives from cheating and the higher the payoff from not cheating. This

yields the existence of a symmetric mixed strategy equilibrium toward which behavior should

converge over time if the game is played repeatedly and players update their beliefs regarding

the rate of cheating among other contestants. If contestants conclude that their opponents are

cheating more frequently than with probability ρ they will do better to not cheat, and if they

conclude that they are cheating less frequently, they do better to cheat. We now illustrate how we

solve for the equilibrium probability of cheating, ρ, as a function of the tournament parameters.

When player i faces N-1 opponents the probability that k of them cheat given that each opponent

cheats with probability ρ is defined by the binomial function $b(k,N\text{-}1,\rho)$. For expositional ease

and consistency with our experimental application, let $N = 3$. In this context, $P(\cdot,\cdot,\cdot)$ continues to

represent the probability that player i wins the tournament. However, now the first argument

represents player i's strategy and the second and third arguments denote his opponents'

respective strategies. If i does not cheat given each of his opponents cheat with probability ρ,

then his expected payoff is

$$(1-\eta)(S)\left\{\begin{matrix}b(0,2,\rho)P(NC,NC,NC)+b(1,2,\rho)P(NC,NC,C)\\+b(2,2,\rho)P(NC,C,C)\end{matrix}\right\}+$$
$$\eta(S)\{b(0,2,\rho)P(NC,NC,NC)+b(1,2,\rho)P(NC,NC)+b(2,2,\rho)\}+w_2 \qquad (4)$$

In the absence of an audit, the probability of winning (the first bracketed term) is the sum of the

probabilities of winning given each possible combination of cheating and non-cheating

opponents, with each term weighted by the probability of that occurrence. The second term in

brackets, indicating the probability of winning if an audit occurs, is similar except that cheating

opponents are disqualified so the P terms are quite different (and in the final case where both

opponents cheat player i wins with probability 1 if there is an audit). We can similarly find that

the expected payoff to player i if he cheats is in this context is

$$(1-\eta)(S)\left\{\begin{matrix}b(0,2,\rho)P(C,NC,NC)+b(1,2,\rho)P(C,NC,C)\\+b(2,2,\rho)P(C,C,C)\end{matrix}\right\}-\eta r+w_2. \qquad (5)$$

Setting these two expressions equal to each other (as they must be in equilibrium) and

rearranging we have

$$(1-\eta)(S)\left\{\begin{matrix}b(0,2,\rho)[P(C,NC,NC)-P(NC,NC,NC)]\\+b(1,2,\rho)[P(C,NC,C)-P(NC,NC,C)]\\+b(2,2,\rho)[P(C,C,C)-P(NC,C,C)]\end{matrix}\right\}=$$
$$\eta(S)\left\{\begin{matrix}b(0,2,\rho)P(NC,NC,NC)\\+b(1,2,\rho)P(NC,NC)+b(2,2,\rho)\end{matrix}\right\}+\eta r \qquad (6)$$

Solving this equation for ρ provides an expression for the equilibrium probability of cheating given values for η, r, and s. In the next section, we discuss the results of experiments designed to test hypotheses that stem from the theoretical model.

LABORATORY EXPERIMENTS

Testing the theoretical model with field data is clearly problematic for a variety of reasons. Most important of these, perhaps, is that it is impossible to know for certain how much cheating takes place in any context without perfect monitoring of behavior. It is the absence of such monitoring, of course, that describes the circumstances the model seeks to capture. Economics experiments allow us to control the parameters of the competition and observe all behavior by contestants to learn whether they respond as theory predicts. A key to the use of the results of laboratory experiments to inform the policy debate is the precept of *parallelism* (Smith, 1982; Plott, 1987; Cummings, McKee, and Taylor, 2001). We establish parallelism through ensuring that the essential features of the field environment are captured in the lab. The experiments designed for this line of research focus on the strategic elements of the theory: we test behavioral arguments.

Experimental Design

Our laboratory experiments are designed to test the responsiveness of the frequency of cheating to changes in the probability of audit and the imposition of an outside penalty for managers caught cheating. Participants are randomly assigned to three-player groups and play the role of division managers in a rank-order tournament. The decision faced by the participant is whether to receive an output draw from a "low" distribution, $y\sim U[15,45]$, or a "high" distribution, $y\sim U[22,52]$. The choice of a draw from the high distribution corresponds with the decision to

cheat, for example by emitting more than permitted in order to increase productivity but falsely reporting lower emissions. As in the model described in the previous section, the group faces a random audit with probability η. If an audit occurs, cheaters are caught with a probability of one and are disqualified from the tournament. Further, cheaters face an outside penalty, r, which is equal to 0 or 5. The eligible (i.e., non-disqualified) participant with the highest output wins the tournament and receives the highest payoff. In particular, the winner receives a payoff of 19 lab dollars and other participants receive seven lab dollars less any penalty if they are disqualified.

Using the experiment parameters above, we can apply the formulas from the theory section to obtain values for win probabilities for player i. In the case where i cheats and his opponents do not we have that $f(y) = 1/30$ and $G(y) = (y$-$15)/30$ for $22 \leq y < 45$ and $G(y) = 1$ for $y \geq 45$. Thus, the win probability for player i given his opponents do not cheat is

$$P(C, NC) = \int_{22}^{45} \left(\frac{1}{30}\right)\left(\frac{y-15}{30}\right)^2 dy + \frac{7}{30} \approx .562 .$$

In the case where i does not cheat and his opponents do we have that $f(y) = 1/30$ and $H(y) = (y$-$22)/30$ for $22 \leq y \leq 45$ and $f(y) = 0$ for $y \geq 45$, such that the win probability for player i is

$$P(NC, C) = \int_{22}^{45} \left(\frac{1}{30}\right)\left(\frac{y-22}{30}\right)^2 dy \approx .150$$

With $P(C,NC)$ and $P(NC,C)$ in hand, we can solve for η_a and η_b using formulas (2) and (3), respectively. For the case where $r = 0$ we have that $\eta_a \approx 0.407$ and $\eta_b \approx 0.155$. When $r = 5$ we have that $\eta_a \approx 0.234$ and $\eta_b \approx 0.114$. Similarly, using expression (6) above and the parameters of each experimental session we can calculate the predicted frequency of cheating, ρ, in a mixed

strategy equilibrium where one exists (i.e., where the session is not designed to elicit a dominant strategy).

We investigate audit probabilities that fall inside and outside the η_a and η_b ranges above. In particular, for $r = 0$, we include treatments corresponding to $\eta = 0.1$, 0.2, 0.32, and 0.5. As the audit probability 0.1 is less than η_b and 0.5 is greater than η_a it follows that for these parameter values there is a dominant strategy to cheat and not cheat, respectively. Audit probabilities of 0.2 and 0.32 give rise to unique mixed strategy equilibria. For $r = 5$ we include treatments corresponding to $\eta = 0.2$ and 0.3. With $\eta = 0.2$ there is a unique mixed strategy equilibrium whereas for $\eta = 0.3$ there is a dominant strategy to not cheat. The unique mixed strategy equilibria are solved for using formula (6). The design parameters and predicted cheating probabilities for the six treatments are summarized in Table 2.

TABLE 2 ABOUT HERE

Although our theoretical model describes a one-shot game, we allow for possible learning through repeated play over T identical decision periods. Repetition appears to be important here given some equilibrium predictions are predicated on mixing strategies. To thwart motivations for strategic-play and efforts at tacit coordination, in each period participants are randomly and anonymously re-assigned to tournament groups.

Experiment instructions are presented both orally and in writing. Decisions are made via laptop computers using software programmed in z-Tree (Fischbacher, 1999). Note that while we make analogies here to managerial decisions on environmental compliance, instructions use neutral

language. The decision to receive a high draw is not framed as cheating or malfeasance so as not to engender uncontrolled payoffs associated with ethical costs of choosing to cheat. Similarly, we characterize the audit simply as a computer "check" of which distribution was chosen. After each period, the participant receives feedback on: (1) his output; (2) his output rank; (3) whether there was an audit; (4) whether he was disqualified; (5) how many opponents were disqualified; and (6) his payoff.

Ninety-six undergraduate student subjects at the University of Tennessee participated in experiments in the Summer and Fall of 2005. Participants were drawn from a large pool of volunteers and represent a wide range of academic majors. The experiments were conducted in a designated experimental economics laboratory. Sessions consisted of nine to fifteen people, and participants were visually isolated through the use of dividers. Matching was anonymous; subjects were not aware of the identity of the other members of their group. The experiment lasted 30 to 60 minutes, and subjects received average compensation of approximately $15. Due to time considerations, the experiment lasted either 20 or 30 periods.

Experiment Results

The results are summarized in Table 3. As we observe, the subjects do not behave exactly as the theory predicts. In particular, using Wilcoxon tests where the unit of measurement is cheating frequency for the individual over all decision periods, we find that predicted and observed cheating is statistically different for all treatments at the 5 percent significance level, with the exception of Treatment 2. Note that observed cheating probabilities vary very little across rounds such that the results of statistical tests do not depend on which periods are considered.

Nevertheless, our results are generally supportive of the theory as it predicts responses to changes in the audit probability. For example, actual cheating drops from 63 percent (Treatment 2) to 42 percent (Treatment 3) when the audit probability increases from 20 percent to 32 percent. This difference is statistically significant using a two-sample Wilcoxon Test ($z = 2.10$, prob. = 0.036). The effect of an outside penalty appears to be less pronounced. For instance, with $\eta = 0.2$, the penalty decreases cheating by 0.1. However, for $\eta = 0.3$, cheating actually increases by 0.12. In both cases, the effect of the penalty is not statistically significant. Overall there is a tendency towards an indifference between cheating or not, with observed rates of cheating below the predicted level when the theory predicts cheating the majority of the time (Treatments 1 and 2) and observed rates of cheating above the predicted level when the theory predicts cheating a minority of the time (Treatments 3 to 6).

TABLE 3 ABOUT HERE

We turn now to a more formal analysis of individual behavior and estimate a probit model of the decision to cheat. To account for unobserved subject heterogeneity, and to allow for possible distribution misspecification, we estimate the parameter covariance matrix using White's robust "sandwich" estimator adjusted for clustering at the individual level. As participant behavior may be influenced by experience in prior periods, and in particular the feedback received after each period, the model controls for factors related to history of play as well as policy parameters. In terms of policy variables, we include an indicator for the presence of a penalty and a variable corresponding to the audit probability. Feedback variables include the proportion of prior "wins by opponent disqualification" whereby the participant won only as the result of competitors with higher output being disqualified, and the proportion of prior "wins by cheating" whereby the

participant won as a result of cheating. These variables correspond to signals of how background win probabilities change conditional on the decisions of other players. As the effects of the exogenous audit probability and the two subjective win probabilities may have more pronounced short-term effects, we also include three indicator variables corresponding to whether there was an audit, whether the subject won by disqualification, and whether the subject won by cheating in the previous period.

TABLE 4 ABOUT HERE

Table 4 presents our estimated probit coefficients and corresponding marginal effects. As predicted, participants respond to the higher audit probability by reducing their probability of cheating. However, the marginal effect suggests that changes in the audit probability has an effect on cheating less pronounced than predicted by theory. In particular, consider the mean audit probability across all non-penalty treatments, which is about 0.28 with an associated cheating probability of roughly 0.5. If the audit probability is increased (decreased) by about 0.13, the theory predicts a decrease (increase) in cheating by about 0.5. However, the model suggests that observed cheating would only increase (decrease) by 0.06 for such a change in the audit probability. If an individual was audited in the previous period, the model suggests an effect inconsistent with theory: he is *more* likely to cheat in the current period. This is the oft observed "gambler's fallacy" behavior, the presence of which at least partially explains why observed cheating is lower than predicted for low audit probabilities and higher than predicted for high audit probabilities. In particular, according to the estimated marginal effect, the presence (absence) of an audit in the previous period increases (decreases) the probability of cheating by 0.185. Consistent with our nonparametric test results, the presence of the penalty has no

statistically significant effect on the cheating probability. This result is surprising, but has a parallel in the law and economics literature where some studies find that increased penalties for criminal offences (such as the death penalty) have little or no deterrent effect on crime rates (Katz, Levitt, and Shustorovich, 2003).

Additionally, the proportion of wins by disqualification and proportion of wins by cheating statistically decreases and increases, respectively, the probability of cheating. There is nearly a one-to-one relationship, which is quite rational, between changes in these subjective win probabilities and changes in cheating probabilities. In particular, for a 0.1 increase in the proportion of wins by disqualification the model estimates that cheating decreases by 0.08. Similarly, a 0.1 increase in the proportion of wins by cheating corresponds with an increase in cheating by 0.09. As these *ceteris paribu*s interpretations are a bit confounded by the presence of the lagged indicator variables associated with the two subjective probability variables, we note that the changes in cheating become 0.1 and 0.09 when the indicator variables are excluded from the model. Finally, we note that a participant winning by disqualification is even more likely to not cheat in the following period.

IMPLICATIONS AND EXTENTIONS

This paper embarks on preliminary steps towards improving the design and implementation of environmental information disclosure programs. By examining manager-level emissions and compliance decisions, we obtain predictions of firm characteristics, namely features of their organizational structures that induce greater non-compliance with environmental regulations and information disclosure programs.

One implication of our model is that the optimal intensity of regulatory enforcement efforts depends on the magnitude of monitoring and enforcement within firms. Firms with managerial compensation systems that generate strong competitive incentives for cheating despite firm-level compliance with disclosure requirements and other regulatory mandates, and which have little internal monitoring of managerial behavior, merit greater regulatory scrutiny than those which more intensively monitor internal behavior. One might also draw an analogy with enforcement of another type of information disclosure mandate, that of financial disclosure. To a large extent financial disclosure requirements are implemented through the requirement that publicly traded firms are subject to an independent audit by an outside auditor. Audits of behavior by the regulators (i.e. The SEC) are very infrequent. Clearly this system is imperfect, as the recent high-profile accounting scandals involving Enron, WorldCom and others make clear. Nevertheless, it remains true that mandating credible monitoring of internal firm behavior, such as through independent auditing, may be an effective means of increasing compliance with information disclosure and other regulatory requirements.

Our results can inform the debate on the efficient design of auditing procedures for verification of the information reported by firms as required under a mandatory disclosure program. The similarities of the underlying decision structure between compliance with corporate tax regulations and environmental reporting regulations suggests that we can gain some insight on how to design appropriate audits from the tax compliance literature. As Alm and McKee (1998) have argued we can learn a great deal about managerial decisions (especially regulatory compliance decisions) from the extensive research work on tax compliance.

The reporting requirements under the various environmental regulations are applied at the firm level. Our analytical framework examines behavior at the sub-firm (e.g., division) level. However, our work suggests that there are systematic links between the organizational structure of the firm and its overall environmental malfeasance and reporting behavior. Specifically, our work suggests that the method of compensation of divisional leaders and the number and size of divisions will affect the firm's overall level of compliance. For many publicly held firms the general form of the compensation structure will be public information as will be the divisional structure. Our discussion of the effects of rank-order tournament compensation schemes on managerial reporting incentives provides some simple insights for the design of an auditing program.

First, one can improve the efficiency of the audit process through the use of systematic or endogenous audits (selecting firms based on observable characteristics). Stranlund and co-authors (Murphy and Stranlund, 2004, 2005; Stranlund and Dhanda,1999) argue that compliance in an emissions trading environment is independent of firm characteristics. This finding suggests that systematic audit rules will not be productive. However, the emissions trading environment differs from simple information disclosure environments. In the case of emissions trading, targeted enforcement does not enhance efficiency because the market for permits yields an equilibrium price such that there are no differential incentives to evade. No such market occurs in response to mandatory information disclosure programs. For these programs, evasion costs and benefits do differ across firms at the margin and these differences may be reflected in observable firm characteristics as suggested by our theoretical development and experimental

results. The structure of the internal organization, in particular the managerial incentives, will affect the propensity to emit and to underreport.

Second, considerable research in tax compliance behavior (e.g., Alm and McKee, 2004, 1998; Alm, Jackson and McKee 2004, 1992; Alm, Cronshaw and McKee, 1993; Chen and Chu, 2005) has shown that individuals and firms respond in predictable ways to the elements of audit regimes. If the results of this literature apply to the setting of compliance with information disclosure programs, then we would expect increased enforcement effort (such as the use of penalties and random audits) to increase compliance. Of particular relevance to the information disclosure programs is the lag in the audit process. Even if compliance with the *reporting* requirement is perfect (the firm reports exactly what is released), the owner-manager could benefit from releases that lower cost of production if the releases are reported to the public with a sufficient lag. A sufficiently long lag may allow the owner-manager to realize his payoff from the assets owned and exit the firm prior to the release of the information and the subsequent negative effect on the firm's value. This suggests that the reporting period should be shortened and audit resources optimized through the use of staggered reporting dates. In this way, the information concerning emissions would be provided to the market in a timely fashion and the anticipated effects on share values realized quickly.

An important distinction between tax compliance and compliance with information reporting requirements is that, in some cases, non-compliance with reporting requirements could result in damages that are not easily reversed. In the case of income tax evasion, the evader can make the government whole through the payment of back taxes and interest. The government may also

argue for the imposition of additional fines given the incomplete detection and punishment regimes (much like punitive damages in tort litigation). In the case of non-compliance with environmental reporting requirements, *ex post* actions will not likely make the public whole. However, the liability system may apply additional penalties on firms that have violated the regulatory standards and failed to comply with reporting requirements.

Information disclosure programs, such as the TRI, have the potential to achieve significant improvements in the environmental behavioral of firms. The extent to which this potential is realized depends on the extent to which the information is accurate and timely. All firms will wish to report only information that casts them in a favorable light and must be "encouraged" to provide truthful and timely information. Our research is directed to improving the performance of information disclosure programs through both the identification of firm characteristics that are more likely to be correlated with environmental malfeasance and incomplete information disclosure as well as the identification of the properties of information disclosure programs that enhance compliance. The former investigations will suggest ways the audit regimes can be improved while the latter will suggest design elements of the information disclosure program.

ENDNOTES

[1] Of course the market will anticipate positive emissions levels in many cases and the reaction of the market will depend on the extent to which reported emissions differ from expectations.

[2] Nalebuff and Stiglitz (1983) term this issue the influence of prize on choice of technique, but do not model the problem. Stiglitz and Weiss (1981) address a related problem of the influence of the interest rate in bank lending on the risk involved in projects undertaken by borrowers.

[3] Of course the cost of monitoring the regulatory compliance behavior of managers can be thought of as simply one aspect of the total cost of regulatory compliance for the firm. Our point here is to separate the costs of implementing full compliance within the managerial incentive system from the direct costs of regulatory compliance (such as costs associated with using "cleaner" production technology).

[4] Internal environmental auditing procedures may increase the validity of this assumption to the extent that the existence of internal records of division managers' reports discourages the owner-manager from choosing to report a level of emissions inconsistent with these reports. Anton et al. (2004) suggest that elements of the internal organization of firms' environmental programs are important in explaining TRI emissions.

[5] Gilpatric (2005) finds that in equilibrium all players choose identical effort in the first stage of the tournament and therefore play a symmetric cheating game in the second stage. Our focus

here is on testing predicted behavior in this symmetric cheating game. Clearly players may not choose identical effort levels, and other circumstances may well occur which render contestants unequal when choosing whether to cheat, but we leave the study of behavior arising in such a setting to future research.

[6] Gilpatric (2005) discusses how behavior differs when audits are independent and shows that correlated audits as discussed here (in which all players are audited or none are) more effectively deter cheating than independent audits of equal probability.

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TABLES

Table 1. Potential Cheating and Non-compliance Cases

Case	Relationship between x and $\hat{x}$	Relationship between $\hat{x}$ and $\hat{z}$	Are managers cheating?	Is firm compliant with reporting requirement?
1	$\hat{x} > x$	$\hat{z} = \hat{x}$	Yes	Yes
2	$\hat{x} > x$	$\hat{z} < \hat{x}$	Yes	No
3	$\hat{x} = x$	$\hat{z} < \hat{x}$	Yes	No
4	$\hat{x} = x$	$\hat{z} = \hat{x}$	No	Yes

Table 2. Design Parameters by Treatment

Treatment	N per contest	Audit Prob. η	Payoffs: (Win, Not Win, Ineligible)	Payoff Spread (s)	Penalty (r)	Predicted Prob. of Cheating (ρ)
1	3	0.10	(19,7,7)	12	0	1.00
2	3	0.20	(19,7,7)	12	0	0.76
3	3	0.32	(19,7,7)	12	0	0.29
4	3	0.20	(19,7,2)	12	5	0.27
5	3	0.30	(19,7,2)	12	5	0.00
6	3	0.50	(19,7,7)	12	0	0.00

Table 3. Observed Cheating In Experiments

Treatment	# Subjects	# Periods	Observed Prob. of Cheating	Predicted Prob. of Cheating	Wilcoxon Test: Observed v. Predicted (z-statistic)
1	15	30	0.74	1.00	-3.26
2	18	20	0.63	0.76	-1.55
3	18	20	0.42	0.29	2.16
4	18	20	0.53	0.27	2.94
5	12	30	0.54	0.00	3.07
6	15	30	0.46	0.00	3.41

Table 4. Probit Model Results

Variable	Coefficient (Robust Standard Error)	Marginal Effect (Robust Standard Error)
Penalty	-0.115 (0.116)	-0.045 (0.046)
Audit Probability	-1.239* (0.409)	-0.488* (0.160)
Audit in Previous Period	0.485* (0.107)	0.185* (0.039)
Proportion of Wins by Opponent Disqualification in Prior Periods	-1.993* (0.76)	-0.785* (0.299)
Win by Opponent Disqualification in Previous Period	-0.612* (0.152)	-0.239* (0.056)
Proportion of Wins by Cheating in Prior Periods	2.160* (0.321)	0.851* (0.127)
Win by Cheating in Previous Period	0.131 (0.092)	0.051 (0.036)
Constant	0.109 (0.162)	
Wald χ^2 (7 d.f.)	131.20*	
Pseudo R^2	0.118	
Number of Observations	2244	

An asterisk indicates the parameter is statistically different from zero at the 5% level.