Corporate Disclosure of Environmental Liability Information: Theory and Evidence*

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Abstract. The decision to disclose information concerning a firm's environmental liabilities is modeled as a sequential game involving the firm, a capital market, and outside stakeholders who can impose proprietary (political) costs on the firm. A partial disclosure equilibrium is derived in which firms reveal information strategically, maximizing the share-value net of expected political costs. Inherent uncertainty regarding the existence and size of the liabilities creates a setting where outsiders are uncertain if management is informed about these liabilities, so firms can plausibly withhold "bad news", that is, they do not disclose liabilities that exceed a threshold level. Three novel hypotheses are that a firm is more likely to disclose as (1) its pollution propensity increases, (2) outsiders' knowledge of its environmental liabilities increases, and (3) the risk of incurring proprietary costs decreases. Empirical support is found for the hypotheses, based on the accounting disclosures made by sample firms selected from the records of the Ontario Ministry of the Environment and Energy.

Improved accounting and auditing standards for environmental disclosure would build on at least three implications of the study:

(1) To the extent that inherent uncertainty leaves managers with discretion as to what to disclose, the partial disclosure equilibrium result suggests that not all firms will comply with disclosure standards.

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Publishing broad environmental performance indicators for companies in non-accounting outlets would increase public awareness of a manager’s private information endowment, making voluntary accounting disclosures of the liabilities more likely.

If a significant decline in stakeholder tolerance of pollution occurs, the expected proprietary costs of disclosing increase, and companies become less likely to disclose.

Condensé
Les études ont, jusqu'à maintenant, fait état de distorsions et d’incohérences dans l’information publiée par les entreprises en matière d’environnement et en ont déduit que cette information ne reflétait pas la performance réelle des entreprises. Les autorités responsables de la réglementation en ce qui a trait aux valeurs mobilières et de l’adoption de normes de comptabilité ont tenté de redresser la situation, mais les entreprises responsables de la réglementation en ce qui a trait aux valeurs mobilières et de l’adoption de normes de comptabilité ont tenté de redresser la situation, mais les entreprises demeurent réfractaires à la publication d’information. Les auteurs de la présente étude proposent un modèle explicatif de cette résistance observée des entreprises à la publication d’information concernant leur responsabilité en matière d’environnement. Ils n’étudient cependant pas la question des techniques d’évaluation. Ils tiennent compte dans leur modèle de trois facteurs susceptibles d’influencer les décisions de la direction en ce qui a trait à la publication d’information : l’incertitude inhérente à l’évaluation de la responsabilité de l’entreprise en matière d’environnement, la propension de l’entreprise à la pollution, et le risque qu’elle court de devoir assumer les coûts liés à l’impact de ses activités sur l’environnement, en publiant de l’information relative à sa responsabilité en matière d’environnement. Le modèle est testé à l’aide de données puissées dans les registres de contrôle du ministère ontarien de l’Environnement et de l’Énergie (MOEE). Les hypothèses dérivées du modèle sont étayées par des données empiriques.

Modèle de publication d’information

L’information relative à la responsabilité de l’entreprise en matière d’environnement est une information stratégique, du fait que les groupes intéressés à la protection de l’environnement pourraient s’en servir comme argument pour obliger les entreprises à assumer les coûts de la pollution dont elles sont la cause et, par exemple, militer en faveur d’un durcissement de la législation ou du boycott des produits de l’entreprise. En outre, la responsabilité des entreprises en matière d’environnement est associée à une extrême incertitude à l’égard d’au moins trois aspects de la question : l’aspect légal, l’aspect technique et l’aspect politique. Cette incertitude inhérente fait en sorte qu’il est impossible d’évaluer avec précision la responsabilité de l’entreprise en matière d’environnement. Il est donc plausible de croire que les entreprises puissent juger préférable de taire les « mauvaises nouvelles » en matière d’environnement, étant donné que les tiers ne peuvent se prononcer, sans engager de coûts, quant à savoir si : a) la direction connaît la mesure de sa responsabilité mais retient délibérément l’information ou si b) l’incertitude a empêché la direction de prendre conscience de l’existence de sa responsabilité ou, en supposant qu’elle connaisse cette responsabilité, d’en évaluer avec précision les conséquences financières.
Le modèle de publication d’information fait intervenir trois parties : un ensemble d’entreprises dans un secteur d’activité caractérisé par une propension donnée à la pollution de l’environnement ; un groupe d’investisseurs neutres à l’égard du risque ; et un opposant partageant la même information que les tiers investisseurs. L’opposant est préoccupé par la performance des entreprises en matière d’environnement ; il peut s’attaquer à une entreprise, en l’obligeant même à assumer les coûts liés à l’impact de ses activités sur l’environnement s’il découvre que la responsabilité de cette dernière excède un certain seuil de tolérance.

La variable aléatoire $y$ représente l’avoir des actionnaires, c’est-à-dire la valeur de l’entreprise après déduction du passif, dont le passif lié à sa responsabilité en matière d’environnement. La fonction de distribution cumulative de $y$, $G(y)$, dont la moyenne est égale à $\mu$, est connue de tous les intervenants ; $\mu$ est interprétée comme étant la propension à polluer qui caractérise les entreprises du secteur. Une proportion $p$ ($0 < p < 1$) des entreprises connaît la valeur de $y$, mais l’opposant et le marché ignorent si une entreprise donnée en est ou non informée. Les entreprises peuvent publier de l’information crédible relative à l’environnement à l’intention du marché et de l’opposant, mais elles ne peuvent mentir, et elles choisissent leur stratégie de publication d’information en vue de maximiser l’avoir des actionnaires.

Comme dans Dye (1986) ainsi que dans Jung et Kwon (1988), la stratégie d’équilibre en ce qui a trait à la publication d’information est définie de telle sorte que l’entreprise publie l’information si $y > \xi$ et retient l’information si $y \leq \xi$, $\xi$ représentant le seuil de publication d’information au point d’équilibre. L’opposant décide de sa cible après avoir observé les comportements de publication ou d’abstention des entreprises. Sa décision est représentée par une fonction binaire $\delta(y)$, où $\delta(y) = 1$ s’il attaque et $\delta(y) = 0$ s’il s’abstient. Le symbole $K$ représente le niveau de tolérance de l’opposant en ce qui a trait aux responsabilités en matière d’environnement. Une attaque peut “porter” si $y < K$ et que le coût $C$ est imposé à l’entreprise par l’opposant. Ainsi, lorsqu’une entreprise publie une valeur de $y$, l’opposant l’attaque et lui impose le coût $C$ si $y < K$. Dans le cas de l’abstention, la probabilité qu’une attaque porte est déterminée par $\Gamma(N)$, la probabilité ultérieure de $y < K$, s’il y a absence de publication.

Le marché réagit à la décision de l’entreprise en matière de publication d’information et à l’attaque de l’opposant, ce qui fait varier la valeur $V$ de l’avoir des actionnaires de l’entreprise de la façon suivante :

$$
V = y - \delta(y)C \\
V = E (y|N) - \Gamma(N)C
$$

Ainsi, deux facteurs peuvent inciter les entreprises à retenir les mauvaises nouvelles : la volonté de retarder l’évaluation négative de $y$ par le marché et celle d’éviter le coût $C$ lié à l’impact des activités de l’entreprise sur l’environnement. Ces incitatifs se renforcent l’un l’autre, puisque la publication de mauvaises nouvelles pourrait aussi déclencher, de la part de l’opposant, une attaque qui porterait. Plusieurs propositions sont dérivées du modèle qui précède, à partir de la notion d’équilibre séquentiel (Kreps et Wilson, 1982) :

1. Ni l’abstention ni la publication complète ne fait partie d’un équilibre séquentiel.
2. Il existe un équilibre de publication partielle (un seuil unique de publication), lorsque les conditions s’y prêtent, les résultats statiques comparatifs étant les suivants :
   a) Le seuil de publication d’équilibre augmente (la publication devenant moins probable) si $K$ augmente de manière notable (c’est-à-dire lorsque l’opposant devient sensiblement moins tolérant à l’égard des responsabilités en matière d’environnement).
b) À mesure que $p$ augmente (davantage d'entreprises étant informées), le seuil de publication d'équilibre diminue (la publication devenant plus probable).

c) Une augmentation dans la propension à polluer $\mu$ incite davantage à la publication.

Les tests empiriques

Les prédictions a, b et c du modèle ont été testées à l'aide des données tirées des registres de contrôle du MOEE relativement à trois activités : les arrêts d'une autorité administrative, les poursuites en matière d'environnement et les déversements de polluants dans l'environnement. L'échantillon final contenait 41 arrêts, 46 poursuites et 19 déversements importants pour la période s'échelonnant de 1982 à 1992, mettant en cause au total 49 entreprises cotées à la Bourse de Toronto. Il est important que l'information relative à ces événements provienne du MOEE, de sorte que les décisions de publication des entreprises puissent être vérifiées en toute indépendance et que leurs conséquences monétaires potentielles soient incertaines.

Les auteurs supposent que la distribution du seuil de publication est logistique, dans un échantillon représentatif d'entreprises ; la publication est donc mesurée à titre de variable muette qui prend la valeur 1 si l'entreprise a traité de l'incident touchant l'environnement et de l'incidence de ce dernier sur l'exploitation ou la situation financière de l'entreprise, dans les rapports qu'elle a soumis à la Commission des valeurs mobilières de l'Ontario, et une valeur de 0 si elle s'en est abstenue. Les auteurs ont eu recours à un modèle logit transversal pour estimer les conséquences de trois facteurs qui, par hypothèse, influent sur le seuil de publication. Les auteurs ont procédé comme suit pour évaluer ces facteurs :

- a) Le risque que l'entreprise doive assumer les coûts liés à l'impact de ses activités sur l'environnement a été évalué, au moyen d'une variable muette, comme étant de 0 (ce qui suppose un opposant plus tolérant) dans le cas des arrêts d'une autorité administrative et de 1 (ce qui suppose un opposant moins tolérant) dans le cas des poursuites et des déversements, compte tenu du fait que les arrêts ne sont pas le résultat d'une faute de l'entreprise, tandis que les poursuites résultent d'une transgression de la législation relative à l'environnement et que les déversements représentent une agression directe contre l'environnement.

- b) La perception des tiers à l'égard de la probabilité que l'entreprise $i$ dispose d'information privilégiée a été évaluée à partir du pourcentage des articles publiés dans les médias en ce qui a trait au comportement de l'entreprise $i$ en matière d'environnement.

- c) La propension à la pollution a été évaluée au moyen d'une variable muette prenant la valeur de 1 si l'entreprise est assujettie à la loi de la Municipal and Industrial Strategy for Abatement (MISA) de l'Ontario et de 0 dans le cas contraire.

Résultats, analyses de sensibilité et limitations

Seulement 35 % des incidents de l'échantillon ont donné lieu à la publication d'information. Les résultats de l'application du logit confirment les hypothèses dérivées du modèle. Les analyses de sensibilité suggèrent que les résultats ne sont pas touchés par le durcissement de la législation relative à l'environnement en 1990, par la taille réduite de l'échantillon ayant servi au contrôle de la régularité des données, et par une mesure de rechange de deux variables servant à l'évaluation. Toutefois, le coefficient estimé du risque que l'entreprise doive assumer les coûts liés à l'impact de ses activités sur l'environnement est devenu non significatif avec la mesure de rechange.

Conclusions

Les constatations des auteurs confirment les prédictions du modèle, puisqu'elles suggèrent que les entreprises usent de stratégie dans la publication d'information en ce qui a trait à leur responsabilité en matière d'environnement. Ces résultats peuvent avoir
trois conséquences pour l’établissement de normes de comptabilité et de politiques gouvernementales axées sur la publication d’information relative à la responsabilité des entreprises en matière d’environnement :

1. Dans la mesure où l’incertitude inhérente à l’estimation des responsabilités laisse une certaine marge de manoeuvre aux membres de la direction en ce qui a trait à l’information devant être publiée aux fins comptables, toutes les entreprises ne se conforment pas nécessairement aux normes de publication de l’information.

2. La publication régulière d’information sur la performance de l’entreprise en matière d’environnement, dans des documents qui ne sont pas de nature comptable, serait un moyen efficace d’encourager la publication d’information comptable, si cette option sensibilisait davantage le public au fait que la direction peut être en possession d’information de cette nature.

3. S’il se produisait un déclin marqué de la tolérance des groupes intéressés à la protection de l’environnement, les coûts estimatifs liés à l’impact des activités des entreprises sur l’environnement que ces dernières devraient assumer par suite de la publication d’information augmenteraient, et les entreprises seraient moins enclines à publier de l’information. Par conséquent, ces groupes d’intérêt décurgeraient la publication d’information si l’on s’attendait, de leur part, à un zèle excessif dans leur attaque contre les sociétés soupçonnées de pollution.

Enfin, bien que le modèle soit axé précisément sur les responsabilités en matière d’environnement, il peut expliquer d’autres décisions de l’entreprise quant à la publication d’information concernant certains éléments de passif éventuels supposant à la fois de l’incertitude et le risque que l’entreprise doive assumer des coûts liés à ses activités ou des coûts politiques.

The measurement and disclosure of firms’ environmental liabilities are major accounting issues (UN 1992; Owen 1992; CICA 1993). The existing literature suggests the widespread reluctance of corporations to disclose such liabilities (UN 1992, 2), and generally accepted measurement standards have yet to emerge (Milne 1991; Cropper and Oates 1992; Barth and McNichols 1994). This study develops a model to explain firms’ observed reluctance to disclose, partially filling a lacuna in the literature that was noted by Ullmann (1985). It does not, however, address the issue of how to measure environmental liabilities.

The paper is organized as follows. After a brief review of the prior empirical literature that motivated the study and a description of the institutional environment, a model of companies’ disclosure incentives is developed, with most of the technical material relegated to Appendix 1. Next, empirical support is found for hypotheses derived from the model, and the paper concludes with limitations and implications of the findings for developing disclosure standards.

Prior empirical literature

Four survey studies have reported bias and inconsistency in companies’ environmental disclosures. Price Waterhouse found that 62 percent of a sample of securities issuers knew they were exposed to environmental liabilities but did not mention the liabilities in financial statements (Roberts 1993). Similarly, Rockness, Schlacter, and Rockness (1988) found that, of 21 chemical companies reporting on-site waste in a U.S. congressional survey, none disclosed contingent liabilities in financial statement notes, and only three mentioned finan-
cial (Superfund) commitments elsewhere in the annual report. Surma and Vondra (1992) found that only 12 percent of 125 major U.S. companies surveyed would disclose estimates of cleanup liabilities discovered by regulatory authorities, whereas a mere 2 percent would do so if such estimates were obtained internally. Harde and Owen's (1992) study of 30 U.K. companies also suggested that companies were reluctant to disclose "bad" environmental news.

Three other studies concluded that firms' environmental disclosures did not reflect their actual performance. Ingram and Frazier (1980) scrutinized 40 U.S. firms that were being monitored by the Council on Economic Priorities (CEP) in 1977. The extent of disclosure (measured by a content index) was unassociated with environmental performance (measured by a pollution control index that had been developed by the CEP). Using similar methods, Wiseman (1982) reported an insignificant association between the CEP's environmental performance ranking and another index that ranked the quality of environmental disclosures. Finally, Freedman and Wasley (1990) canvassed both voluntary disclosures in the annual reports and mandatory disclosures in the 10-K reports of U.S. companies in four polluting industries. Neither medium contained disclosures that reflected firms' environmental performance.¹

Securities regulators and accounting standard setters have tried to redress the inadequacy in disclosure that these studies imply. Yet, reluctance to disclose persists. As a prelude to the present study, interviews were conducted with officials from the Ontario Ministry of the Environment and Energy (MOEE). The interviews revealed that some firms had asked the ministry not to issue press releases after it served them with pollution control orders. The premise of the study is that, to develop and enforce disclosure standards, regulators must take into account the special nature of information concerning environmental liabilities and the consequent incentives for disclosure or nondisclosure.

Institutional background
In Ontario, the authority of the MOEE to monitor and enforce environmental legislation stems from the Environmental Protection Act (EPA) the Revised Statutes of Ontario (RSO), 1980 and other related laws. The EPA became more stringent with 1990 revisions (R.S.O. 1990) that coincided with the election of the New Democratic Party in Ontario. The 1990 revisions reflected higher societal expectations; therefore, environmental liabilities would be expected to increase after 1990. Empirical controls for this change in legislation are described in the results section of this paper.

Canadian accounting standards are another source of regulation. The Canadian Institute of Chartered Accountants (CICA) Handbook requires companies to accrue material loss contingencies if they are both likely to occur and estimable (s. 3290.12); if they are likely to occur, but are not estimable, disclosure is required for material items (s. 3290.15). However, the inherent uncertainty about the potential materiality of environmental liabilities (described in a later section of the paper) still leaves managers with discretion

In response to a perceived reluctance of firms to disclose environmental liabilities, the Ontario Securities Commission (in *OSC Policy Statement 5.10*, 1990) enhanced the requirements for companies to discuss environmental concerns in OSC filings. Barth et al. (1995) discuss a similar increase in disclosure enforcement by the Securities and Exchange Commission (SEC) starting in 1990. Again, this shift over time in disclosure standards called for appropriate controls in the empirical tests conducted in this paper.

**Prior disclosure models**

It has long been known that economic agents will voluntarily reveal private information to distinguish themselves from the worst types (Akerlof 1970; Spence 1973; Milgrom 1981). When credible signals are feasible, full disclosure is optimal (Dye 1986, 331). Two factors, however, can result in partial disclosure: proprietary costs and outsiders' uncertainty concerning whether firms have received private information. This paper extends the literature by incorporating both factors simultaneously and developing a model that explains the partial accounting disclosure of environmental liabilities.

**Proprietary costs**

Verrecchia (1983) showed that firms would withhold information to avoid incurring an exogenous proprietary cost. A partial disclosure equilibrium would occur because uninformed observers could not tell if the information was withheld because it was (1) "bad news" or (2) "good news", but not good enough to warrant incurring the proprietary cost. Darrough and Stoughton (1990), Wagenhofer (1990), and Feltham and Xie (1992) extended this model to encompass endogenous proprietary costs, showing that either partial or full disclosure could occur. In the models derived to date, however, proprietary costs have stemmed from disclosing good news that could benefit competitors in a market-entry game. This paper shows that similar results hold when the costs are triggered by disclosing bad news such as an environmental liability.

Environmental liability information is proprietary because stakeholders could use it to impose costs on polluting companies. Government agencies could use such information as a pretext for investigations that would increase compliance costs. Moreover, disclosure could invite costly litigation by previously uninformed victims of environmental incidents; affect the availability of debt and equity capital (Saxe 1991; Piette 1992); benefit competitors' green-marketing strategies aimed at environmentally conscious consumers; and provide ammunition for environmental protection groups, such as Greenpeace, to press for stricter legislation or boycotts of the company’s products.
Uncertain information endowment

Environmental liabilities stem from many obligations whose financial consequences are uncertain, ranging from emission control to cleanup of contaminated sites (Barth and McNichols 1994; Milne 1991; Cropper and Oates 1992). The uncertainty has at least three dimensions: legal, technical, and political. Legal uncertainty exists because firms' responsibilities change as environmental legislation evolves. Technical uncertainty comes from the fact that cleanup technologies are often rudimentary and the costs involved are not well understood. Finally, social-political norms are ever-changing; public pressure may force companies to take increasingly costly cleanup or abatement measures.

Any or all of these uncertainties may seriously inhibit the accurate assessment of a firm's environmental liability. Therefore, firms can plausibly suppress bad environmental news because outsiders cannot costlessly distinguish between two cases: (1) management knows the amount of liability, but intentionally withholds the information, and (2) uncertainty prevented management from learning whether a liability exists or, if it exists, from accurately assessing its financial impact.

Dye (1985) developed a partial disclosure model in which outsiders were uncertain whether management had received private information and management could not credibly signal that it had not. Jung and Kwon (1988) extended the idea, allowing outsiders to reassess the probability that managers had received private information, given that they disclosed nothing. Based on this conditional probability, they derived a partial disclosure equilibrium in which managers would reveal good news that exceeded a unique threshold level. The present paper draws heavily on this work, but simultaneously models the effect of proprietary costs on disclosure.

Figure 1 Time line of the events

<table>
<thead>
<tr>
<th>t = 0</th>
<th>t = 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firms endowed private info on y ∈ [0,1] with prob. p</td>
<td>Firms decide to disclose or not</td>
</tr>
<tr>
<td>Opponent decides to strike or not</td>
<td>Investigation after an attack is launched</td>
</tr>
<tr>
<td>Market reacts to both disclosure and strike decisions</td>
<td>C is imposed if investigation reveals y &lt; K</td>
</tr>
</tbody>
</table>

Disclosure model: Structure and assumptions

Figure 1 depicts a disclosure game with three players: a set of firms in an industry with a given propensity to pollute the environment; a group of risk-neutral, outside investors; and an opponent with the same information as investors. The opponent represents other outside parties who are concerned about the firms' environmental performance; it may strike a firm, imposing proprietary costs, if it finds that the firm's environmental liability exceeds a certain tolerable limit.
The random variable $y$ is conceived as shareholders’ equity, that is, firm value after deducting liabilities, including the environmental liability. A lower realization of $y$ would mean greater environmental liability and lower equity value. Without loss of generality, $y$ is assumed to belong to a compact set $y \in Y = [0,1]$. Thus, $y$ is the shareholders’ fraction of firm value after deducting the environmental liability. Modelling the firm’s potential liability in this way, as a range of values with upper and lower bounds, is consistent with the *Disclosure of Measurement Uncertainty* (CICA Handbook 1508) and *Disclosure of Certain Significant Risks and Uncertainties* (AICPA Accounting Statement of Position 94.5).

The cumulative distribution function of $y, G(y)$, with mean $\mu$, is known to all three players; $\mu$ is interpreted as the pollution propensity of the firms in the industry. If the firms became more pollution prone, they would be expected to have greater environmental liabilities and $\mu$ would decrease.

It is assumed that a portion $p$ ($0 < p < 1$) of the firms know the value of $y$, but the opponent and the market do not know if any given firm is informed or not. Thus, $1 - p$ reflects the inherent uncertainty involved in assessing environmental liabilities; as $p$ increases, the ex ante probability that a firm knows its environmental liability also increases. It is further assumed that firms can credibly announce environmental information to the market and the opponent, but they must either truthfully reveal $y$ or disclose nothing. This assumption can be supported by the existence of a high penalty for lying, if caught. Firms are rational, in that, they choose a disclosure strategy to maximize shareholders’ equity.

As in Dye (1986) and Jung and Kwon (1988), a firm’s disclosure strategy is defined by the set $N = [0, \xi]$, such that, $y \in N$ is not disclosed, $\xi$ being a disclosure threshold. (Thus, the firm discloses if $y > \xi$, and withholds the information if $y \leq \xi$.) If $N$ is of measure zero, full disclosure occurs, that is, all $y \in Y$ are disclosed. $E(y|N)$ is the conditional expected value of $y$, given that nondisclosure is observed. Rationality requires that $E(y|N)$ is endogenous with the firm’s disclosure strategy and that $E(y|N) \leq \mu$. It is assumed that firms cannot credibly announce that they have no private information because such knowledge-based claims are costly to verify and could preclude a due-diligence defence in future environmental litigation. Indeed, none of the sample firms in this study made such a claim.

The opponent decides whom to strike after observing firms’ disclosures or nondisclosures. Its decision is represented by a binary function $\delta(y)$, where $\delta = 1$ if it strikes, and $\delta = 0$ otherwise. Let $k > 0$ be the opponent’s striking cost, and $K$ the opponent’s tolerance level for environmental liabilities. The opponent is assumed to derive a benefit $B > k > 0$ by imposing an exogenous proprietary cost $C > 0$ on any firm known to have $y < K$. A strike is said to be “successful” if $y < K$ and $C$ is imposed. Thus, when a firm discloses a value of $y$, the opponent’s decision rule is straightforward:
$\delta(y) = \{0$ for $y \geq K, 1$ for $y < K\}$ when $y$ is disclosed

With nondisclosure, the likelihood that a strike would be successful is determined by $\Gamma(y<K|N)$, the posterior probability that $y < K$, given nondisclosure. Henceforth, to simplify the notation, this posterior probability is represented by $\Gamma(N)$. Generally, then, the opponent would attack only if $\Gamma(N)B > k$; only this case is analyzed in this paper, that is, the cost-benefit structure is assumed to be such that the opponent always attacks nondisclosers.$^{10}$

It is assumed that a strike causes the true value of $y$ to be revealed, but the strike is successful only if $y < K$. If the opponent attacks and finds $y \geq K$, then $B = C = 0$; if the opponent does not attack, the probability is zero that the opponent will impose the cost $C$ on the firm.

In summary, the firm incurs $C$ for sure when it discloses $y < K$ and with probability $\Gamma(N)$ when it does not disclose. Thus, $K$ reflects the risk that a nondiscloser will incur the cost $C$; as $K$ increases, the opponent grows less tolerant of environmental liabilities and more likely to strike successfully.

The market reacts to the firm’s disclosure decision and the opponent’s attack, adjusting the firm’s value $V$ as follows:

\[
V = y - \delta(y)C \quad \text{if } y \text{ is disclosed,}
\]
\[
V = E(y|N) - \Gamma(N)C \quad \text{if nondisclosure is observed.}
\]

Thus, firms have two possible incentives to withhold bad news: to avoid the market’s negative assessment of $y$, and to avoid the proprietary cost $C$.\textsuperscript{11} The incentives reinforce each other, because disclosing bad news could also trigger a successful strike by the opponent.

Because the market and the opponent do not know whether a firm is informed or not when nondisclosure is observed, they revise their expectations about the firm’s environmental liability, recognizing that the firm might not have received private information. Following Jung and Kwon (1988), $E(y|N)$, the posterior expectation of $y$ given nondisclosure, is as follows:

\[
E(y|N) = \frac{\int_0^\xi pydG(y) + (1-p)\mu}{\int_0^\xi pfdG(y) + (1-p)}
\]

Two kinds of firms may have $y < K$, given nondisclosure: those that are not informed; and those that are informed, but who know that $y$ is less than the equilibrium disclosure threshold. Those in the latter group prefer to remain silent, letting the market price the expected value of the environmental liability. Therefore, $\Gamma(N)$ depends on the cutoff value, $K$, relative to the equilibrium disclosure threshold, as follows:
The models of Dye (1986) and Jung and Kwon (1988) constitute a special case where \( K < 0 \), that is, the opponent is infinitely tolerant, so \( \Gamma(N) = 0 \) and it is as if the opponent did not exist. It can also be shown that the prospect of the opponent striking does not affect the firms' disclosure decisions when \( \xi < 1 \). Then, \( \Gamma(y < K|N) = 1 \) and Jung and Kwon's results obtain. The present paper considers the range \( 0 < N < 1 \), so that the presence of the opponent affects the firms' disclosure decisions. The equilibrium nondisclosure set \( N \) is determined by the following:

\[
N = \{ y \mid y - \delta(y)C < E(y|N) - \Gamma(N)C \}.
\]

**Disclosure strategies: Sequential equilibrium analysis**

A strategy is part of a sequential equilibrium (Kreps and Wilson 1982) if two conditions hold:

1. **Sequential rationality:** The firm's disclosure strategy maximizes firm value \( V \), given the market's reaction and the opponent's strategy.
2. **Consistency:** The market's and the opponent's beliefs are consistent with the firm's disclosure strategy.

**Proposition 1**

Nondisclosure is not part of a sequential equilibrium; that is, \( N \not\in Y \).

**Proof:**

There are always values of \( y \in Y = [0, 1] \), such that, the firm is better off disclosing:

**Case 1:** \( \mu > K \). Consider \( \mu < y^* < 1 \). Because \( y^* > \mu > \mu - \Gamma(N)C \), the firm is better off disclosing \( y^* \). Thus, \( y^* \not\in N \).
Case 2: $\mu < K$. Consider $K < y^* < 1$. Because $y^* > K > \mu > \mu - I(N)C$, the firm is better off disclosing $y^*$. Thus, $y^* \notin N$.\(^\text{13}\)

Proposition 1 is a general result requiring no restrictions on the parameters $K$ or $C$, or on the prior distribution $G(Y)$. The firm will always dispel the opponent's pessimistic beliefs by disclosing good news.

Proposition 2
Full disclosure is not part of a sequential equilibrium; that is, $N \not\in \varnothing$.

Proof:
$E(y\mid N)$ must be equal to 0 to provide incentives for firms to disclose everything. However, $E(y\mid N) = 0$ is inconsistent with the information structure when nondisclosure is observed because sequential rationality requires $E(y\mid N) > 0$; therefore, the firm has the incentive to suppress any $y \in [0,E(y\mid N))$, for any values of $C$ and $K$ and any distribution $G(y)$. Therefore, $N \not\in \varnothing$.\(^\text{14}\)

Proposition 3
A partial disclosure equilibrium exists under two conditions:

1. $\xi_2 \leq K < 1$ and $\int_0^\mu p G(y)dy > C(1 - p)(1 - G(K))$; and
2. $\xi_1 \geq K > 0$ and $G(K)C < \mu (1 - p)$.

Proof:
See Appendix 1 for the Proof of proposition 3 as well as propositions 3a, 3b, 3c, and 3d. The appendix also defines the cutoff values of $\xi_1$ and $\xi_2$. Proposition 3 gives sufficient conditions under which firms disclose information strategically, maximizing share value, net of liabilities and proprietary costs. In equilibrium, firms conceal environmental liabilities that exceed a threshold level; that is, they withhold bad news. The disclosure threshold is supported by the outsiders' uncertainty regarding the firm's information endowment.\(^\text{15}\) The next section shows how the equilibrium disclosure threshold is affected by changing the model parameters.

Comparative statics

Impact of $K$ on disclosure
The firm's risk of bearing the cost of a successful strike is reflected by the fact that $I(N)$ increases as $K$ increases. The impact of $K$ on the firm's disclosure decision is as follows:

Proposition 3a.
The partial equilibrium disclosure threshold level $\xi$ increases (disclosure becomes less likely), as $K$ increases from $K \leq \xi_1$ to $K \geq \xi_2$. 
This finding extends our understanding of corporate disclosure in two ways. First, it shows that both the size of the political cost and the risk of its being imposed are jointly important; political costs matter only if they will be incurred with positive probability. Second, it suggests that, if a significant decline in stakeholder tolerance of pollution occurs, the expected proprietary costs of disclosing increase, and companies would grow less likely to disclose environmental liability information. During his discussion of the paper at the 1996 Contemporary Accounting Research Conference, Jack Hughes observed that the negative relationship between $K$ and equilibrium disclosure threshold holds only for significant variation in $K$. As the graph in Appendix 1 illustrates, for small variations in $K$, increasing $K$ can actually increase disclosure. We selected the empirical proxy for $K$, as discussed in the empirical test section, with this point in mind.

**Impact of $p$ on disclosure**

Proposition 3b

As $p$ increases, the equilibrium disclosure threshold $\xi$ decreases (disclosure becomes more likely); that is, $\partial \xi / \partial p < 0$.

Recall that $p$ is the outsiders' assessment of the probability that firms know they have nonzero environmental liabilities. As $p$ increases, $\Pi(N)$ (outsiders' posterior probability that $y < K$, given nondisclosure) increases, and more firms will have news to report that is "good" compared with this more pessimistic probability.

Proposition 3 is consistent with the observation that U.S. petroleum firms provided more environmental disclosure following the 1989 Exxon Valdez oil spill (Patten 1992). It also suggests why, as noted previously, companies asked the MOEE not to issue press releases after it had served them with cleanup orders. Such news would prompt outsiders to revise $p$ upward, reducing firm value and forcing more firms in the industry to disclose.

A policy implication is that the dissemination of environmental performance records by such agencies provides a natural incentive for companies to disclose environmental liabilities. This could be a more effective way of encouraging disclosure than promulgating additional accounting regulations for two reasons: (1) The marginal cost would be low since government agencies already maintain such records. (2) Stricter accounting standards would be costly to enforce because of the uncertainty inherent in assessing the liabilities.

**Impact of $C$ on disclosure**

The impact of $C$, the proprietary cost, must be analyzed jointly with that of $K$, the ex ante risk of the opponent successfully imposing $C$ on the firm.
Proposition 3c
At equilibrium,
\[ \frac{\partial \xi}{\partial C} < 0 \text{ when } K \leq \xi_1: \text{ The disclosure threshold decreases (more disclosure is likely) as } C \text{ increases.} \]
\[ \frac{\partial \xi}{\partial C} > 0 \text{ when } K \geq \xi_2: \text{ The disclosure threshold increases (disclosure becomes less likely) as } C \text{ increases.} \]

In case (1), the opponent is relatively tolerant, because \( K \) is below the equilibrium disclosure threshold. Then, on average, a firm’s incentive to differentiate itself from the worst polluters by disclosing dominates the incentive to pool, and an increase in \( C \) strengthens this incentive to disclose. In case (2), the opponent is relatively intolerant because \( K \) exceeds the disclosure threshold. Then, on average, a firm has the incentive to mitigate the negative market assessment and the imposition of \( C \) by not disclosing; and an increase in \( C \) increases the equilibrium disclosure threshold, causing less disclosure even though the political cost \( C \) is unavoidable.

Impact of \( \mu \) on disclosure
Pollution propensity is represented by \( \mu \), firms’ ex ante expected equity value, net of environmental liabilities. As \( \mu \) decreases, pollution propensity increases; \( \mu \) affects the equilibrium disclosure threshold by influencing outsiders’ beliefs about \( y \), given nondisclosure.

Proposition 3d
An increase in pollution propensity induces more disclosure, that is, \( \frac{\partial \xi}{\partial \mu} > 0 \).

Proposition 3d implies that, all else being equal, as pollution propensity increases (\( \mu \) decreases) disclosure grows more likely because uninformed parties form more pessimistic beliefs, driving down the equilibrium disclosure threshold. An implication for auditors comes from the converse of the latter statement: all else being equal, firms in industries with less pollution propensity are more likely to conceal information than those in more pollution-prone industries. Next, we discuss the empirical tests of the model’s predictions.

Empirical tests

Research design and data
The predictions of the model were tested using data pertaining to significant environmental incidents in Ontario. The incidents were identified from sources independent of the firms’ own disclosure documents; then, the disclosure documents were checked to see if the firms had disclosed information about the liabilities.

MOEE enforcement records pertaining to three activities were canvassed:\(^\text{20}\) administrative orders, environmental prosecutions, and major spills, each of which is described in the following sections. Each would generate legal
obligations consistent with the accounting definition of liabilities (Brown, Collins, and Thornton 1993). Firms' disclosure decisions were then checked by cross-referencing these incidents with corporate filings with the Ontario Securities Commission (OSC).^21

Orders, prosecutions, and spills

Administrative orders are issued by the MOEE under Ontario's Environment Protection Act. For example, a 1982 order issued to Algoma Steel Corp. Ltd. involved $80 million in compliance costs.^^ Compliance may entail upgrading production facilities, installing new pollution control equipment, modifying production processes, and initiating any other pollution abatement measures deemed necessary by the Ministry.

Environmental prosecutions enforce environmental regulations, imposing punitive fines and other injunctions on violators. Legal costs can be considerable, because the prosecution and defence involve lengthy procedures requiring both technical and legal expertise. A convicting court can also issue judicial orders, similar in effect to the administrative orders, mandating costly preventive or remedial measures to reduce the risk of further damage to the environment.

Finally, spills are discharges of pollutants into the environment. If a significant spill had occurred, a firm would expect to incur costs of cleaning it up, either voluntarily or after receiving an order from the MOEE.

The MOEE supplied a list of 270 administrative orders issued from January 1982 to December 1992, 45 of which were issued to companies listed on the Toronto Stock Exchange (TSE). The study focused on public companies, to be consistent with previous work, and because TSE-listed companies' disclosure documents were available at a reasonable cost. The details of the 45 orders were obtained under the Freedom of Information and Privacy Protection Act. Four orders were excluded because they pertained to companies whose securities were not traded when the orders were issued or because the companies did not have complete disclosure files with the OSC. Appendix 2 lists the 41 orders remaining in the final sample, involving 21 TSE-traded companies.

The Communications Branch of the MOEE provided a list of 46 prosecution cases during 1988-1992, involving 32 TSE-listed companies. All of these observations, listed in Appendix 3, were usable.

The MOEE maintains an electronic database of spills that occurred in the jurisdiction of Ontario from 1988 onward. Complete spill records were obtained for 10 industrial sectors: transportation, hydro utilities, petroleum, chemical, metallurgical, pulp and paper, mining, food processing, forestry, and other manufacturing. A total of 14,772 spills were recorded for these ten industries during the five-year period, 1988-1992. Because significant spills could not be reliably identified from the descriptions provided on the database, a gradual elimination strategy was employed. The following were eliminated:

(1) spills with insignificant volume (fuel oil < 500 liters; PCB-laced oil < 50 liters)
(2) spills with insignificant cleanup costs (identified as "no environmental impact" and "zero cleanup." Examples are gaseous emission and waste water spills, for which cleanup is impossible)
(3) spills by non-TSE-listed companies
(4) spills that were effectively dealt with by spill prevention facilities such as in-plant sewage processing facilities and spill containment design
(5) spills of solid and nontoxic materials (for example, solid fertilizer, salt, ore, animal waste, beer, etc.) Such spills are relatively easy to clean up and have little long-term impact on the environment.

Of 14,772 spills, 191 remained after the significance screening. To control further for immaterial spills, the remaining 191 spill records were examined, focusing on (1) quantity of materials spilled, (2) the nature of the spill in terms of cleanup difficulty and environmental impact, and (3) relative size of the company. This procedure generated 19 significant spills from the remaining 191 records. These are listed in Appendix 4.23

Econometric specification
The theory implies that the equilibrium disclosure threshold level \( \xi \) is influenced by three factors: outsiders' information level \( p \), risk of adverse action \( K \), and pollution propensity \( \mu \). Because the effect of the proprietary (political) cost \( C \) is intertwined with that of \( K \), the empirical tests focus on the influence of \( K \) only. A cross-sectional logit model, predicated on the assumption that the disclosure threshold is logistically distributed in a cross-section of firms, captures the effects of the three factors:

\[
d_i = \log \left( \frac{D_i}{(1 - D_i)} \right) = \alpha + \beta_1 \pi_i + \beta_2 \kappa_i + \beta_3 \lambda_i + \epsilon_i
\]

where

\( D_i \) is the cumulative logistic probability that firm \( i \) will disclose; \( d_i \) is therefore defined as the log odds of disclosure
\( \pi_i \), a proxy for \( p_i \), is the probability that outsiders perceive that firm \( i \) has private information as to the value of \( y \)
\( \kappa_i \), a proxy for \( K_i \), is the risk that the opponent will impose proprietary costs on firm \( i \)
\( \lambda_i \), a proxy for \( \mu_i \), is firm \( i \)'s pollution propensity
\( \epsilon_i \) is measurement error

Table 1 summarizes the discussion that follows, stating how the proxy variables were measured and how they relate to the constructs that were used in the propositions. It also summarizes the expected impact of the explanatory proxy variables on disclosure.
Measurement

Disclosure decisions
For each environmental incident in the sample, corporate filings with the OSC were examined for both the year of and the year following the incident. Disclosure documents examined included all of those stipulated by OSC disclosure regulations: annual reports, Annual Information Forms (AIFs), Management Discussion and Analysis (MD&A), quarterly reports, and press releases.24

Disclosure was measured as a dummy variable, taking the value of 1 if a firm discussed the environmental incident in OSC filings, and 0 otherwise. Invariably, the discussions described the actions a firm was taking in response to the order, prosecution, or spill; often they also mentioned the financial impact of those actions. Thus, this proxy can be viewed as a stylized disclosure index, conditional on the known occurrence of an incident.

Outsiders' perception that firm i has private information, \( \pi_i \)
Though the data came from public records, \( p \) is not 1 for the sample incidents, because there is still uncertainty as to the actions that the firm would take in response to the order, prosecution, or spill and the financial consequences of the actions.

Because \( p \) is not observable, it was proxied by \( \pi_i \), measured as the percentage of articles in the media that related to environmental aspects of firm i.25 The proxy can be viewed as the degree of public knowledge of firm i's environmental matters. Justification for the proxy is predicated on two assumptions: (1) Outsiders form beliefs about management's knowledge of environmental liabilities using publicly available information and (2) Each new article that appears in the media concerning the environmental aspects of firm i causes outsiders to revise upward the probability the management has received private information concerning the dollar consequences of the firm's environmental liabilities.

A search of LEXIS-NEXIS and a detailed reading of environmentally related articles of the sample firms showed that the second assumption was plausible. For most firms, the articles pertained to the same general problem that culminated in an order, prosecution, or spill; each successive article would have updated investors' posterior beliefs about the dollar consequences of the problem; however, residual uncertainty remained about the dollar consequences (i.e., \( p < 1 \)) when management was considering disclosure in formal channels.

Accordingly, the Canadian Index database was searched for news items relating to the sample firms.26 For the calendar year in which the incident occurred, news items relating to the company were identified.27 Then, \( \pi_i \) was set equal to the number of environment-related articles concerning firm i, divided by the total number of articles concerning firm i during the incident year. The denominator of \( \pi_i \) controls for size, because large firms would normally receive more media attention than smaller ones.
<table>
<thead>
<tr>
<th>Theoretical variable</th>
<th>Definition / Proposition</th>
<th>Empirical proxy</th>
<th>Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\xi$: Disclosure threshold.</td>
<td>Firms withhold liability realization $y &lt; \xi$, depending on the following three variables.</td>
<td>$d = \log[D/(1 - D)]$</td>
<td>Maintained hypotheses is that the disclosure threshold is logistically distributed in the cross section of firms, depending on the following three proxy variables</td>
</tr>
<tr>
<td>The firm discloses less (or is less likely to disclose) as $\xi$ increases.</td>
<td></td>
<td>Log odds of disclosure, where $D$ is the cumulative probability of disclosure, assuming $\xi$ is logistically distributed across firms. For model estimation, $D = 1$ for disclosure, 0 for nondisclosure.</td>
<td></td>
</tr>
<tr>
<td>$\rho$: Opponent's information level, i.e., ex ante probability that management has received private information about firm's environmental liability.</td>
<td>$3b: \partial \xi/\partial \rho &lt; 0$ Firms are more likely to disclose if opponent is more certain that management has received private information.</td>
<td>$\pi$ Proportion of articles published citing environment-related concerns for the firm</td>
<td>$\beta_1 &gt; 0$</td>
</tr>
<tr>
<td>$K$: Risk of adverse action by opponent (or opponent's intolerance of pollution). Opponent strikes if $y &lt; K$.</td>
<td>$3a$: Firms are less likely to disclose if the opponent is less tolerant of pollution.</td>
<td>$\kappa$ $\kappa = 1$ for prosecutions and spills; 0 for administrative orders.</td>
<td>$\beta_2 &lt; 0$</td>
</tr>
<tr>
<td>$\mu$: Firm's pollution propensity (increases as $\mu$ decreases)</td>
<td>$3d: \partial \xi/\partial \mu &gt; 0$ Firms are more likely to disclose if pollution propensity is higher</td>
<td>$\lambda$ $\lambda = 1$ for MISA monitored firms that discharge directly to ground water; 0 for others</td>
<td>$\beta_3 &gt; 0$</td>
</tr>
</tbody>
</table>
If no news items were found for firm $i$ during an incident year, all items related to the environmental aspects of firm $i$ during 1982-94 (the whole time span of the database) were identified and $\pi_i$ was set equal to the number of environment-related articles divided by the total number of articles involving the firm for the 12-year period. If no environmental items were found concerning firm $i$ at all, $\pi_i$ was set equal to zero. To ensure that $\pi_i$ would not be contaminated by actual corporate disclosures of the liabilities, $\pi_i$ was measured for the 12 months preceding the month of the disclosure for six incidents that were disclosed in the OSC filings during the same calendar year as the incidents occurred.\(^{28}\)

To summarize, for 57 of our 106 sample observations, $\pi_i$ is the proportion of all articles devoted to environmental matters in the calendar year when the order or prosecution was issued or the spill occurred. For six of the 106 sample observations, $\pi_i$ equals the proportion of all articles devoted to environmental matters in the 12 months prior to the month when disclosures were made. For the 43 of 106 sample observations, $\pi_i$ is the proportion of all articles in the 12-year period devoted to environmental matters.

Risk of adverse action $\kappa_i$
Recall from the discussion of Proposition 3a that a significant variation in tolerance is required in order to predict a negative association between disclosure and the risk of attack by environmental stakeholders. We select our proxy with the objective of achieving a significant variation. The risk of incurring proprietary costs was proxied by setting $\kappa_i = 0$ (implying a more tolerant opponent) for orders and $\kappa_i = 1$ (implying a less tolerant opponent) for prosecutions and spills, on the basis that orders do not imply any wrongdoing, whereas prosecutions suggest violations of environmental legislation and spills are outright assaults against the environment. Thus, within each category, the dollar amount of the liability is assumed to be associated with the seriousness of the problem and the utility that the opponent expects to derive from striking the polluter; but a $1 million liability would be more likely to provoke the opponent if it stemmed from a prosecution or spill, and less likely to provoke the opponent if it resulted from an order.

### TABLE 2
A summary of disclosure decisions

<table>
<thead>
<tr>
<th></th>
<th>Number of observations</th>
<th>Number of disclosures</th>
<th>Number of nondisclosures</th>
<th>Percentage disclosure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orders</td>
<td>41</td>
<td>22</td>
<td>19</td>
<td>53.6%</td>
</tr>
<tr>
<td>Prosecutions</td>
<td>46</td>
<td>15</td>
<td>31</td>
<td>32.6%</td>
</tr>
<tr>
<td>Spills</td>
<td>19</td>
<td>0</td>
<td>19</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>106</td>
<td>37</td>
<td>69</td>
<td>34.9%</td>
</tr>
</tbody>
</table>
Disclosure decisions by industry category

<table>
<thead>
<tr>
<th>Category</th>
<th>Disclosure</th>
<th>Nondisclosure</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulp &amp; paper mills</td>
<td>8</td>
<td>14</td>
<td>22</td>
</tr>
<tr>
<td>Steel &amp; metal extraction</td>
<td>15</td>
<td>16</td>
<td>31</td>
</tr>
<tr>
<td>Mining</td>
<td>9</td>
<td>20</td>
<td>29</td>
</tr>
<tr>
<td>Others</td>
<td>5</td>
<td>12</td>
<td>24</td>
</tr>
</tbody>
</table>

Chi-square test: $X^2 = 5.2822$, d.f. = 3

Thus, disclosure decisions by industry category, as described in Table 3, are not statistically independent at $\alpha = 0.1$ level ($X^2 = 6.2513$).

Pollution propensity $\lambda_i$

Quantifying pollution propensity is challenging because of the technical uncertainty involved in assessing environmental damage. For example, comparing the pollution propensity of the steel industry versus that of the pulp and paper industry would entail comparing the environmental impact of sulphur dioxide versus that of dioxin. Thus, the proxy was derived indirectly, as follows.

The MOEE believes that companies discharging directly to surface water pose especially high environmental risks because the discharges bypass municipal sewage treatment systems. Under the Municipal and Industrial Strategy for Abatement (MISA) law, the MOEE monitored 169 companies that discharged polluting effluents directly to surface water in Ontario, requiring them to account for their discharges continuously and adopt procedures to control any abnormality in the discharges (Report on the 1991 Industrial Direct Discharges In Ontario, 1993). It was assumed that MISA-monitored firms had higher pollution propensity than those that were not monitored. Because the sample firms were culled from MOEE records, they were all subject to MISA. Thus, $\lambda_i$ was set equal to 1 if firm $i$ was MISA-monitored, and zero otherwise.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Stand. dev.</th>
<th>Variance</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D$</td>
<td>0.35</td>
<td>0.49</td>
<td>0.23</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>$\tau$</td>
<td>0.08</td>
<td>0.14</td>
<td>0.02</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>0.61</td>
<td>0.49</td>
<td>0.24</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>0.63</td>
<td>0.48</td>
<td>0.23</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Correlation matrix of explanatory variables

<table>
<thead>
<tr>
<th></th>
<th>$\tau$</th>
<th>$\kappa$</th>
<th>$\lambda$</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau$</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\kappa$</td>
<td>0.01</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\lambda$</td>
<td>-0.15</td>
<td>-0.12</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>
Results

Descriptive statistics

Table 2 summarizes the sample firms' disclosures. Overall, only 35 percent of the sample incidents resulted in disclosure: 54 percent of the orders, 33 percent of the prosecutions and none of the spills. Table 3 gives the frequency of disclosure by industry category. Although the chi-square test may weakly reject the null of random cell assignment, no obvious patterns are apparent from the table. Pulp and paper and mining, two industries well known for their environmental problems, exhibit disclosure proportions (36 and 31 percent, respectively) that differ little from the overall proportion of 35 percent. Further, inclusion of an industry dummy variable in our basic logit model (not reported) does not alter our results, and the coefficient on the dummy variable is insignificant.

Table 4 presents descriptive statistics for the proxy variables. The percentage of articles mentioning firms' environmental issues averaged eight percent, with a minimum of zero and a maximum of 100 percent. The mean of $\kappa$, 0.61, reflects the fact that 61 percent of the observations were prosecutions and spills versus the 39 percent that were orders. Finally, the mean of $\lambda$, 0.63, shows that nearly two-thirds of the sample firms were MISA-monitored. The correlation matrix (Table 5) does not suggest any serious correlations among the explanatory variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimated coefficient</th>
<th>Asymptotic standard error</th>
<th>Asymptotic $t$-ratio</th>
<th>Elasticity at mean</th>
<th>Weighted aggregate elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi$</td>
<td>11.11</td>
<td>3.35</td>
<td>3.31*</td>
<td>0.58</td>
<td>0.35</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>-1.69</td>
<td>0.51</td>
<td>-3.32*</td>
<td>-0.71</td>
<td>-0.38</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>1.24</td>
<td>0.58</td>
<td>2.13†</td>
<td>0.53</td>
<td>0.45</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.35</td>
<td>0.60</td>
<td>-2.26</td>
<td>-0.92</td>
<td>-0.63</td>
</tr>
</tbody>
</table>

Log-likelihood function: -51.88
Log-likelihood (0): -60.57
Likelihood ratio test: 33.38* (3 d.f.)
Maddala $R^2$: 0.27
Cragg-Uhler $R^2$: 0.37
McFadden $R^2$: 0.24
$R^2$ Adjusted for degrees of freedom: 0.22
Chow $R^2$: 0.27
Percentage of correct predictions: 76.4%

* 0.005 significance level (one-tailed test)
† 0.025 significance level (one-tailed test)
<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimated coefficient</th>
<th>Asymptotic standard error</th>
<th>Asymptotic t-ratio</th>
<th>Elasticity at mean</th>
<th>Weighted aggregate elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi$</td>
<td>8.97</td>
<td>3.30</td>
<td>2.71*</td>
<td>0.46</td>
<td>0.29</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>-1.26</td>
<td>0.52</td>
<td>-2.41†</td>
<td>-1.11</td>
<td>-0.84</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>1.16</td>
<td>0.58</td>
<td>1.99†</td>
<td>0.44</td>
<td>0.41</td>
</tr>
<tr>
<td>Constant</td>
<td>0.06</td>
<td>0.88</td>
<td>0.07</td>
<td>0.04</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Log-likelihood function $- 49.08$
Log-likelihood (0) $- 59.33$
Likelihood ratio test $20.49^*$ (3 d.f.)
Maddala $R^2$ 0.21
Cragg-Uhler $R^2$ 0.28
Mcfadden $R^2$ 0.17
$R^2$ adjusted for degrees of freedom 0.14
Chow $R^2$ 0.20
Percentage of correct predictions 69%

* 0.005 significance level (one-tailed test)
† 0.025 significance level (one-tailed test)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimated coefficient</th>
<th>Asymptotic standard error</th>
<th>Asymptotic t-ratio</th>
<th>Elasticity at mean</th>
<th>Weighted aggregate elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi$</td>
<td>10.51</td>
<td>3.56</td>
<td>2.95*</td>
<td>0.51</td>
<td>0.34</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>-1.72</td>
<td>0.55</td>
<td>-3.11*</td>
<td>-0.78</td>
<td>-0.41</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>0.96</td>
<td>0.60</td>
<td>1.61</td>
<td>0.43</td>
<td>0.36</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.27</td>
<td>0.61</td>
<td>-2.09</td>
<td>-0.94</td>
<td>-0.66</td>
</tr>
</tbody>
</table>

Log-likelihood function $- 44.19$
Log-likelihood (0) $- 56.90$
Likelihood ratio test $25.40^*$ (3 d.f.)
Maddala $R^2$ 0.24
Cragg-uhler $R^2$ 0.34
Mcfadden $R^2$ 0.22
$R^2$ Adjusted for degrees of freedom 0.20
Chow $R^2$ 0.24
Percentage of correct predictions 74.2%

* 0.005 significance level (one-tailed test)
**TABLE 9**

Logit results with alternative measures of $\kappa$ and $\lambda$

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimated coefficient</th>
<th>Asymptotic standard error</th>
<th>Asymptotic $t$-ratio</th>
<th>Elasticity at mean</th>
<th>Weighted aggregate elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi$</td>
<td>9.42</td>
<td>3.41</td>
<td>2.76*</td>
<td>0.47</td>
<td>0.29</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>-0.22</td>
<td>0.39</td>
<td>-0.55</td>
<td>-0.23</td>
<td>-0.17</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>1.37</td>
<td>0.66</td>
<td>2.08†</td>
<td>2.47</td>
<td>2.07</td>
</tr>
<tr>
<td>Constant</td>
<td>-4.77</td>
<td>2.19</td>
<td>-2.18</td>
<td>-3.15</td>
<td>-2.50</td>
</tr>
</tbody>
</table>

Log-likelihood function $- 57.07$

Log-likelihood (0) $- 68.57$

Likelihood ratio test $22.99^*$ (3 d.f.)

Maddala $R^2$ 0.20

Cragg-Uhler $R^2$ 0.27

Mcfadden $R^2$ 0.17

$R^2$ adjusted for degrees of freedom 0.14

Chow $R^2$ 0.19

Percentage of correct predictions 72.6%

* 0.005 significance level (one-tailed test)

† 0.025 significance level (one-tailed test)

* Logit results

The results in Table 6 support the hypotheses in Table 1. One-tailed $t$-tests imply that the coefficients of the three explanatory variables are all significantly different from zero, are in the directions hypothesized, and are at the 0.025 or 0.005 level. The positive coefficients of $\pi$ and $\lambda$ suggest that when outsiders think it is more likely that management has knowledge of the amount of the liability, and as the firm becomes more pollution-prone, disclosure becomes more likely. The negative coefficient of $\kappa$ suggests that a higher risk of incurring proprietary (political) costs would deter disclosure.

The likelihood ratio test is well below the 0.005 significance level, suggesting that the logit model explains a significant amount of the variation in disclosure. The model correctly predicts 76.4 percent of the disclosure decisions, and the various $R^2$ measures are reasonable. Sample size is important in logit analysis because parameter estimates are only asymptotically normal (Maddala 1991). Prior studies suggest that $t$-tests for small samples are conservatively biased, compared to the nominal significance level for sample sizes as small as 50, whereas this study has the 106 observations. Thus, it seems unlikely that the null hypotheses were rejected because of the small sample size in this study.
Sensitivity Analyses

**Logit results with time dummy for pre- and post-1990**
As mentioned at the beginning of this paper, 1990 marked a change in both environmental legislation and disclosure requirements in Ontario. To test whether these developments led to increased disclosure after 1989, the logit analysis was repeated with a time dummy taking the value 1 for observations after 1990, and zero otherwise. The coefficient of the dummy variable was positive, but insignificant; moreover, inclusion of the dummy variable did not affect the inferences concerning the other three variables.

**Logit results without spill observations**
As discussed previously, the selection of 19 spill observations from the MOEE's spill database involved subjective judgements. Moreover, because none of the spills were disclosed, the inclusion of spill observations might bias the significance of the estimated coefficient of \( \kappa \). Thus, the logit analysis was repeated without the spill observations. Results appear in Table 7. Including or excluding spill data had little impact on the inferences.

**Robustness checks for violations of independence assumptions**
Because some sample firms had more than one environmental incident per year, the following analysis was conducted to see if the results were dominated by a few firms making more disclosures than others in the sample. For any firm with more than one observation in a particular year, one observation was randomly selected. This procedure eliminated 13 observations. The results of logit analysis using the remaining 93 observations appear in Table 8. The only noticeable impact on the inferences was a lower significance level for the coefficient of \( \lambda \), which could be due to the reduced sample size.\(^{31}\)

The inclusion of a given firm more than once in the empirical model gives rise to concerns about the independence of the model disturbance term across observations. A stricter analysis was conducted by randomly selecting only one observation for each firm. This resulted in 49 observations. The results of logit analysis with this reduced sample, but with the original proxies, did not differ significantly from those in Table 8, and thus are not reported.

**Logit Analysis with alternative measures of \( \kappa \) and \( \lambda \)**
\( \kappa \) and \( \lambda \) were proxied by the types of liabilities and by whether the sample firms were MISA-monitored. To see if the results were sensitive to these proxy measures, assistance was obtained from Beak Consultants, a prominent Ontario environmental consulting firm, to develop alternate measures for \( \kappa \) and \( \lambda \) based on operational characteristics of the sample firms.

After an analysis of the primary and secondary standard industrial codes (SIC) for each sample firm, \( \kappa \) was proxied by the sample firm's concentration on consumer products. The consultants said that firms with more consumer-ori-
ented products are subject to higher risk of political attack than those with more industrial products. Beak developed a trichotomous ranking for the sample firms, with $K = 3$ for firms producing mostly consumer products, $K = 2$ for firms producing both industrial and consumer products, and $K = 1$ for those producing mostly industrial products. The alternate $\lambda$ measure was also trichotomous with $\lambda = 3$ for highly polluting firms, $\lambda = 2$ for polluting firms and $\lambda = 1$ for less polluting firms. Beak developed this proxy, using its expertise in industrial pollution consulting, considering each sample firm's operational characteristics and past pollution performance.

Results of the logit analysis using these alternate $K$ and $\lambda$ proxies appear in Table 9. A noticeable difference is that the estimate of the coefficient of $K$ is not statistically significant, although its sign is as hypothesized. This finding may reflect the fact that empirically measuring the political risk associated with disclosing environmental liabilities is difficult.

**Robustness checks for omitted variables**

It would be desirable to measure the materiality for each incident because generally accepted accounting principles (GAAP) and the OSC disclosure regulations require disclosure of only material information (Scott 1994). If materiality were correlated with the explanatory variables, omitting it would bias the coefficient estimates (Fomby, Hill, and Johnson 1984, 402). Moreover, if measures of materiality were available, a rival alternate hypothesis could be addressed: firms' auditors force them to disclose any orders, prosecutions, or spills that are material. Ironically, this simple disclosure explanation conflicts with the results of the model, because it predicts that bad news (i.e., material financial liabilities) will be disclosed, whereas the model predicts that bad news will be withheld and good news disclosed.

Attempts were made, unsuccessfully, to assess the materiality of the sample incidents with the help of Beak. The difficulty stemmed mainly from the limited description available to us regarding the orders, prosecutions, and spills, and hence the extreme uncertainty associated with the financial consequences of the incidents. Still, the data themselves defy the simple explanation that material incidents are disclosed and immaterial ones are not. Indeed, for 10 of the 37 sample observations where disclosure took place, the text of the disclosure explicitly mentioned that the financial consequences were not material.

**Concurrent empirical research**

In related research, Barth et al. (1995) studied factors influencing firms' decisions to accrue and disclose information about environmental liabilities in the United States. Overall, the results are consistent with the central implication of the model developed in the present paper: managers reveal environmental information strategically. For example, the results suggest that companies tend to be concerned about the proprietary costs of disclosing information that could jeopardize negotiations with other potentially responsible parties regarding the
allocation of cleanup costs. This finding is consistent with the implication of the theory developed in the present paper, which suggests that disclosure declines as the perceived risk of incurring proprietary costs increases. Consistent with the model's prediction that firms can plausibly withhold bad news, but disclose good news, Barth et al.'s results also suggest that firms with good news (i.e., a lower number of Superfund sites than expected, given industry averages) disclose more.

**Limitations and future research**

It would be desirable to model firms' environmental disclosures in more general contexts where

1. Management actions would influence the probability distribution of environmental liabilities.
2. The timeliness of disclosures would affect firms' expected litigation costs (Skinner 1992).^{33}
3. Auditors would play an explicit role in ensuring that corporate disclosures complied with the GAAP.^{34}

Also, the robustness of the empirical results could be tested by using other proxies for the explanatory variables and larger and more diverse samples. In addition, we concede that there may not be a one-to-one correspondence between our chosen proxies and their theoretical constructs. As pointed out by Jack Hughes in his discussant's comments, the problem of overlap in what our proxies measure is least severe for our chosen proxy for pollution tolerance (risk of attack).

**Conclusions**

The paper poses a game-theory model that explains why firms are reluctant to disclose environmental liability information. Empirical evidence supports the model's predictions, suggesting that firms disclose such information strategically.

The study has three implications for accounting standard setting and for public policy directed at corporate environmental liabilities.

1. To the extent that inherent uncertainty leaves managers with discretion as to what to disclose, our partial disclosure equilibrium result suggests that not all firms will comply with disclosure standards.
2. Publishing corporate environmental performance regularly, in non-accounting outlets, would be an effective way to encourage disclosure if it increased public awareness of a manager's private information endowment, making voluntary accounting disclosures of the liabilities more likely. Already, both the SEC and the EPA are moving in that direction by making data on polluting firms available to interested parties (Roussey 1992).
(3) If a significant decline in stakeholder tolerance of pollution occurs, the expected proprietary costs of disclosing increase and companies become less likely to disclose. Ironically, this suggests that environmental stakeholders would actually discourage disclosure if they were expected to be over-zealous in striking corporations suspected of being polluters.

Though the model focused specifically on environmental liabilities, it may shed light on corporate disclosure decisions concerning other contingent liabilities that involve both uncertainty and the risk of incurring proprietary or political costs.

Appendix 1

Proof of Proposition 3

(1) When $K \leq 0$ or when $K \geq 1$

$K \leq 0$ implies that $\Gamma(N) = 0$. Thus, $V = E(y|N) = \xi = \gamma_D$ where $\gamma_D$ is the equilibrium disclosure threshold in Jung and Kwon (1988).

$K \geq 1$ implies that $\Gamma(N) = 1$. Thus, $V = E(y|N) - C = \xi - C$. The impact of political cost cancels out, the equilibrium disclosure threshold $\xi$ is the same as $\gamma_D$ once again.

(2) When $\xi_2 \leq K$, we show that a new disclosure threshold $\xi$ exists, and that it shifts to the right of $\gamma_D$, that is, $\xi > \gamma_D$. From $V = E(y|N) - \Gamma(N)C$, the rationality condition requires that the conjectured threshold value $\xi$ be fulfilled; that is, the $\xi$ value chosen by the firm must be consistent with the $\xi$ value conjectured by the opponent and the market. In other words, the market value of the firm, given nondisclosure, can be expressed as the following:

$$V = \frac{\xi}{p\int_{y}dG(y) + (1-p)\mu} - \frac{\xi}{p\int_{y}dG(y) + (1-p)} C$$

$$= \frac{\xi}{p\int_{y}dG(y) + (1-p)} - \frac{\xi}{p\int_{y}dG(y) + (1-p)}$$

$$= \xi - C$$

A straightforward algebraic manipulation of equation (1) yields the following equation:

$$(1-p)(\mu - \xi) = p\int_{y}G(y)dy - (1-p)(1 - G(K))C$$

(2)
Let:
\[ \omega(\xi) = (1 - p)[(\mu - \xi) + (1 - G(K))C] - \int_0^\xi pG(y)dy \]

Further, assume that the following condition is satisfied:
\[ p\int_0^\mu G(y)dy > C(1 - p)(1 - G(K)) \]

One can see easily that \( \omega'(\xi) < 0, \omega(0) > 0, \) and \( \omega(\mu) < 0 \) indicate that there is a unique \( \xi \) in \((0, \mu)\), such that \( \omega(\xi) = 0 \) (i.e., solving equation (2)).

Political cost \( C \) is explicitly incorporated in the equilibrium value of nondisclosing firms as \( \xi_2 \leq K \). \( \xi_2 \) is defined as \( \xi \) that solves equation (2) when \( K = \xi \). It is shown in the proof for proposition 3a (next) that \( \xi \) is monotonically decreasing in \( K \). Thus, for any \( K \geq \xi_2 \), the equilibrium disclosure threshold \( \xi \) must be less than \( \xi_2 \). Because investors know that \( K \geq \xi_2 > \xi \), political cost \( C \) is explicitly incorporated in the equilibrium value of nondisclosing firms.

To see that the new equilibrium disclosure threshold will shift to the right of \( \gamma_D \),
\[ V = E(y|N) - \Gamma(N)C = \xi - C, \] thus, \( \xi = E(y|N) + (1 - \Gamma(N))C > E(y|N) = \gamma_D \).

(3) When \( \xi_1 \geq K \), we show that a new disclosure threshold \( \xi \) exists, and that it shifts to the left of \( \gamma_D \), that is, \( \xi < \gamma_D \). From \( V = E(y|N) - \Gamma(N)C \), again the rationality condition requires that the conjectured threshold value \( \xi \) be fulfilled; that is, that the disclosure threshold value chosen by the firm be consistent with the \( \xi \) value conjectured by the opponent. In other words, the market value of the firm, given nondisclosure, can be expressed as follows:
\[
\begin{align*}
V &= \frac{\xi}{p\int_0^\xi dG(y) + (1 - p)\mu} - \frac{K}{p\int_0^\xi dG(y) + (1 - p)} C \\
&= \frac{\xi}{pG(\xi) + (1 - p)} - \frac{G(K)}{pG(\xi) + (1 - p)} C \\
&= \xi
\end{align*}
\]

A straightforward algebraic manipulation of equation (3) yields the following equation:
\[ (1 - p)(\mu - \xi) = \int_0^\xi pG(y)dy + G(K)C \]
Let:
\[ \omega(\xi) = (1 - p)(\mu - \xi) - \int_0^\xi G(y)dy - G(K)C \]

Further, assume the following: \( G(K)C < \mu(1 - p) \)

Again, it can be easily seen that \( \omega(\xi) < 0, \omega(\mu) < 0, \text{and} \omega(0) > 0 \) under this assumption. Thus, \( \omega(\xi) \) is a decreasing function of \( \xi \). \( \omega(0) > 0 \) and \( \omega(\mu) < 0 \) indicate that there is a unique \( \xi \) in \((0, \mu)\), such that, \( \omega(\xi) = 0 \) (i.e., solving equation (4)).

Note that political cost \( C \) is not explicitly included in the equilibrium value of nondisclosing firms because \( K \leq \xi_1 \) in this case. \( \xi_1 \) is defined as the value \( \xi \) that solves equation (4) when \( K = \xi \). It is shown in the proof for Proposition 3a that \( \xi \) is monotonically decreasing in \( K \). Thus, for any \( K \leq \xi_1 \), the equilibrium disclosure threshold \( \xi \) must be greater than \( \xi_1 \). Because investors know that \( K \leq \xi_1 < \xi \), political cost \( C \) is only implicitly reflected in the equilibrium value of nondisclosing firms.

To see that the new equilibrium disclosure threshold shifts to the left of \( \gamma_D \),
\[ V = E(y|N) - I(N)C = \xi, \text{thus,} \quad \xi = E(y|N) - I(N)C < E(y|N) = \gamma_D. \]

(4) When \( \xi_1 < K < \xi_2 \), there is no pure strategy for the market and the opponent to impose the political cost when nondisclosure is observed. Thus, there is no pure strategy disclosure equilibrium in this case. Although a partial disclosure equilibrium may be possible if one allows for mixed strategies for the market and the opponent (i.e., the opponent will attack with a probability \( q \)), we do not wish to analyze mixed strategy equilibrium in this paper.

Proof of proposition 3a

First, we show that the equilibrium disclosure threshold \( \xi \) is monotonically decreasing in \( K \).

Case 1:
\( K \geq \xi_2 \), differentiate equation (2) w.r.t. \( K \);
\[ -(1 - p) \frac{\partial \xi}{\partial K} = pG(\xi) \frac{\partial \xi}{\partial K} + C(1 - p)G'(K) \]
\[ \frac{\partial \xi}{\partial K} = - \frac{C(1 - p)G'(K)}{(1 - p) + pG(\xi)} < 0 \]

Note that \( G'(K) > 0 \) as it is the density function of \( G(y) \). \( \xi_2 \) is defined as the solution to equation (2) when \( K = \xi \). The monotonic condition ensures that \( \xi = \gamma_D \) is the minimum equilibrium disclosure threshold solution for equation
(2) when $K = 1$, and that $\xi = \xi_2$ is the maximum disclosure threshold value for equation (2) when $K = \xi_2$.

**Case 2:**

$K \leq \xi_1$, differentiate equation (4) w.r.t. $K$;

$$
- (1 - p) \frac{\partial \xi}{\partial K} = pG(\xi) \frac{\partial \xi}{\partial K} + G'(K)C
$$

$$
\frac{\partial \xi}{\partial K} = - \frac{G'(K)C}{(1 - p) + pG(\xi)} < 0
$$

$\xi_1$ is defined as the solution to equation (4) when $K = \xi$. The monotonic condition ensures that $\xi = \gamma_D$ is the maximum equilibrium disclosure threshold solution for equation (4) when $K = 0$, and that $\xi = \xi_1$ is the minimum equilibrium disclosure threshold value for equation (4) when $K = \xi_1$.

Because we established in the Proof of proposition 3 that $\xi > \gamma_D$ when $K \geq \xi_2$, and $\xi < \gamma_D$ when $K \leq \xi_1$, these two conditions, combined with the monotonic conditions established here for equations (2) and (4), imply that the equilibrium disclosure threshold $\xi$ for $K \geq \xi_2$ will be greater than that for $K \leq \xi_1$. The monotonical relationship between $\xi$ and $K$ in equilibrium can be described in the following graph.

---

**Proof for proposition 3b**

**Case 1:**

$K \geq \xi_2$, differentiate equation (2) w.r.t. $p$;
\[-(\mu - \xi) - (1 - p)\frac{\partial \xi}{\partial p} = \int_0^\xi G(y)dy + pG(\xi)\frac{\partial \xi}{\partial p} + C(1 - G(K))\]

\[\frac{\partial \xi}{\partial p} = -\frac{(\mu - \xi) + \int_0^\xi G(y)dy}{pG(\xi) + (1 - p)} < 0\]

Note that $\xi$ is less than $\mu$ in equilibrium.

**Case 2:**

$K \leq \xi_1$, differentiate equation (4) w.r.t. $p$;

\[-(\mu - \xi) - (1 - p)\frac{\partial \xi}{\partial p} = \int_0^\xi G(y)dy + pG(\xi)\frac{\partial \xi}{\partial p}\]

\[\frac{\partial \xi}{\partial p} = -\frac{(\mu - \xi) + \int_0^\xi G(y)dy}{pG(\xi) + (1 - p)} < 0\]

Again, note that $\xi < \mu$ in equilibrium.

**Proof for proposition 3c**

**Case 1:**

$K \geq \xi_2$, differentiate equation (2) w.r.t. $C$;

\[-(1 - p)\frac{\partial \xi}{\partial C} = pG(\xi)\frac{\partial \xi}{\partial C} - (1 - p)(1 - G(K))\]

\[\frac{\partial \xi}{\partial C} = \frac{(1 - p)(1 - G(K))}{pG(\xi) + (1 - p)} > 0\]

**Case 2:**

$K \leq \xi_1$, differentiate equation (4) w.r.t. $C$;

\[-(1 - p)\frac{\partial \xi}{\partial C} = pG(\xi)\frac{\partial \xi}{\partial C} + G(K)\]

\[\frac{\partial \xi}{\partial C} = -\frac{G(K)}{pG(\xi) + (1 - p)} < 0\]
Proof for proposition 3d

Case 1:
\[ K \geq \xi_2, \text{ differentiate equation (2) w.r.t. } \mu; \]
\[
(1 - p) - (1 - p) \frac{\partial \xi}{\partial \mu} = pG(\xi) \frac{\partial \xi}{\partial \mu}
\]
\[
\frac{\partial \xi}{\partial \mu} = \frac{(1 - p)}{pG(\xi) + (1 - p)} > 0
\]

Case 2:
\[ K \leq \xi_1, \text{ differentiate equation (4) w.r.t. } \mu; \]
\[
(1 - p) - (1 - p) \frac{\partial \xi}{\partial \mu} = pG(\xi) \frac{\partial \xi}{\partial \mu}
\]
\[
\frac{\partial \xi}{\partial \mu} = \frac{(1 - p)}{pG(\xi) + (1 - p)} > 0
\]

Appendix 2
Sample firms subjected to orders

<table>
<thead>
<tr>
<th>Company name</th>
<th>Type of order</th>
<th>Date (y/m/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abitibi-Price Inc. (Thunder Bay)</td>
<td>Control Order</td>
<td>1992/11/19</td>
</tr>
<tr>
<td>Abitibi-Price Inc. (Iroquois)</td>
<td>Control Order</td>
<td>1985/08/01</td>
</tr>
<tr>
<td>Abitibi-Price Inc. (Fort William)</td>
<td>Control Order</td>
<td>1985/04/29</td>
</tr>
<tr>
<td>Abitibi-Price Inc. (Provincial Paper)</td>
<td>Control Order</td>
<td>1985/04/29</td>
</tr>
<tr>
<td>Abitibi-Price Inc. (Thunder Bay)</td>
<td>Control Order</td>
<td>1985/04/29</td>
</tr>
<tr>
<td>Algoma Steel Corporation Ltd.</td>
<td>Control Order</td>
<td>1982/06/30</td>
</tr>
<tr>
<td>Algoma Steel Corporation Ltd.</td>
<td>Control Order</td>
<td>1986/10/03</td>
</tr>
<tr>
<td>Algoma Steel Corporation Ltd.</td>
<td>Control Order</td>
<td>1986/11/04</td>
</tr>
<tr>
<td>Algoma Steel Corporation Ltd.</td>
<td>Control Order</td>
<td>1988/09/23</td>
</tr>
<tr>
<td>Alcan Smelter &amp; Chemicals Ltd.</td>
<td>Control Order</td>
<td>1990/07/04</td>
</tr>
<tr>
<td>Bank of Montreal</td>
<td>Minister’s Order</td>
<td>1984/05/01</td>
</tr>
<tr>
<td>Canada Cement LaFarge Ltd.</td>
<td>Control Order</td>
<td>1986/12/22</td>
</tr>
<tr>
<td>CN Rail</td>
<td>Minister’s Order</td>
<td>1987/12/23</td>
</tr>
<tr>
<td>CN Rail</td>
<td>Minister’s Order</td>
<td>1988/02/18</td>
</tr>
<tr>
<td>Abitibi-Price Inc.</td>
<td>Minister’s Order</td>
<td>1987/12/23</td>
</tr>
<tr>
<td>Abitibi-Price Inc.</td>
<td>Minister’s Order</td>
<td>1988/02/18</td>
</tr>
<tr>
<td>CP Forest Products Ltd. (Thunder Bay)</td>
<td>Control Order</td>
<td>1989/10/23</td>
</tr>
<tr>
<td>CP Forest Products Ltd. (Dryden)</td>
<td>Control Order</td>
<td>1989/10/23</td>
</tr>
<tr>
<td>Domtar Inc. (Packaging/Container)</td>
<td>Control Order</td>
<td>1989/10/25</td>
</tr>
<tr>
<td>Domtar Inc. (Packaging/Container)</td>
<td>Control Order</td>
<td>1992/01/06</td>
</tr>
<tr>
<td>Domtar Inc. (Fine Paper)</td>
<td>Control Order</td>
<td>1990/01/09</td>
</tr>
</tbody>
</table>
### Appendix 3
Sample firms prosecuted by the MOEE

<table>
<thead>
<tr>
<th>Company name</th>
<th>Date (y/m/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abitibi-Price Inc.</td>
<td>1992/02/10</td>
</tr>
<tr>
<td>Alcan Aluminum Ltd.</td>
<td>1992/11/23</td>
</tr>
<tr>
<td>Alcan</td>
<td>1989/03/16</td>
</tr>
<tr>
<td>Algoma Central Corporation</td>
<td>1990/11/16</td>
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<tr>
<td>Algoma Steel Corporation Ltd.</td>
<td>1990/10/05</td>
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<tr>
<td>Algoma Steel Corporation Ltd.</td>
<td>1989/07/21</td>
</tr>
<tr>
<td>Algoma Steel Corporation Ltd.</td>
<td>1989/02/22</td>
</tr>
<tr>
<td>Algoma Steel Corporation Ltd.</td>
<td>1991/07/12</td>
</tr>
<tr>
<td>Canadian Pacific Forest Products Ltd.</td>
<td>1992/01/13</td>
</tr>
<tr>
<td>Canadian Pacific Forest Products Ltd.</td>
<td>1990/12/07</td>
</tr>
<tr>
<td>Canadian Pacific Ltd.</td>
<td>1989/07/24</td>
</tr>
<tr>
<td>Deak Resources Corporation</td>
<td>1992/03/XX</td>
</tr>
<tr>
<td>Denison Mines Ltd.</td>
<td>1991/09/18</td>
</tr>
<tr>
<td>Denison Mines Ltd.</td>
<td>1989/07/28</td>
</tr>
<tr>
<td>Dofasco Inc.</td>
<td>1989/08/03</td>
</tr>
<tr>
<td>Domtar Inc.</td>
<td>1991/08/09</td>
</tr>
<tr>
<td>Domtar Inc.</td>
<td>1988/09/16</td>
</tr>
<tr>
<td>Domtar Inc.</td>
<td>1991/05/30</td>
</tr>
<tr>
<td>Domtar Inc.</td>
<td>1991/04/17</td>
</tr>
</tbody>
</table>
Appendix 4
Sample firms with significant spills

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Date of the spill (y/m/d)</th>
<th>Material spilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algoma Central Railway</td>
<td>19900424</td>
<td>24,000 L fuel to creek</td>
</tr>
<tr>
<td>Algoma Steel Corporation Ltd.</td>
<td>19880608</td>
<td>900,000 L coal tar to plant</td>
</tr>
<tr>
<td>American Barrick Resources Corporation</td>
<td>19881031</td>
<td>120,000 L tailings slurry</td>
</tr>
<tr>
<td>Ateba Mines Inc.</td>
<td>19890502</td>
<td>Polishing pond overflow</td>
</tr>
<tr>
<td>Canadian Pacific Forest Products Ltd.</td>
<td>19910425</td>
<td>Black liquor to river</td>
</tr>
<tr>
<td>Canamax Resources Inc.</td>
<td>19890420</td>
<td>&gt;700 tons of tailings</td>
</tr>
<tr>
<td>Deak Resources Corporation</td>
<td>19910309</td>
<td>Tailings overflow with cyanide</td>
</tr>
<tr>
<td>Company</td>
<td>Date</td>
<td>Environmental Incident</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>------------</td>
<td>----------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Denison Mines Ltd.</td>
<td>19890307</td>
<td>10 tonnes of uranium slurry</td>
</tr>
<tr>
<td>ERG Resources Ltd.</td>
<td>19890318</td>
<td>Large cyanide solution spill</td>
</tr>
<tr>
<td>Falconbridge Ltd.</td>
<td>19880924</td>
<td>12 tons of 97% sulphuric acid</td>
</tr>
<tr>
<td>Giant Yellowknife Mines Ltd.</td>
<td>19890521</td>
<td>Mines-bypass (heavy metals)</td>
</tr>
<tr>
<td>Giant Yellowknife Mines Ltd.</td>
<td>19910408</td>
<td>Tailings pond wall breach</td>
</tr>
<tr>
<td>Kelsey-Hayes Canada Ltd.</td>
<td>19890322</td>
<td>Light oil to creek</td>
</tr>
<tr>
<td>Lac Minerals Ltd.</td>
<td>19890306</td>
<td>Cyanide leachate to creek</td>
</tr>
<tr>
<td>Rayrock Yellowknife Resources Inc.</td>
<td>19881119</td>
<td>54,000 L crude oil</td>
</tr>
<tr>
<td>Renabie Gold Mines Ltd.</td>
<td>19910919</td>
<td>PCB liquid leak</td>
</tr>
<tr>
<td>SICO Inc.</td>
<td>19920225</td>
<td>Solvent in storm sewer</td>
</tr>
<tr>
<td>St. Andrew Goldfields Ltd.</td>
<td>19900217</td>
<td>90,800 L tailings</td>
</tr>
<tr>
<td>Timmins Nickel Inc.</td>
<td>19910904</td>
<td>Tailings pond overflow</td>
</tr>
</tbody>
</table>

Endnotes
1 These studies pertain only to U.S. and U.K. firms. Discussions with environmental experts in Canada indicated that Ontario’s environmental and disclosure laws and enforcement are less stringent than those in the United States. Thus, disclosure in Ontario would be expected to be even less adequate than that described in the U.S. studies.
2 Thornton (1983, 82, on “the paradox of unasserted claims”) discusses how disclosure might affect court decisions. He found that corporations do not report unasserted claims (157). More recently, Canadian companies cited unclear legal implications of disclosing environmental liabilities as a major concern with the CICA handbook section on disclosure of land reclamation and restoration provisions (Moore 1991, 54).
3 Investors are concerned about corporate environmental liabilities because environmental stakeholders have higher priority over the residual values of bankrupt firms than lenders and shareholders under the existing environmental legislation. Major Canadian lending institutions have developed procedures to screen the potential environmental risk from business loans (CICA 1992, Appendix 2 and 3).
4 For example, Greenpeace launched a public relations campaign against MacMillan Bloedel, protesting against clear-cut logging in British Columbia. Besides losing business, the firm had to explain to the public its good intentions by taking out one full page advertisement in a national newspaper in Canada (Globe and Mail, March 22, 1994).
5 Though the legal responsibility to clean up spills is clear, the actual cost to clean up a spill varies dramatically, depending on the pollutant(s) discharged, the geological conditions of the spill site, the underground water distribution, weather conditions, the surrounding population, and the cleanup technology employed.
6 For example, owing to public pressure, Amoco Canada Petroleum Ltd. spent millions of dollars to clean up a crude oil spill in an Alberta swamp, against experts’ recommendation that nature be allowed to absorb the spill. The result
was a man-made disaster when heavy cleanup equipment drove the oil underground and caused even more damage to the environment (See Oil Cleanup Did More Ill Than Good. Montreal Gazette, June 2, 1991, A9).

7 Slemrod (1989) noted a similar phenomenon in the area of taxation. Because of the inherent complexity of tax laws and the uncertainty in applying the law to one’s specific situation, often the tax authority cannot determine whether there has been intentional (fraudulent) or unintentional nondisclosure of tax liabilities.

8 Dye (1986, note 6, 334) made a similar assumption.

9 This assumption means that the firm and management are not distinguished. Moral hazard is absent because the firm’s disclosure strategy will not affect the distribution of y or its realized value. Wagenhofer (1990, note 3) gives arguments supporting this assumption.

10 The case where \( f(y < K) < kIB \) is ignored because the opponent would attack only if \( y < K \) were disclosed, ignoring the potential environmental liabilities of nondisclosing firms and losing its strategic role. This may lead to a nonexistent or degenerate equilibrium where firms disclose nothing up \( y = K \).

11 This assessment is consistent with empirical evidence. Shane and Spicer (1983) reported market reactions to the release of corporate pollution information. Blacconiere and Patten (1994) found that the market anticipated increased regulatory costs in the U.S. chemical industry following Union Carbide’s chemical disaster in Bhopal, India, in 1984.

12 See proof for proposition 3 in Appendix 1.

13 We thank Sunil Dutta whose suggestions simplify the exposition of this proof.

14 Thus, contrary to Wagenhofer (1990) and Darrough & Stoughton (1990), endogenizing proprietary costs does not lead to a full disclosure equilibrium because of the opponent’s incomplete information about the firm’s information endowment.

15 As discussed previously, \( f(N) = 0 \) when \( K \leq 0 \) and the opponent will never attack when nondisclosure is observed. Then, for nondisclosing firms, \( V = E(yN) = \gamma_D \), where \( \gamma_D \) is the equilibrium disclosure threshold in Jung and Kwon (1988). When \( K \geq 1 \), \( f(N) = 1 \), meaning that the opponent will always attack and the firm always incurs cost \( C \) with probability 1. Thus, \( V = E(yN) - C = \gamma_D - C \), so \( \gamma_D \) is still the equilibrium disclosure threshold. Therefore, the disclosure threshold \( \gamma_D \) established by Jung and Kwon is a special case of the model.

To see how the risk of the opponent’s attack will alter the equilibrium disclosure threshold \( \gamma_D \) as established in Dye (1985), let us examine a firm with a \( y \in (\gamma_D, K) \) first (thus, \( K > \gamma_D \)). Assuming that \( \gamma_D \) still holds, if the firm discloses, it realizes the value \( y - C \). If it does not disclose, it realizes \( \gamma_D - f(N)C \). Hence, the firm is better off not disclosing if \( y < \gamma_D + (1 - f(N))C \). Thus, \( \gamma_D \) cannot be the equilibrium disclosure threshold as there are clearly \( y \in (\gamma_D, K) \) such that \( y < \gamma_D + (1 - f(N))C \). We showed in the proof that the new equilibrium disclosure threshold \( \xi \) will shift to the right of \( \gamma_D \).

Similarly, when \( y \in (K, \gamma_D) \) (thus, \( K < \gamma_D \)), firms will have incentives to disclose if \( y > \gamma_D - f(N)C \). Again, \( \gamma_D \) cannot be the equilibrium cutoff in this game because there exist \( y \in (K, \gamma_D) \) such that \( y > \gamma_D - f(N)C \). Thus, the new equilibrium \( \xi \) will shift to the left of \( \gamma_D \), as is shown in Appendix 1.

16 When \( K \leq 0 \) and \( K \geq 1 \), the size of political costs will not affect disclosure. When \( K \leq 0 \), the risk of incurring political cost disappears. When \( K \geq 1 \), the political cost becomes unavoidable. How political costs affect management disclosure decisions will be a continuing research interest in the years to come. For instance, Penno (1995) showed that for certain specifications of political cost functions, political costs have no impact at all on management disclosure decisions.
Note that silence does not reduce the risk of attack by the opponent, because the opponent is assumed to form rational posterior beliefs, given silence. $K$ alters disclosure decisions because, when $K$ is large (i.e., $K > \xi$), a firm with $y < \xi$ gets a better market valuation by being silent, even if $y > E(y|N)$. The firm prefers to have the market price the expected political cost $\Gamma(N)C$ than incur the certain political cost $C$ that would result from disclosing $y < K$. The opposite holds when $K$ is small (i.e., $< \xi$). Though $y$ may be less than $E(y|N)$, some firms that would be silent in Dye’s (1985) setting, with no opponent, would now get a better market valuation by disclosing. Such firms would rather have the market price their actual $y$ than $yD - \Gamma(N)C$. They know that $y > K$, so no political cost will be incurred as $\delta(y > K) = 0$.

Proposition 3b is consistent with Jung and Kwon’s (1988) proposition 2 and Dye’s (1985) corollary 1 but is derived from a model that includes a strategic opponent.

One could argue that the public became aware of potential environmental danger associated with ocean oil transportation after the Exxon spill. This new level of knowledge would induce companies in the business to disclose more in order to dispel the public pessimism.

There is no data set in Canada similar to the U.S. Superfund site data as used by Barth and McNichols (1994).

According to the model, nondisclosure per se is informative. Thus, outsiders must be aware that an incident occurred in order to be aware of nondisclosure. Because the data were identified from public records, it was assumed that some outsiders were aware of the incidents prior to firms’ disclosure decisions.


It is recognized that this procedure involves some subjective judgement because of the uncertainty associated with assessing cleanup liabilities. The impact of spill data on the significance of the empirical model is assessed later.

A frequency distribution of disclosure media used by the sample firms for the 37 disclosures is as follows: AIFs 24, Annual reports 20, Form 27 (the OSC material information disclosure form) 1, Quarterly reports 2, Press release 1. The total is greater than 37 as some disclosures were made in more than one disclosure vehicle.

King and Wallin (1991) circumvent the unobservability of $\pi_r$ by using experimental laboratory market data. Campbell, Sefcik, and Soderstrom (1996) use a hazard-rating score and aggregate-site settlement to measure uncertainty associated with Superfund site cleanup liabilities.

The Canadian Index database covers articles published since January, 1982, in eight major Canadian newspapers and over 200 Canadian business and trade periodicals, including *The Financial Post*, *The Financial Times*, and *Globe and Mail Report on Business*. It is an index database and does not provide the text of all articles except for some key words used in the original articles. LEXIS/NEXIS was not used because that database does not contain articles from many of the mainstream Canadian publications such as the *Globe & Mail* and the *Toronto Star*.

The search was conducted using joint key words in the following order: COMPANY NAME YEAR (ENVIRONMENT? OR POLLUT? OR EMISSION? OR EFFLUENT? OR DISCHARG? OR CONTAMINA? OR CLEANUP OR CLEAN? ADJ UP OR SPILL?).

As a robustness check, if no news items were found for firm $i$ during an incident year, $\pi_r$ was simply set equal to zero. Results were qualitatively the same as those reported in the text.
It was suggested that the number of spills would serve as a proxy for pollution propensity. This suggestion is not implemented for three reasons: (1) the MOEE’s spill records go back only to 1988, whereas our sample goes back to 1982; (2) most spills reported to the MOEE are trivial (e.g., a few liters of gasoline), so the number of spills would not reflect pollution risk; (3) it would be hard to adjust for firm size.

See Maddala (1991, 792). Simulation studies report that \( t \)-tests for individual parameter estimates tend to incorrectly reject the null hypothesis less frequently than indicated by the nominal significance levels for logit (Stone and Rasp 1991) and probit models (Noreen 1988).

When the Table 8 logit analysis was repeated using the alternative proxy for \( \lambda \) described in the next section of the paper, the coefficient of \( \lambda \) was positive and significant at the .01 level.

We thank the authors for permission to cite these results.

Much of the empirical work in the litigation field uses U.S. data. Clarkson and Simunic (1994) argue that Canada is a less litigious environment than the United States. As a check on litigation effects, we repeated our basic logit analysis with a dummy variable included to capture the 15 firms in our sample that are cross-listed on the New York Stock Exchange. Given the more litigious U.S. environment, we tested whether this dummy is positively associated with the probability of disclosure. The coefficient on the dummy is insignificant and our results remain the same. We thank Gregory Waymire for the suggestion to perform such tests.

Though recent CICA (1992, 1993) publications have covered environmental liabilities and environmental auditing in a very general way, auditing standards for environmental liabilities are not well developed.

This is a sufficient condition to ensure a pure strategy equilibrium. If \( G(y) \) follows a normal distribution, as in Verrecchia (1983, 1990a), the condition is automatically satisfied for any finite \( P, C, \) and \( K \).

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