

Toxic release inventories and green consumerism: empirical evidence from Canada

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Abstract. Do firms abate pollution in response to actual or anticipated green consumerism? Lacking direct observational data on the extent of green consumerism, we construct an indirect method to elicit its effect on pollution abatement. If environmentally motivated consumers target companies rather than particular facilities of a multi-product firm, green consumerism can be identified through intra-firm inter-plant spillover effects in pollution abatement. We test the prediction that 'environmentally-leveraged' firms with consumer market exposure experience larger emission reductions. We use 1993–99 panel data from Canada's National Pollutant Release Inventory (NPRI), with pollutants adjusted for toxicity. Our empirical results find statistically significant evidence of green consumerism, but its economic magnitude is very small. JEL Classification: Q2, R3

Inventaires des émanations toxiques et consumérisme vert : résultats pour le Canada. Est-ce que les entreprises réduisent la pollution en réponse au consumérisme vert – présent ou anticipé? Comme on n'a pas de façon de le savoir directement, on élabore une méthode indirecte de mesurer son impact sur la réduction de la pollution. Si des consommateurs intéressés à l'environnement ciblent certaines sociétés plutôt que des installations particulières d'une entreprise multi-produit, le consumérisme vert a un impact détectable via des effets de retombées des politiques de réduction de pollution intra-firme entre les

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installations. On met au test l'hypothèse que les entreprises qui sont exposées à des pressions sur le marché effectuent des réductions de pollution plus importantes. Utilisant des données de l'inventaire national des rejets de polluants du Canada pour 1993–99, on trouve que l'effet du consumérisme vert est statistiquement significatif mais économiquement très faible.

1. Introduction

The dissemination of environmental information is increasingly being used by governments as a policy instrument to induce firms to reduce their environmental impacts. Publication of information about facilities' pollutant releases can complement regulatory programs by indicating which facilities are in compliance with existing standards or by suggesting priorities for development of new standards. However, information may also serve as a substitute for regulation to the extent that it prompts non-governmental actors to exert market pressure on firms to voluntarily reduce their pollutant releases. In this paper we take aim at the latter and focus, in particular, on the influence of 'green' consumers.

Our paper is concerned with the effectiveness of green consumerism in response to the publication of Canada's National Pollutant Release Inventory (NPRI). The data set spans the years 1993–99, covering nearly 2,500 facilities reporting emissions of 192 pollutants into the air, water, land, and subsoil. In the absence of direct information on consumer behaviour, we devise a theoretical and empirical strategy that allows us to indirectly identify the impact of green consumerism. We then apply our methodology to the available data and look for evidence that green consumerism has had a significant impact on firms' level of emissions, rates of change in emissions, and pollution intensity. We separately consider different release media (air, water, land, subsoil, and offsite transfers), and find evidence that companies respond most strongly to consumer pressures by reducing their releases to air and transfers of wastes off site, but also by increasing less visible releases to subsoil via underground injection.

Our paper is the first to investigate the effectiveness of green consumerism empirically on a national level. It is also the first to study green consumerism in a Canadian context. While we do find evidence that green consumerism has had an impact on firms' emissions, our indirect method of eliciting green consumerism does not allow us to discern whether companies are reducing their releases in response to actual consumer pressure or in anticipation of such pressure.¹ Nevertheless, even if our results were entirely due to pre-emptive

1 This is a significant shortcoming from a policy perspective. Ideally, we would like to provide an estimate of how much emissions are reduced when consumers punish individual companies for above-average emission levels by reducing purchases of their goods by a given percentage amount. However, the unavailability of comprehensive micro-data required for calculating such an estimate puts such a study thoroughly out of reach.

activity by companies, they still reveal the potential effectiveness of green purchasing behaviour by consumers.

In the following section we provide context for the notion of green consumerism. In section 3 we sketch a simple partial-equilibrium model that provides a mechanism through which we are able to identify the effect of green consumerism. Section 4 discusses how we aggregate our data across pollutants, and in section 5 we preview and discuss our data sources, with special attention given to the NPRI. Section 6 provides details of the empirical implementation, and our empirical results are discussed in section 7. Section 8 concludes.

2. Identifying green consumerism

The concept of environmental information as an effective policy tool to reduce emissions has gathered support in numerous countries. Informational strategies for environmental protection are predicated on the assumption that firms will respond to pressure from consumers, workers, investors, and community groups armed with more complete information about firms' environmental practices. The significant reduction of toxic releases reported during the first few years of the U.S. Toxic Release Inventory (TRI) has prompted some observers—such as Organization for Economic Co-operation and Development (1996) and Gunningham and Grabosky (1998)—to speculate that this combination of information dissemination and stakeholder pressures might even be more effective than traditional regulation of environmental discharges. Putting this hypothesis to the test empirically is one objective of our paper.

Consumers and other stakeholders (e.g., investors, employees, and community activists) can readily obtain information about facilities covered in the NPRI through searchable databases on the web. Environment Canada maintains a web interface at www.ec.gc.ca/pdb/querysite/html/queryform.cfm.² Canadian environmental groups have also provided more user-friendly access to the NPRI data via the 'PollutionWatch' Web site (www.pollutionwatch.org), which is modelled on a comparable U.S. site developed by the U.S. group Environmental Defense (www.scorecard.org). PollutionWatch reported that in the first two days following the launch of their Web site, it received just under 3 million "hits" and prompted users to send roughly 1200 faxes (as facilitated by the site) to polluting companies. Consumers can also gain information from NPRI indirectly via newspaper stories about the inventory, which tend to coincide

2 According to Environment Canada, in June 2002 this web server counted 3,668 sessions with a total of 28,325 page views. The average visitor spent about seven minutes querying the database. About 40% of visitors were referred to the site from Environment Canada's main web server, while another 40% were referred to the site from the *Toronto Star*, which carried an article about the NPRI during that month. Queries on the web server are reported by Environment Canada staff to be significantly higher following the release of new NPRI data every year.

with the release of each annual report. It is noteworthy that one of the most common techniques reporters have used to gain readers' interest has been to identify by name the top few national or regional polluters.³

Ideally, we would like to measure green consumerism through what households and businesses buy, linking particular products to production facilities. There are two difficulties with this approach: there are no data sets that cover purchases from both households and businesses at a sufficiently high level of disaggregation; and there are no comprehensive data sets that link products to individual plants. Thus, we employ a rather indirect strategy, which relies on an identification assumption that focuses on multi-product (multi-sector) firms. We assume that consumers use the NPRI to identify facilities with high levels of pollution and to identify the companies that own them, but that they cannot link those facilities directly to particular products. Consumers can therefore 'punish' companies but not particular plants. Consequently, multi-sector firms will experience a spillover effect through which a low-revenue high-emission sector may negatively impact sales in a high-revenue low-emission sector. The extent to which firms are subject to such a negative intra-firm externality we call 'environmental leverage.'

The *raison d'être* of the NPRI is to enable various stakeholders in society, including consumers, to exact pressure on firms to reduce their pollution. However, the motivations for green consumerism can be diverse. Consumers living in the vicinity of a plant may change their purchasing behaviour in order to encourage reduction of pollution to which they are personally exposed. However, even in the vicinity of a facility, and increasingly as the distance from the facility extends, such behaviour will turn on consumers' willingness to forgo the temptation to free-ride on others' green consumerism. Other consumers may be motivated by altruism, regardless of any risks to themselves.⁴ There is some anecdotal evidence of green consumerism. In the fall of 1999 both Sweden's IKEA AB and the U.S. firm Home Depot Inc. announced that they would purchase only wood products certified by third parties as sustainably harvested. In response to such pressures, Weyerhaeuser Canada has ended its controversial clear-cut logging practices in coastal British Columbia.⁵

3 See, for example, Brian McAndrew, 'Ottawa issues a list of nation's polluters: Montreal-area firm tops new public inventory,' *Toronto Star*, 27 April 1995, A2 (which listed 11 companies by name based on the performance of individual facilities they own); Barrie McKenna, 'Major Canadian companies on list of North America's worst polluters,' *Globe and Mail*, 3 March 1998, A3; Kathleen Engman, 'Calgary-owned plants top pollution list,' *Calgary Herald*, 29 July 1998, B1; and John Duncanson 'Toxin levels will be public,' *Toronto Star*, 18 May 2002.

4 In exceptional cases, even distant consumers may perceive immediate self-interest if a connection is made between pollutants released to the environment at the point of production and contaminants present in consumer products. Thus, in the case of the pulp and paper industry, consumer demand for chlorine-free paper in Western Europe pressured pulp mills as far away as Indonesia to change their production processes to reduce both releases of dioxins to the environment and dioxins in paper products. See Harrison (2001).

5 *Globe and Mail*, March 20, 2000.

If green consumers eschew products from highly polluting firms, those firms will have incentives to reduce their emissions voluntarily. However, this market-based process will be hampered by the free-rider problem and the fact that pollution may be local rather than global. Still, green consumerism does not necessarily have to be manifest as a *realized* downward shift in demand to have an impact on firms' pollution abatement activity. It would suffice that companies anticipate consumer reaction in response to information about their emission levels. In this regard, it is relevant that Canadian firms could look to six years of experience with the U.S.-TRI. Although it was clear that most U.S. consumers did not search the Internet for pollutant data on particular facilities, they were much more likely to be exposed to interpretation of the raw TRI data by the press as well as media coverage of analyses by environmentalists that used TRI data to shame individual companies (Lynn and Kartez 1994).

In addition to providing a basis for market pressures via green consumerism or investment, information disseminated through the NPRI may also be used by stakeholders to press for municipal, provincial, or federal environmental regulation. Thus, much of the literature on toxic release inventories emphasizes the role of 'community pressure.' It is worth noting, however, that individuals in one community may have greater or less capacity and inclination to respond to environmental information than in another. Pollution levels have been linked to community characteristics such as income in cross-sectional studies. For example, Brooks and Sethi (1997) and Ringquist (1997) find an empirical relationship between pollution levels and per capita income. This empirical relationship may be linked to local regulatory interventions as well as to the location choice of companies and individuals. Two other studies, Grant (1997) and Brooks and Sethi (1997) find evidence that reductions in pollution after release of U.S.-TRI data are linked to educational and income characteristics of communities. The authors speculate that wealthy communities are better able to access information and are more politically empowered to act on the available information. This could result in greater regulatory pressure to the extent that empowered citizens employ the political process or greater market pressures to the extent that they engage in public campaigns to shame particular facilities.

Relationships between community demographics and facility releases could be indicative of either regulatory or market pressures. Similarly, both green consumers and regulators would be expected to focus attention on facilities with the largest emissions and those located in the most densely populated neighbourhoods. However, one would anticipate regulatory and consumer pressures to be expressed differently in other respects. For instance, regulators, who typically employ technology-based standards, might be expected to focus more on how pollution intensive a facility is relative to other facilities in the same sector, whereas local communities or activists are unlikely to care whether a facility's greater emissions are justified

by higher levels of production. On the other hand, consumers are more likely to pressure entire companies, rather than particular facilities, and to exert particular influence on consumer product-oriented firms, neither of which is likely to concern regulators.

3. Theory

We use a novel approach to identify consumer reaction based on a type of information asymmetry between firms and consumers. Because we cannot directly observe (or measure) changes in demand due to green consumerism, we allow for the possibility that firms may suffer from a green-consumerism spillover effect if they are sectorally diversified with some sectors producing more pollution than others. Concretely, we assume that (1) consumers have information about emissions from individual plants, but (2) at least *some* consumers cannot attribute a firm's products to individual production plants. Thus, at least some environmentally motivated consumers will not be able to distinguish which goods are associated with pollution and consequently may reduce consumption of all goods produced by a firm rather than just the ones that cause pollution. This is a relatively conservative way of getting at green consumerism, and is likely to understate its effect.

We consider a simple model of a multi-plant firm that produces quantities x_i of goods $i = 1, \dots, n$. Goods production may vary in unabated pollution intensity, denoted by z_i . The company devotes effort $\theta_i \geq 0$ to pollution abatement related to the production of good i . This may be thought of as an investment into abatement equipment. Abatement cost for each plant will thus be $a_i \theta_i z_i x_i$, where a_i indicates the costliness of the abatement technology for plant i . Through abatement, emissions are reduced to $\exp(-\theta_i)$ times the unabated level. Total emissions are

$$E(\mathbf{x}, \theta) = \sum_i E_i(x_i, \theta_i) = \sum_i z_i x_i \exp(-\theta_i). \quad (1)$$

Abatement effort is subject to diminishing returns: $E_\theta < 0$ and $E_{\theta\theta} > 0$.

Consumers can exert pressure on the revenues of the firm, reducing effective demand by a factor of $1 - \gamma E(\mathbf{x}, \theta)$. Here γ denotes the intensity of green consumerism, that is, how much consumers lower demand in response to ambient emissions. Goods sell at price p_i and are produced at marginal cost $c_i x_i$. Goods production is additively separable in costs and emissions. These assumptions give rise to the following profit function:

$$\Pi = \left[\sum_i p_i x_i \right] [1 - \gamma E(\mathbf{x}, \theta)] - \sum_i \left[a_i \theta_i z_i x_i + \frac{1}{2} c_i x_i^2 \right]. \quad (2)$$

We maximize company profit Π with respect to outputs x_i and abatement efforts θ_i . We define $m \equiv \sum_i p_i x_i$ as a measure of the company's size. The n pairs of first-order conditions⁶ are

$$\partial\Pi/\partial x_i = p_i(1 - \gamma E(\mathbf{x}, \theta)) - m\gamma E_i(x_i, \theta_i)/x_i - a_i\theta_i z_i - c_i x_i = 0 \tag{3}$$

$$\partial\Pi/\partial\theta_i = m\gamma E(x_i, \theta_i) - a_i z_i x_i \leq 0 \quad \perp \quad \theta_i \geq 0, \tag{4}$$

with \perp denoting complementary slackness. Using the definition of $E_i(x_i, \theta_i)$, the first-order condition (4) for the optimum abatement effort yields the solution:

$$\theta_i^* = \ln \left[\frac{\gamma m}{a_i} \right]. \tag{5}$$

Abatement effort is increasing in consumer reaction γ , and it is decreasing in the abatement cost factor a_i . Abatement effort also increases with the size m of the firm. Because consumer reaction is directed at the entire firm, not just at an individual polluting plant, abatement effort is determined by the company's size (m), not by an individual plant's size ($p_i x_i$).

Equation (5)'s complementary slackness condition implies that green consumerism must be sufficiently high to trigger abatement effort. For abatement to take place, that is, $\theta_i^* > 0$, it must hold that $\gamma > a_i/m$. This means that the intensity of consumer reaction must exceed a threshold governed by the marginal abatement cost a_i . As different plants will face different a_i s, an increase in γ will switch abatement regimes in individual plants in ascending order of the a_i s.

Let $\sigma_i \equiv p_i x_i/m$ denote the revenue share of plant i . Assume that i is a plant that generates large amounts of pollution, while the other plant(s) are generating little or no pollution. Then the leverage ratio $\lambda_i \equiv (1 - \sigma_i)/\sigma_i$ is a measure of the extent to which revenue of all but the i th plant is exposed to activity in the i th plant. The λ_i^* s are determined through the set of first-order conditions in (3). Noting that $m = p_i x_i (1 + \lambda_i)$ and inserting the optimal abatement effort (5) back into the emissions equation (1) yields

$$E^*(\lambda^*, \gamma) = \sum_i \frac{z_i/p_i}{1 + \lambda_i^*} \left\{ \frac{a_i}{\gamma} I \left[\gamma > \frac{a_i}{m} \right] + m I \left[\gamma \leq \frac{a_i}{m} \right] \right\}, \tag{6}$$

where $I[\bullet]$ denotes the indicator function. Equation (6) reveals our key theoretical result: emissions of plant i decrease with the degree of consumer reaction γ and the degree of environmental leverage, which depends on λ_i^* . Furthermore, the denominator of equation (6) shows that environmental leverage and consumer intensity interact multiplicatively. There is a direct effect of green consumerism γ , and a leveraged effect $\gamma\lambda_i^*$. Environmental leveraging implies a positive (empirical)

6 It is easily verified that the second-order conditions satisfy the requirements for a profit maximum.

relationship between z_i and λ_i , so that above-average pollution intensity of a facility coincides with below-average revenue share.

Equation (6) also reveals the distinct *technique* and *composition* effects of green consumerism. To back out these two effects, we totally differentiate $E_i^*(\lambda_i^*; \gamma)$ with respect to γ when $\theta_i > 0$. For simplicity, we consider the case of a firm with only two plants: a ‘brown’ plant i with $z_i > 0$ and a ‘green’ plant j with $z_j = 0$. We take the point of view of plant i and drop the i subscripts. Thus,

$$dE^* = \left[\frac{\partial E^*}{\partial \gamma} + \frac{\partial E^*}{\partial \lambda^*} \frac{\partial \lambda^*}{\partial \gamma} \right] d\gamma. \tag{7}$$

Green consumerism leads to a change in abatement effort (technique) as measured by θ^* , which is represented by the term $\partial E^*/\partial \gamma$. Green consumerism also leads to an adjustment in the composition of output λ^* , captured by $(\partial E^*/\partial \lambda^*)(\partial \lambda^*/\partial \gamma)$. What are the directions of these two effects? From (6) it is obvious that $\partial E^*/\partial \gamma < 0$ and $\partial E^*/\partial \lambda^* < 0$. Inspection of the second of the two derivatives reveals that an increase in λ will lead to a greater emission reduction when the plant is more pollution intensive. This is an important observation: environmental leverage is conditioned on the (relative) pollution intensity of a plant. When we determine the sign of $\partial \lambda^*/\partial \gamma$,⁷ we find that in response to green consumerism the firm will reduce its brown-good sector in favour of the green-good sector ($\partial \lambda^*/\partial \gamma > 0$). The composition effect augments the technique effect.⁸

In the discussion above we have assumed that a plant is carrying out pollution abatement, focusing only on the case where green consumerism is above the abatement threshold for a given plant. In the absence of knowledge about the true a_i s, the indicator functions in (6) can be interpreted as a probabilistic mixing of abatement and non-abatement at a particular plant. Thus an increase in γ will increase the likelihood of surpassing the abatement threshold and, in turn, will lower emissions. The plants with the lowest abatement cost will be first in line; they are the ‘low-hanging fruit’ for pollution abatement. Empirically, we need to know which plants are most likely to abate. This ‘participation probability’ interacts multiplicatively with the intensity of green consumerism γ and the environmental leverage parameter λ . If plants with above-average emissions are more likely

7 The set of first-order conditions (3) imply a non-linear relationship between cost ratio $\phi \equiv (c_i/p_i^2)/(c_j/p_j^2)$ and output composition λ such that $\phi = \Phi(\lambda)$. For notational convenience we will drop the i subscripts. Without any pollution abatement $\lambda^* = \phi$, but when $\theta > 0$, solving $\phi = \Phi(\lambda)$ directly for λ produces an unwieldy expression. Since we are interested only in signing the derivative, using implicit function calculus provides an elegant workaround. Let $\omega \equiv az/p$ and $\mu \equiv 1 + \lambda$. Further let $\psi \equiv \omega(1 + \theta^*)$. Then $\Phi(\lambda) = \lambda[\mu(1 - \psi) - \omega]/(\mu - \omega)$. Thus, $\partial \Phi/\partial \gamma = -\omega\mu\lambda/[\gamma(\mu - \omega)] < 0$ and $\partial \Phi/\partial \lambda^* = 1 - \psi/[1 + \omega(1 - \omega)/(\mu - \omega)^2] > 0$. Here it must hold that the abatement costs are not prohibitively high; a sufficient condition is $\psi < 1$, or $\omega < 1/(1 + \theta^*)$. Using implicit function calculus, $\partial \lambda^*/\partial \gamma = -(\partial \Phi/\partial \gamma)/(\partial \Phi/\partial \lambda^*)$. With the previously determined signs for the right-hand-side derivatives, we find that $\partial \lambda^*/\partial \gamma > 0$ under quite general conditions.

8 The relationship between the two effects is determined by the magnitude of the abatement cost parameter a . When abatement is getting cheaper ($a \rightarrow 0$), the derivative $\partial \lambda^*/\partial \gamma \rightarrow 0$ and the composition effect becomes increasingly weaker relative to the technique effect.

candidates for pollution abatement than plants with below-average emissions, there will be an empirical technological relationship between abatement cost a and pollution intensity z . An inverse relationship between a and z would amplify the effect that environmental leverage is conditioned on the pollution intensity of a plant. In our empirical implementation we must therefore allow for this interaction when we construct a measure of a firm's 'effective' environmental leverage.

We conclude this section by restating our key empirical prediction: emissions will be lower for companies that are simultaneously environmentally leveraged and exposed to consumer markets. We condition the effect of environmental leverage on plants that have above-average emission intensities.

4. Toxicity of pollutants and aggregation issues

The foregoing model is predicated on consumers' perception and valuation of the risks associated with emissions reported to pollutant release inventories. In technical terms, our parameter γ reflects an aggregation of perceived risks and thus reflects consumers' opinions about the relative importance of different pollutants. However, it is noteworthy that most such inventories, including NPRI, report only the weight of each substance released, without any adjustment for toxicity. If green consumers react merely to the reported weight of releases, without regard to the wide variation in toxicity of the different substances included in the inventory, firms would be expected to respond by reducing the total weight of their releases in the most cost-effective manner. Such a strategy would not necessarily yield the greatest reduction in risk and, indeed, could result in an increase in risk if it is cheaper for a facility to substitute low-volume, high-toxicity substances for high-volume, low-toxicity ones. On the other hand, if consumers have other sources of information on toxicity, or know that some substances are more notorious than others for their toxicity as a result of past publicity, responsive facilities will focus more on reducing the most toxic substances.⁹

Following the example, of Hettige, Lucas, and Wheeler (1992) and Horvath et al. (1995), and more recently Shapiro (1999), we have tried to take into account the varying toxicity of NPRI substances. Like Shapiro (1999), we are using the EPA Chronic Human Health Indicator (CHHI) for the purpose of aggregating pollutants.¹⁰ An important advantage of the CHHI data is that EPA has developed separate toxicity scores for each chemical depending on whether exposure occurs

9 In its annual report the NPRI identifies which substances are carcinogens and which have been identified as toxic under the Canadian Environmental Protection Act.

10 The earlier studies by Hettige, Lucas, and Wheeler (1992) and Horvath et al. (1995) rely on threshold limit values (TLVs) adopted by the American Conference of Governmental Industrial Hygienists, but this approach has several limitations. TLVs are designed to reflect the toxicity of airborne substances only, and the same toxicity rankings may not apply to other forms of exposure. Another drawback is that TLVs are developed for occupational settings, where exposures to toxic substances tend to be high relative to ambient environmental exposures. The same toxicity rankings may not hold at lower exposure levels.

via oral intake or inhalation. We have employed inhalation scores for releases to air, and oral toxicity scores for all other releases.¹¹ CHHI scores are based only on chronic effects and do not consider acute effects of exposure. However, this is arguably more appropriate in the light of the low-level exposures resulting from most environmental releases. CHHI indicators do not address multiple effects, effects of concurrent exposures to multiple substances, or environmental impacts other than human health.¹² To interpret our numbers, note that the CHHI adjustment expresses pollution in ‘methanol units.’

Although we address toxicity, exposure (which is related to factors such as efficacy of treatment or storage and environmental persistence of the pollutant) is not covered by our adjustment factors. This is a serious caveat that we acknowledge but—for lack of data—cannot improve upon.

In the light of the possible discrepancy between consumers’ perception of risks in the absence of toxicity data and our best estimate of the toxicity-adjusted risk, we defined the dependent variables in our empirical analysis both with and without toxicity adjustment. Our findings were quite similar in either case. We report results for only the toxicity-adjusted case, because they provide a more meaningful indication of actual trends in toxic pollution.

5. Data preview

We have used data from Canada’s NPRI, which covers roughly 2500 facilities over the period 1993–99. Facilities below a certain size (i.e., those with fewer than 10 employees that do not produce or use NPRI substances in quantities greater than 10 tons, and those in certain exempt categories such as educational institutions) are not required to report. According to Olewiler and Dawson (1998), of the roughly 32,000 manufacturing establishments identified by Statistics Canada, less than 8% report to the NPRI.

Although between 1993 and 1999 facilities were required to report discharges of 245 substances, 73 of which were added to the inventory in 1999,¹³ reports were received for only 192 substances, with an average between three and four substance reports per facility each year.¹⁴ NPRI focuses on ‘toxic’ substances and thus does not include many traditional pollutants, such

- 11 This assumes that the ultimate source of human exposure from land-based disposal techniques, including landfills, surface land-application, and underground injection will be via surface or ground water contamination.
- 12 CHHI coverage of NPRI substances is incomplete, but we can account for over 90% of the raw weight of pollutants by either method. One potential bias is with respect to nitrate; the CHHI does not provide either oral or inhalation scores.
- 13 The number of substances was increased again in 2000 to include highly toxic ‘micropollutants’ that are released in small quantities, with a lower reporting threshold applying to those pollutants.
- 14 In 1999 about one-third of all companies report only a single pollutant, about half report three or fewer pollutants, and less than 9% report ten or more pollutants. The largest number of pollutants reported by any firm is 55.

TABLE 1
Classification of Observations, 1993–1999

| On-Site Releases | Off-Site Transfers | N | % |
|------------------|--------------------|--------|-------|
| Positive | Positive | 3,332 | 26.30 |
| Positive | Zero | 3,700 | 29.21 |
| Zero | Positive | 1,853 | 14.63 |
| Zero | Zero | 3,782 | 29.86 |
| Total | | 12,667 | 100.0 |

as greenhouse gases, particulates released to air, or suspended solids discharged to water. These excluded substances undoubtedly present significant risks to health and the environment, and thus one cannot conclude that trends in NPRI discharges tell the full story. However, since the focus of this paper is on the impact of information dissemination as a policy instrument, and inventories of criteria pollutants are not readily available to the public, the focus on NPRI data alone is justified.

Table 1 shows the breakdown of observations by emission class. There are four combinations of zero or positive onsite releases and offsite transfers. *Onsite releases* include direct releases to air, water, soil, and subsurface (via underground injection) at the facility site. *Offsite transfers* comprise wastes shipped to other facilities for treatment, storage, or disposal. About 30% of observations indicate zero overall pollution. Just over half of all observations indicate positive onsite releases, with about half of these also reporting positive offsite transfers. In 15% of our observations, facilities reported only offsite transfers. As indicated in table 7, where facilities had both positive onsite releases and offsite transfers, the share of offsite transfers relative to total emissions is clustered around the 0% and 100% marks.

Table 2 focuses on year-to-year changes and transitions between zero and positive emissions (including offsite transfers). Just over half of our observations indicate continuing positive levels of toxic releases, and about 40% of observations indicate continuing zero releases. Because of the importance of zero-emission facilities, we will consider them separately in our empirical analysis.

In Harrison and Antweiler (2003) we have documented extensively trends in onsite pollution releases and offsite transfers. Thus, we will highlight only the most important findings here. Overall, between 1993 and 1999 onsite emissions dropped by 27% by weight, equivalent to an 11% reduction after adjustment for toxicity. At the same time, offsite transfers decreased at most by 9% by weight,¹⁵ but increased by 127% after adjustment for toxicity. We found

15 NPRI staff believe that confusion with respect to the definition of offsite transfers lead to over-reporting of that stream in 1993, which would tend to overstate reductions or understate increases since then.

TABLE 2
Year-to-Year Emission Changes

| Change in Releases | N | % |
|----------------------|--------|-------|
| Positive to Positive | 5,334 | 53.0 |
| Positive to Zero | 286 | 2.8 |
| Zero to Positive | 468 | 4.7 |
| Zero to Zero | 3,971 | 39.5 |
| Total | 10,059 | 100.0 |

evidence that regulatory interventions in the pulp and paper industry (C-SIC 27) led to a substantial reduction of releases to surface water. This industry was the only industry that faced new discharge regulations at the national level during this period, and it was also subject to extensive reform of regulations and permits at the provincial level in the early 1990s (Harrison, 1996). In our empirical analysis we thus exclude this industry to prevent regulation being misidentified as green consumerism. We also exclude a single facility in Quebec, Kronos, that dramatically reduced its releases in response to regulatory enforcement action by both the federal government and the province. With these adjustments for regulatory intervention, total onsite releases increased by 4% by weight, and decreased 13% in toxicity-adjusted terms. In contrast, offsite transfers decreased 8% in weight but increased 127% in toxicity-adjusted terms. This implies that the average toxicity of onsite releases has decreased, while it has significantly increased for offsite transfers.¹⁶

We have matched the NPRI data with data from the Canadian Census at the level of facilities to control for location-specific effects. Our ability to control for company-specific effects was hampered by a lack of comprehensive company data. Even relevant information for publicly traded companies was often incomplete and thus would have introduced an unacceptable selection bias into our sample. Throughout our empirical analysis we control for industry-specific effects at the 3-digit C-SIC level for facilities and the 2-digit C-SIC level for companies.¹⁷ We document our data sources in the appendix.

6. Empirical implementation

In order to test the implications of our theoretical model, we need to operationalize the concept of green consumerism as expressed in equation (6). This

¹⁶ These figures are not adjusted for the larger number of reporting facilities in 1999 compared with those in 1993. The qualitative result remains unchanged, however, when we focus only on continuous reporters in 1993 and 1999; see Harrison and Antweiler (2003).

¹⁷ We use the 2-digit level for companies to allow for the diversification of firms. We consider a firm to be in a particular 2-digit C-SIC industry if the majority of its employees are active there.

requires that we construct a suitable empirical measure of ‘environmental leverage’ that we can interact with a firm’s exposure to consumer markets. The abatement-only part of equation (6) can be expressed using relative emission intensities $\kappa_i \equiv [E_i^*/p_i x_i]/[E^*/m] = E_i^*/[\sigma_i E^*]$ so that $\sum_i \kappa_i \sigma_i = 1$. Defining $\omega_i \equiv a_i z_i/p_i$ and $\Omega \equiv \sum_i \omega_i \sigma_i$ as the individual and average abatement coefficients, it follows that $E^* = [\Omega/\gamma] \sum_i \kappa_i / (1 + \lambda_i)$. This expression is the basis for our empirical implementation. Because an environmentally leveraged firm must exhibit a positive correlation between leverage ratio λ_i and relative pollution intensity κ_i , we must suitably interact κ_i and λ_i when constructing our empirical measure of environmental leverage.

In what follows we denote time periods by subscript t , facilities by subscript f , companies by subscript c , and industrial sectors by subscript i . Let E_{fct} denote the (toxicity-adjusted) emissions of facility f in period t , where facility f is a daughter of company c , and let $E_{ct} \equiv \sum_f E_{fct}$ denote the company’s total emissions during that period. Likewise, Q_{fct} is the facility’s size (which we proxy by employment L_{fct} ; see below), and $Q_{ct} \equiv \sum_f Q_{fct}$ is the size of the company. Further, let $\Xi_{fct} \equiv E_{fct}/Q_{fct}$ denote the facility’s pollution intensity, and let $\Xi_{ct} \equiv E_{ct}/Q_{ct}$ denote the pollution intensity of the entire company.

Capturing the notion of environmental leverage requires a measure that (a) should increase with the size of the company’s revenue exposed to the intra-firm externality; (b) should increase with the degree to which a facility’s pollution intensity exceeds the company average; and (c) should be independent of the company’s degree of fragmentation. Point (a) is the basic notion of environmental leverage as expressed by the λ parameter in our theoretical model. Point (b) expresses the notion that increases in λ will lead to greater emission reductions when a plant’s emission intensity is above average (as expressed by parameter κ above), or when a plant becomes more likely to initiate pollution abatement (which we predict is also correlated with pollution intensity). Lastly, point (c) implies that environmental leverage should not increase just because a company has a large number of small units instead of a few but large units. Ideally, our measure should also be well behaved empirically, which means that it should discount outliers. We therefore try to choose a ‘conservative’ measure. For an individual facility we define its environmental leverage as

$$\lambda_{fct} \equiv \left[1 - \frac{Q_{fct}}{Q_{ct}} \right] \max \left\{ 0, \ln \left[\frac{\Xi_{fct}}{\Xi_{ct}} \right] \right\}. \tag{8}$$

At the level of industrial sectors we use E_{ict} and Q_{ict} instead of E_{fct} and Q_{fct} , and define λ_{ict} correspondingly. A company with activities in n_{ct} industrial sectors is subject to environmental leverage, which we define as $\Lambda_{ct} \equiv \sum_{i=1}^{n_{ct}} \lambda_{ict}$. Equation (8) defines environmental leverage as the product of the revenue share exposed to the leverage and the excess pollution intensity. The logarithmic transformation is an effective way to prevent the few very large excess pollution intensities from

gaining undue influence. The maximum transformation ensures that leverage is positive only where facilities can be identified as excess-polluters.¹⁸

Our theoretical model tells a story that has implications both at the facility level *and* at the company level. Hence, we find it prudent to consider both in our empirical analysis. At the facility level, pollution-intensive and environmentally leveraged facilities may be those where the ‘low-hanging fruit’ can be plucked most easily. These units may quite likely have lower marginal abatement costs.¹⁹ At the facility level we will therefore employ λ_{fct} as defined in (8). There is an additional advantage in considering the facility level. Since the precise location of each facility is known, it is possible to control for a larger set of location-specific determinants of emission levels.

The NPRI data do not identify the size of a facility other than through the number of people employed there. We therefore use the number of employees L_{fct} as our proxy for Q_{fct} , though we acknowledge that this is unsatisfactory, since capital intensity varies substantially across industrial sectors.²⁰ In order to compensate for this problem, we allow for fixed (or random) industry effects, since these will also capture sectoral differences in pollution intensities.

For green consumerism to have an effect on an individual company, this company must be sufficiently exposed to consumer markets. To see the extent of consumer-proximity we introduce the measure

$$\Gamma_{ct} \equiv \left[\sum_{i=1}^{n_{ct}} \gamma_{it} Q_{ict} \right] / \left[\sum_{i=1}^{n_{ct}} Q_{ict} \right], \quad (9)$$

where $\gamma_{it} \in [0, 1]$ is the fraction of final (consumer) goods output relative to total output in industry i in year t .²¹ To test our green consumerism hypothesis we will focus our attention on the interaction of Γ_{ct} and Λ_{ct} (or λ_{fct} in the case of facility-level regressions).²²

Because we are first and foremost interested in the effect on a company’s (or facility’s) emission level, the (toxicity-adjusted) onsite emission level is our natural choice of dependent variable. As we observe that emission levels are log-normally distributed, it is appropriate to use a log-transformation of the

18 We have also experimented with other functional forms and have verified that our results are not an artefact of our particular definition of environmental leverage. The maximum function also expresses the notion that only the most polluting facilities will be subject to abatement effort, as green consumerism pushes them over the abatement threshold.

19 This assumption appears to be confirmed by the data, since the most pollution-intensive facilities are experiencing the highest emission reductions.

20 The technical appendix to Antweiler, Copeland, and Taylor (2002) provides evidence of a systematic relationship between capital intensity and pollution intensity for sulphur dioxide. Similar relationships may exist for other pollutants as well.

21 For technical reasons we were able to construct such a measure, with great effort, only for 1997. It is safe to assume, however, that the γ_{it} ratios are quite stable over time. We have constructed γ_{it} at the 4-digit C-SIC level.

22 We do not enter Γ_{ct} directly into our regressions because they would coincide—to a large extent—with our industry (fixed or random) effects.

level of emissions. Having defined E_{fct} as a facility's sum of emissions adjusted by toxicity, we define $x_{fct} \equiv \ln(E_{fct})$ as our principal dependent variable. As we know little about the exact nature of the functional relationship between our dependent variable and our regressors, we find it appropriate to consider two additional dependent variables that allow for slightly different interpretations of our results. Our alternative dependent variables are the log-change in emissions $\Delta x_{fct} \equiv (x_{fct} - x_{fct,t-s})/s$ (i.e., the growth rate of emissions) and the log of pollution intensity $\xi_{fct} \equiv \ln(\Xi_{fct})$. Here s is the number of years since the last observation (in case there is a gap between observations). The company-level variables are constructed analogously. Our dependent variables thus focus on the *level*, the *change* in, and the *intensity* of, emissions.

The NPRI does not identify parent companies other than by name.²³ Instead, we rely on a carefully constructed concordance in which we identify through matching parent names (which may differ in spelling). This concordance is likely to understate true parentage, since we are unable to identify all nested or conglomerative relationships among corporations. Because we are thus underestimating the true level of a company's sectoral diversity, our estimates will also tend to understate the importance of green consumerism.

7. Results

Table 5 presents our key results at the level of companies and facilities, respectively. In all cases we employ fixed-effects regressions,²⁴ where we group our data by 2-digit and 3-digit C-SIC industries for companies and facilities, respectively.²⁵ There are a total of 129 3-digit industries with an average of about 60 observations each; 115 of these industries have positive onsite emissions. The three pairs of regressions ('level,' 'growth rates,' and 'intensity') are conditional on a company or facility's having positive on-site releases. Summary statistics for the regressors at the company and facility level are shown in tables 3 and 4.

23 The 2000 release introduces for the first time Dun and Bradstreet numbers. However, these are still too spotty to utilize for the purpose of identifying parents.

24 In an earlier version of our paper we have also used random effects (R.E.) estimation, and found that the results were highly similar. Because the Wald- χ^2 statistic of the Hausman test rejects R.E. in favour of F.E. in most regressions, we report only F.E. results in this paper. However, the results from our fixed-effects and random-effects regression are quite similar.

25 We have eliminated several data points from this and all other regressions. First, we have excluded two facilities in all years: Kronos in Varennes (Quebec), which undertook significant reductions of on-site releases that could overwhelm other trends, and the Giant gold mine in Yellowknife, a facility that contributes a significant share of the increase in toxicity-adjusted transfers. We have also removed two further data points in 1999 only that involve a one-off transfer from Phillip Mill Services at Firestone to a processing plant by Safety-Kleen, since Environment Canada believes those facilities' reports to be in error. We have excluded the pulp and paper industry (C-SIC 27), which faced new provincial and federal regulations over the period in question, so as to avoid misrepresentation of regulation and green consumerism. Finally, we lose some observations at the facility level because we are unable to match regional data to facility location due to incorrect or missing location data.

TABLE 3
Summary Statistics/Company Level

| Variable | Definition/Unit | Mean | Std.Dev. | Min. | Max. |
|---------------------------|-----------------------------------|--------|----------|---------|--------|
| Scale | $\ln(L_t)$ | 5.244 | 1.440 | 2.303 | 10.148 |
| Change in Scale | $\ln(L_t) - \ln(L_{t-1})$ | 0.031 | 0.237 | -2.944 | 2.938 |
| Offsite Transfer Share | τ_t | 0.219 | 0.351 | 0.000 | 1.000 |
| Pollution Intensity | $\ln(E_t/L_t)$ | -6.472 | 3.595 | -19.365 | 5.069 |
| Sectoral Diversity | \bar{n}_{ct} | 0.077 | 0.245 | 0.000 | 2.755 |
| Environmental Leverage | Λ_{ct} | 0.092 | 0.379 | 0.000 | 5.499 |
| Interaction Term | $\Gamma_{ct} \times \Lambda_{ct}$ | 0.005 | 0.033 | 0.000 | 0.749 |
| Consumer Market Proximity | Γ_{ct} | 0.203 | 0.254 | 0.000 | 0.996 |

TABLE 4
Summary Statistics/Facility Level

| Variable | Definition/Unit | Mean | Std.Dev. | Min. | Max. |
|---------------------------|------------------------------------|--------|----------|---------|--------|
| Scale | $\ln(L_t)$ | 4.838 | 1.407 | 0.000 | 8.896 |
| Change in Scale | $\ln(L_t) - \ln(L_{t-1})$ | 0.009 | 0.268 | -4.436 | 4.357 |
| Offsite Transfer Share | τ_t | 0.188 | 0.328 | 0.000 | 1.000 |
| Pollution Intensity | $\ln(E_t/L_t)$ | -6.542 | 3.749 | -19.564 | 5.692 |
| Income of Region | $\ln(I_t)$ | 1.559 | 0.213 | 0.982 | 2.286 |
| Population Density | $\ln(N_{jt}/A_{jt})$ | 5.407 | 2.198 | 0.000 | 8.798 |
| Unionization Rate | % | 28.121 | 19.340 | 0.000 | 76.563 |
| Environmental Leverage | λ_{fct} | 0.181 | 0.471 | 0.000 | 4.520 |
| Interaction Term | $\Gamma_{ct} \times \lambda_{fct}$ | 0.010 | 0.061 | 0.000 | 1.730 |
| Consumer Market Proximity | Γ_{ct} | 0.149 | 0.222 | 0.000 | 0.996 |

Our key result is that we find a significant coefficient for the interaction term of environmental leverage and consumer proximity $\Gamma_{ct}\Lambda_{ct}$ in the company-level regressions in table 5 (columns A, B, and C). Environmentally leveraged companies exposed to consumer markets do indeed have lower levels of emissions. Because the estimate of Λ_{ct} is positive, environmental leverage without consumer-market exposure is linked to a higher level of emissions.²⁶ As the level of consumer-market exposure increases, the emission-reducing effect from the interaction term takes over and eventually leads to an overall reduction in emissions at sufficiently high levels of Γ_{ct} . The estimates in column (A) indicate that green consumerism leads to a reduction of emissions for an 'average' firm when $\Gamma_{ct} > 0.086$.²⁷ Thus a 9% exposure to consumer markets

26 The positive sign is consistent with our theory. If green consumerism is weak, many or all facilities of a firm will not surpass the abatement threshold a_i/m . In the extreme case of no abatement activity in any plant, $E^* = m \sum_i (z_i/p_i)/(1 + \lambda_i)$. Because emission intensity z and leverage ratio λ are positively correlated when a company is environmentally leveraged, assume that $z_i = \rho \lambda_i$ with $\rho > 0$. Then an increase in λ will indeed increase emissions: $\partial E^*/\partial \lambda_i = m \rho / p_i (1 + \lambda_i)^2 > 0$.

27 We solve $0.6052\Lambda_{ct} - 7.0781\Lambda_{ct}\Gamma_{ct} < 0$ for Γ_{ct} when $\Lambda_{ct} = 0.092$, the sample mean found in table 3.

is sufficient for green consumerism to lead to emission reductions. At full exposure ($\Gamma_{ct}=1$), an average company has 45% lower emissions than at zero exposure ($\Gamma_{ct}=0$).²⁸ In column (C) our results indicate that pollution intensity is down by 28% when a company faces full consumer-market exposure. However, the average firm in our sample has an exposure of only about 20%. Evaluated at sample means, there is virtually no joint effect from consumer market exposure and environmental leverage.

An obvious concern about our empirical strategy is the possibility that Λ_{ct} merely captures a company's sectoral diversification. We are controlling for this possibility by including a regressor that measures a company's sectoral diversification explicitly. Instead of using the number of sectors n_{ct} directly, we define $\tilde{n}_{ct} \equiv (\sum_i L_{it})/(\max_i\{L_{it}\}) - 1$ as an employment-weighted diversification index, taking the largest industrial sector as the baseline by which we scale activities in other sectors.²⁹ By construction, an undiversified company has $n_{ct}=1$ and $\tilde{n}_{ct}=0$. Our estimates in table 5 indicate that a one-standard deviation shift of \tilde{n}_{ct} (0.245) is associated with an increase in emissions of 31% (column A), and a 13% increase in pollution intensity (column C). This effect is mitigated by the fact that environmental leverage and sectoral diversity are somewhat correlated.³⁰

We are also interested in determining the extent to which onsite releases and offsite transfers are substitutes. For this purpose we enter the offsite transfer share $\tau_{ct} \equiv O_{ct}/(E_{ct} + O_{ct})$, where O_{ct} is the amount of offsite transfers, and, as before, E_{ct} is the amount of onsite releases. Our results in column (A) indicate that a 10%-point increase in the transfer share coincides with a 20% lower level of onsite releases. Because the same shift in τ reduces pollution intensity by only about 8%, offsite transfers must involve higher-toxicity substances than onsite releases.³¹

In column (B) we estimate emission growth rates and find that pollution-intensive facilities are reducing emissions more quickly (or increasing emissions more slowly). Emission reductions also occur more quickly where companies rely to a larger degree on offsite transfers. We further find significant time trends in the growth-rate and pollution-intensity regressions. These trends may be a result of (exogenous) technological progress in abatement technologies, but they may also be a response to market or regulatory pressures unaccounted for in our analysis.

28 This is calculated from $100\% \{1 - \exp[(0.6052 - 7.0781)(0.092)]\}$.

29 This scaling ensures that a company's minor activities outside the primary industrial sector are not given undue weight. For example, a company with 1,000 employees in one sector and 10 employees in another sector should not be considered as diversified as another company with 1,000 employees in both sectors.

30 The Pearson correlation coefficient for the correlation between Λ_{ct} and \tilde{n}_{ct} is 0.54.

31 This observation is backed up by our earlier observations discussed in the 'Data preview' section. If the receiving facilities are better equipped to deal with these substances, this may indeed be beneficial.

TABLE 5
Company-Level and Facility-Level Regressions

| Dependent Variable | (A) | (B) | (C) | (D) | (E) | (F) |
|------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| | x_{ct} | Δx_{ct} | ξ_{ct} | x_{jct} | Δx_{jct} | ξ_{jct} |
| Intercept | -7.0796 ^c (18.02) | -1.7763 ^c (11.00) | -2.2065 ^c (10.45) | -6.1698 ^c (13.94) | -2.0109 ^c (5.870) | -2.7684 ^c (7.760) |
| Scale | 1.1043 ^c (25.68) | 0.0111 (.4000) | 0.0002 (.0100) | 1.0442 ^c (29.47) | -0.0633 ^a (2.200) | -0.0426 (1.420) |
| Change in Scale | | 1.2153 ^c (7.540) | | | 0.4361 ^c (3.610) | |
| Offsite Transfer Share | -2.2083 ^c (14.49) | -0.6314 ^c (5.880) | -0.7965 ^c (6.990) | -2.1473 ^c (16.85) | -0.9097 ^c (8.900) | -1.2737 ^c (11.90) |
| Pollution Intensity | | -0.3297 ^c (35.75) | 0.6044 ^c (60.98) | | -0.4684 ^c (58.54) | 0.4392 ^c (57.73) |
| Income of Region | | | | -0.1046 (.5400) | -0.0154 (.1000) | 0.0330 (.2000) |
| Population Density | | | | -0.0404 (1.750) | -0.0207 (1.100) | -0.0122 (.6200) |
| Unionization Rate | | | | -0.0125 ^b (1.750) | -0.0045 (1.270) | -0.0063 (1.700) |

| | | | | | | | |
|---------------------------------|--|---------------------------------|---------------------------------|---------------------------------|--------------------------------|---------------------------------|---------------------------------|
| Sectoral Diversity | \tilde{n}_{ct} | 1.0984 ^c (4.170) | 0.4655 ^b (2.600) | 0.4894 ^c (2.530) | 1.7776 ^c (18.14) | 0.3293 ^c (3.950) | 1.0960 ^c (13.02) |
| Environmental Leverage | Λ_{ct} or λ_{yct} | 0.6052 ^b (3.440) | 0.1676 (1.330) | 0.3294 ^c (2.430) | 1.7776 ^c (18.14) | 0.3293 ^c (3.950) | 1.0960 ^c (13.02) |
| Interaction Term | $\Gamma \times \Lambda$ or $\Gamma \times \lambda$ | -7.0781 ^c (3.960) | -3.0246 ^a (2.480) | -3.8543 ^b (2.750) | -0.5765 (.7900) | -1.7995 ^b (2.980) | 0.1217 (.2000) |
| Time Trend | $t - 1996$ | -0.0201 (.7600) | -0.0803 ^c (3.520) | -0.0678 ^b (2.890) | -0.0113 (.5600) | -0.0997 ^c (5.230) | -0.1025 ^c (5.170) |
| Observations | | 4065 | 3268 | 3268 | 6281 | 5044 | 5210 |
| Groups | | 41 | 40 | 40 | 112 | 110 | 111 |
| Adjusted/Pseudo R^2 | | 0.2085 | 0.2986 | 0.6034 | 0.1884 | 0.3285 | 0.5074 |
| Hausman Test/Wald χ^2 (df) | | 75.11 ^c | | 120.47 ^c | 6.6 | 33.53 ^c | 46.25 ^c |

NOTES: Dependent variables are the log of onsite releases (x_{ct} or y_{ct}), the log changes in onsite releases (Δx_{ct} or Δy_{ct}), and the log of pollution intensity (ξ_{ct} or ξ_{yct}). Subscripts f , c , and t denote facility, company, and time. Emissions are adjusted for toxicity using CHHI measures. The estimation employs fixed effects (F.E.) based on 2-digit Canadian-SIC industry groups for the company-level regressions and 3-digit Canadian-SIC groups for the facility-level regressions. Companies with zero onsite releases were excluded from this set of regressions. T-statistics (without sign) are given in parentheses. Significance at the 95%, 99%, and 99.9% levels are indicated with the superscripts a, b, and c. In the Δx_{ct} and Δy_{ct} regressions of columns (B) and (E), $\ln(L_{jt})$, Λ_{ct} , λ_{yct} and Γ_{ct} have been suitably replaced by their one-period lagged counterparts.

Turning to our facility-level regressions in columns (D)–(F) of table 5, we allow for additional facility-specific codeterminants. In particular, we are able to control for the population density and income in the area surrounding a facility,³² and we control for unionization rates as a potential alternative route of “green pressure.” We enter population density and income in log form. Not surprisingly, emissions are lower in populated urban areas in both level and intensity. Similarly, emissions (and pollution intensity) are lower in areas with higher average household income. Our estimates for these two regressors are not significant,³³ but we do find a small but significant effect of unionization rates on emission levels. A 10%-point increase in the unionization rate is linked to a 12% decrease in emission levels.

Our estimates of environmental leverage and its interaction with consumer-market proximity provide a somewhat weaker case compared to the company level. The estimates in columns (D) and (F) are not significant, but in the rates-of-change regression (E) we are able to confirm the results obtained in columns (A)–(C) for the company level. We find evidence that environmentally leveraged facilities are reducing onsite releases more quickly.

In table 6 we investigate whether the picture established in table 5 is still valid when we focus on particular release streams. Onsite emissions may be released directly into the air or water, injected underground (subsoil), or disposed of on land (e.g., through onsite landfills or land application). Additionally, releases may be transferred offsite. Our estimates of Λ and $\Lambda \times \Gamma$ paint a stunningly different picture depending on the media into which emissions are released. We find that green consumerism is quite pronounced in the case of releases to air and offsite transfers. On the other hand, underground injections are much higher when environmentally leveraged companies are exposed to consumer markets. Perhaps this is indicative of an ‘out of sight—out of mind’ strategy, but this result has to be viewed with caution because the estimates in column (C) are based on observations from just seven industrial sectors all of which face little consumer market exposure. If companies relied on offsite transfers as a mechanism to alleviate (perhaps more visible) onsite releases, the estimate of $\Lambda_{ct} \times \Gamma_{ct}$ in column (E) might well be positive. It is not. Environmentally leveraged companies appear to reduce offsite transfers when exposed to consumer markets.

32 We define the surrounding areas as the census enumeration areas within a 4 km radius of each NPRI facility, covering an area of approximately 50 km². Regional income and population density are calculated as population-weighted averages across the enumeration areas in the facility’s vicinity. Our regional reference data correspond to the census year 1991 and thus have no time dimension.

33 We also tried non-linear specifications that included a linear and quadratic term, reminiscent of the environmental Kuznets curve literature. There is weak (statistically insignificant) indication that emissions peak at around \$50,000 of average household income. Regional per capita income and population density are correlated. When we use only population density in our specification, it is typically significant.

TABLE 6
Emission Method Regressions/Company Level

| Dependent Variable | (A) Air | (B) Water | (C) Subsoil | (D) Land | (E) Offsite |
|---------------------------------|---|---------------------------------|---------------------------------|---------------------------------|----------------------------------|
| Intercept | -6.9317 ^c (15.61) | -7.9431 ^c (9.860) | -5.3682 ^c (4.020) | -5.1668 ^c (5.220) | -6.5053 ^c (11.69) |
| Scale | $\ln(L_t)$ 1.1286 ^c (26.05) | 0.7854 ^c (6.580) | 0.7914 ^b (2.950) | 0.2687 (1.880) | 0.7663 ^c (13.15) |
| Offsite Transfer Share | τ_t -2.3816 ^c (16.00) | -0.5537 (1.250) | -1.8834 (1.340) | -0.6427 (1.020) | |
| Sectoral Diversity | \tilde{n}_{ct} 1.0771 ^c (4.160) | -0.6288 (.9900) | -0.2724 (.2300) | 0.5693 (.7300) | 1.0110 ^b (2.780) |
| Environmental Leverage | Λ_{ct} or λ_{jct} 0.5149 ^b (3.040) | -0.2276 (.6800) | -0.4878 (.6700) | 2.0898 ^c (3.870) | 1.2024 ^c (5.100) |
| Interaction Term | $\Gamma \times \Lambda$ or $\Gamma \times \lambda$ -8.4019 ^c (4.870) | 11.1803 (1.940) | 52.3786 ^b (3.310) | -2.7821 (.5600) | -11.2014 ^c (4.120) |
| Time Trend | $t - 1996$ -0.0021 (.0800) | -0.2096 ^b (2.860) | 0.0497 (.3400) | -0.0612 (.6300) | 0.0312 (.8600) |
| Observations | 3747 | 833 | 149 | 627 | 3531 |
| Groups | 41 | 24 | 7 | 29 | 42 |
| Adjusted/Pseudo R^2 | 0.2428 | 0.0732 | 0.2189 | 0.0426 | 0.0664 |
| Hausman Test/Wald χ^2 (df) | 11.27 | 14.6 ^c | | 19 ^b | 19.53 ^b |

NOTES: Dependent variables are the log of onsite releases (x_{ct}), the log changes in onsite releases (Δx_{ct}), and the log of pollution intensity (ξ_{ct}). Emissions are adjusted for toxicity using CHHI measures. The estimation procedure uses fixed effects (F.E.) based on 2-digit Canadian-SIC industry groups. Observations where emissions are zero were excluded. T-statistics (without sign) are given in parentheses. Significance at the 95%, 99%, and 99.9% levels are indicated with the superscripts *a*, *b*, and *c*.

TABLE 7
Distribution of Offsite Transfer Shares $\tau_i \equiv O_i/(O_i + E_i)$

| | 0 | >0 ≤0.1 | >0.1 ≤0.2 | >0.2 ≤0.5 | >0.5 <0.8 | ≥0.8 <0.9 | ≥0.9 <1 | 1 |
|----------|-------|------------|--------------|--------------|--------------|--------------|------------|-------|
| <i>n</i> | 3,700 | 1,393 | 276 | 523 | 391 | 148 | 601 | 1,853 |
| % | 41.6 | 15.7 | 3.1 | 5.9 | 4.4 | 1.7 | 6.8 | 20.9 |

Many of the facilities in our sample have zero onsite emissions, zero offsite transfers, or both. Even when both are positive, table 7 reveals that the offsite transfer share $\tau_i = O_i/(E_i + O_i)$ is clustered around the 0% and 100% marks. We focus on the determinants of zero emission by employing Probit regressions (with random industry effects). In column (A) of table 8 we define

TABLE 8
Zero Emitters, and Onsite Releases vs. Offsite Transfers

| Dependent Variable | | (A) | (B) | (C) | (D) |
|--------------------|-----------------------------------|---------------------------------|---------------------------------|---------------------------------|---|
| | | $E_i = 0$ and $O_i = 0$ | $E_i > 0$ and $O_i = 0$ | $E_i = 0$ and $O_i > 0$ | $\tau_i > 0.9$ vs. $\tau_i < 0.1$ |
| Intercept | | 0.6137 ^c (5.446) | 0.3031 ^a (2.326) | -0.2328 (1.548) | -0.0327 (.2200) |
| Scale | $\ln(L_i)$ | -0.2346 ^c (19.30) | -0.1347 ^c (10.19) | -0.2230 ^c (13.91) | -0.1216 ^c (7.985) |
| Income of Region | $\ln(I_i)$ | -0.1216 (1.895) | 0.2107 ^b (2.822) | 0.2418 ^b (2.892) | -0.0345 (.4090) |
| Population Density | $\ln(N_j/A_j)$ | 0.0014 (.2130) | -0.0524 ^c (6.561) | 0.0217 ^a (2.277) | 0.0547 ^c (6.071) |
| Unionization Rate | % | 0.0060 ^c (6.475) | -0.0002 (.2120) | -0.0012 (.9980) | -0.0029 ^a (2.535) |
| Spillover Leverage | λ_{it} | | -0.2330 ^c (5.932) | 0.0104 (.2360) | 0.1807 ^c (4.088) |
| Interaction Term | $\Gamma_{ct} \times \lambda_{it}$ | | 1.5287 ^c (4.244) | -0.1251 (.3230) | -1.0667 ^a (2.385) |
| Time Trend | $t - 1996$ | -0.0369 ^c (5.384) | -0.0093 (1.165) | -0.0327 ^c (3.661) | -0.0004 (.0440) |
| Observations | | 11565 | 8081 | 8081 | 6786 |
| Groups | | 129 | 120 | 120 | 120 |

NOTES: Estimation method is random-effects probit. All the dependent variables are binary. χ^2 -statistics are given in parentheses. Significance at the 95%, 99%, and 99.9% levels are indicated with the superscripts *a*, *b*, and *c*. In column (A) the indicator variable is one when a facility has no releases whatsoever, and is zero if it has positive onsite releases or offsite transfers. In column (B) the indicator is one when a facility has positive onsite release but no offsite transfers; it is zero in all other cases. In column (C) the indicator variable is one when a facility has positive offsite transfers but no onsite releases; it is zero in all other cases. In column (E) the indicator variable is one when a facility transfers more than 90% of its emissions offsite, and is set to zero when a facility transfers less than 10% of its emissions offsite. Observations in the intermediate range are dropped from the regressions.

the binary dependent variable as one when facilities have no emissions whatsoever (onsite or offsite), and zero if there are some positive releases. Zero-emitters can of course not be environmentally-leveraged, so we exclude the corresponding regressors. We find that small facilities have a significantly higher probability of being zero emitters. This is not as straightforward as it might at first appear, since NPRI reporting rules require that facilities report as little as 1 kilogram of waste.³⁴ Facilities that have minimal emissions and are under pressure from investors or consumers to reduce their releases may find it worth the extra effort to eliminate emissions completely. Alternatively, small facilities may simply assign fewer resources to completing NPRI reports and thus may be more inclined to ‘round down.’ We also find that facilities in sectors with higher levels of unionization are more likely to report zero releases and transfers.

In columns (B) and (C) the binary dependent variables indicate whether facilities have only onsite releases or only offsite transfers, respectively, excluding observations where facilities have no releases whatsoever. Seen in conjunction, our estimates indicate that environmentally leveraged facilities that are exposed to consumer markets are less likely to rely exclusively on offsite transfers. Regressions (B) and (C) suffer from the clustered distribution of offsite transfer shares shown in table 7. Facilities are primarily either onsite emitters or offsite transferers. To deal with this clustering, in column (D) we drop all facilities in an intermediate range of 10–90% of offsite transfers, and lump together the remaining observations at both ends. This yields the conclusion that environmentally leveraged facilities are less likely to rely heavily on offsite transfers when they are exposed to consumer markets. We also find that the likelihood of relying heavily on offsite transfers increases, not surprisingly, when the facility is located in densely populated areas.

We conclude this section by contemplating the overall environmental impact of environmental leveraging. Our empirical model does not contain policy variables that would easily lend themselves to ‘what if’ experiments. We do not observe variations in our theoretical green consumerism parameter γ ; we observe only firms’ consumer market exposure, which varies very little over time. But while we cannot double our empirical Γ , we may ask what happens if green consumerism had twice its force, and we doubled the estimate corresponding to $\Gamma \times \Lambda$ from -7 to -14 . At the sample average for $\Gamma \times \Lambda$, this doubling would lead to a mere 3.5% reduction in overall emissions. Green consumerism, although present, is a rather weak force. In the light of this result, it is doubtful that green consumerism can act as a substitute for other emission-reducing incentive systems such as green taxes, emission permit trading, or direct regulatory intervention.

34 Facilities with emissions of less than 1 tonne are also given an option of reporting releases within certain ranges, such as 0 to 0.2 tonnes, 0.2 to 0.4 tonnes, and so on. Since we have used the mid-point for such ranges, these estimates cannot account for the greater propensity of smaller facilities to report 0 emissions.

8. Conclusions

In this paper we have set out to test the empirical relevance of 'green consumerism.' We have developed a simple economic model that yields plausible predictions. We test these predictions empirically using 1993–99 panel data from Canada's National Pollutant Release Inventory. Green consumerism is predicated on the assumption that consumers use NPRI to inform themselves about facilities' and companies' polluting behaviour. Alternatively, a company's perception that it is vulnerable to green consumerism as a result of the impact of NPRI publicity on its reputation may suffice to induce changes in its emissions. In this case, NPRI information may help companies to compare their own environmental performance with those of competitors.

In previous work we found that the majority of reductions in releases reported to NPRI since 1993 have been the result of traditional regulation. However, setting aside facilities that most clearly changed their behaviour in response to regulation, we find evidence of green consumerism among the remaining facilities when we allow for the possibility that consumers target companies rather than products. Firms that are active in different industrial sectors may be subject to an intra-firm inter-plant externality that magnifies the impact of green consumerism. This spillover effect is conditional on the degree to which the different units are 'environmentally leveraged' against each other, and on the degree to which firms are exposed to consumer markets. What we mean by environmental leverage is the extent to which a company's low-revenue pollution-intensive units expose the high-revenue units with low pollution intensity to the effect of green consumerism. Our empirical estimates confirm the existence of a green-consumerism effect that influences a company's level of emissions, its pollution intensity, as well as its emission growth rate. Environmentally leveraged companies that are exposed to consumer markets clearly make greater progress in reducing their emissions. Such firms apparently make a greater effort to reduce releases to air and offsite transfers, while increasing releases via the less-visible option of underground injection. While the effect of green consumerism is visible, our estimates suggest that the overall environmental impact of green consumerism is small in magnitude.

While our primary results focus on the company level, we are also interested in activities at the level of facilities. There we are able to control for local characteristics such as income and population density. Emissions are lower where the population is more dense and where a sector is characterized by higher levels of unionization.

In this study we have pursued a rather indirect route to elicit the effect of green consumerism in the light of limitations on available data. As a consequence, our results have to be interpreted with caution. We cannot claim to have found conclusive evidence that consumers are punishing above-average polluters. That is beyond the scope of our study. What we have found is that companies apparently take into consideration their exposure to consumer markets and the

potential for intra-firm environmental externalities when planning their emission levels. Our study shows that companies reckon with green consumerism. By implication, companies will reduce emissions further if they face pressure from an increasing number of environmentally conscientious consumers who are increasingly well informed about emissions in their own neighbourhoods and their country.

Data appendix

The NPRI data for the years 1993–2000 can be downloaded from the Environment Canada Web site at <http://www.ec.gc.ca/pdb/npri>. As discussed in our paper, adjustments needed to be made to ensure consistency across years in terms of coverage of pollutants.

The EPA chronic human health indicators (CHHI) are available from the United States Environmental Protection Agency Web site at http://www.epa.gov/oppt/env_ind/. The indicators are contained in a document entitled ‘Toxics release inventory relative risk-based environmental indicators: interim toxicity weighting summary document,’ authored by Nicolaas W. Bouwes and Steven M. Hassur.

Census data for 1991 at the level of enumeration areas are available from Statistics Canada. File P9104 contains income and population data. Facility locations are available as longitudes in latitude information, but in those cases where a facility location was not identified in this manner we have imputed the location from the postal code by using the postal code conversion file. For large enumeration areas we have taken the longitude and latitude of the midpoint. Distances between enumeration areas and facilities were calculated as great-circle distances.

Unionization rates for individual facilities were approximated by matching them with those found in a Statistics Canada table organized by 2-digit C-SIC codes and provinces in 1997.

The consumer-market proximity measures for each industry were calculated from the 1997 Statistics Canada National DU and DF matrices at the L level of aggregation (catalogue number 15F0001XDB). Concordances between L-aggregations and 4-digit C-SIC industries was constructed from additional Statistics Canada sources. Concordances are surjective (but not bijective).

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