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Can Consumers Enforce Environmental Regulations? The Role of the Market in Hazardous Waste Compliance

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Abstract

To assess the role that consumers can play in encouraging environmental compliance, we examine the U.S. hazardous waste management industry to determine (1) whether environmental performance affects consumer demand and (2) whether markets affect compliance behavior. We find that noncompliance does decrease demand, at least in the short-term. While we do not find any evidence that market size affects compliance, local competition does appear to increase compliance. However, as competition becomes less localized, it has a smaller, if any, effect. Finally, regardless of the pressures exerted by consumers to comply, commercial managers are more likely to violate than on-site managers.

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1. Introduction

As resources available for traditional, monitoring-based enforcement of environmental regulations decrease at both the state and federal level, regulators must look to other methods to encourage compliance.[1] One alternative source of enforcement pressure is the market. As many authors have recognized, both consumers and investors have the potential to exert significant influence on environmental performance.[2] In theory, consumers that care about the environment should favor products and manufacturers that are environmentally protective. Similarly, investors should demand higher levels of environmental performance both to gain competitive advantage in the market and to limit future liability. However, for consumers and investors to be effective at changing environmental behavior, they must have information on a firm's environmental performance.

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[1] For example, President Bush's FY 2006 budget request for EPA significantly cuts funding to the states who are responsible for over 95% of environmental inspections (Environmental Council of the States April 12, 2005 Press Release, available at www.ecos.org). At the federal level, the number of positions for compliance monitoring decreased by over 17 percent from FY 2001 to FY 2003 (GAO Report GAO-02-1096R available at www.gao.gov).

[2] Grabosky (1994) provides a detailed discussion on the role of commercial environmentalism in environmental protection. World Bank (2000) also provides a general discussion about the role of markets in environmental regulation.

Over the past decade, EPA has worked to increase access to such information through programs like the Toxics Release Inventory (TRI) and the Enforcement and Compliance History Online (ECHO) database. A number of studies have shown that such information does appear to influence investor behavior and, in turn, firm environmental performance.[3] However, to our knowledge there is no evidence as to whether consumers also use such information to act as informal regulators.[4] The purpose of this paper is to determine whether consumers can act as a complement to traditional enforcement efforts by examining compliance in the hazardous waste management industry. The hazardous waste management industry provides a good test of this hypothesis for two reasons: (1) the consumers in this market – hazardous waste generators – have a vested interest in the environmental performance of hazardous waste managers and (2) the information necessary to distinguish between competitors should be readily available.

Under the Resource Conservation and Recovery Act (RCRA), generators of hazardous waste are responsible for their waste from "cradle to grave" and are liable for any environmental damages that result from their waste. Generators may choose to manage their own waste or pay a licensed hazardous waste management facility to take the waste. However, a generator continues to be liable for any damages that result from mismanagement of its waste regardless of who

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[3] See, for example Konar and Cohen (1997) and Foulon, Lanoie, and Laplante (2002).

[4] There are a number of empirical papers that focus on eco-labeling or green products (see, for example, Bjorner, Hansen and Russell (2004) and Teisl, Roe, and Hicks (2002)). The majority of these papers seek to determine the factors that influence consumer preferences and their willingness to pay for green products rather than on the extent to which consumers can influence environmental compliance.

treats and disposes of the waste. Thus generators who choose to send waste to commercial waste management facilities have an incentive to ensure that those facilities are complying with hazardous waste regulations and managing waste in an environmentally safe manner. For example, the Minnesota Pollution Control Agency recommends that generators visit prospective hazardous waste management facilities and investigate each facility's compliance record prior to contracting with them for management services.[5] Moreover, Alberini and Bartholomew (1999) show that consumers of hazardous waste management services do appear to consider the compliance history of facilities in choosing where to send waste.[6]

The paper examines the effect of hazardous waste management facilities' environmental performance on consumers' demand for their services and, in turn, whether markets can affect the compliance behavior of hazardous waste managers. The remainder of this paper is organized as follows. Section 2 discusses the related literature on environmental compliance and the role of consumers and markets in affecting environmental performance. Section 3 provides a brief background on hazardous waste management and enforcement in the US. Section 4 presents the empirical analysis and Section 5 concludes.

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[5] "10 Steps to Compliance," Minnesota Pollution Control Agency, Hazardous Waste Fact Sheet 1.06, May 2000.

[6] However, their results are mixed. Using data on the disposal choice of California halogenated solvent waste generators, the authors found that generators were less likely to ship to publicly traded firms with a past record of violations, although they were more likely to ship to privately held firms with violations.

2. Related Literature

The studies most closely related to this analysis are those that examine the effect of environmental information disclosure on investors and/or the performance of regulated entities. A number of papers have shown that stock market prices respond to negative environmental information such as environmental enforcement actions (e.g., Badrinath and Bolster, (1996)), TRI emission levels (e.g., Hamilton (1995)), and general noncompliance or poor environmental performance (e.g. Lanoie, Laplante, and Roy (1998)).[7] A study by Konar and Cohen (1997) goes a step further to examine not only the effect of public disclosure on investor behavior, but also the effect of investor behavior on the environmental performance of regulated entities. The authors analyze the effect of TRI disclosures on the stock prices of U.S. firms as well as the effect of stock price declines on subsequent pollution levels. They find that firms with the largest negative stock price reactions to the release of environmental information responded with the largest decreases in future pollution. Thus not only do investors respond to poor environmental performance, firms change environmental performance in response to investor actions.

A few studies have focused on the effect of information disclosure on firm environmental behavior without explicitly modeling the response of consumers or investors. For example, Afsah, Laplante, and Wheeler (1997) find that creation of a public disclosure program in Indonesia resulted in significant improvements in environmental performance of the firms involved in the program. While the firms may have been concerned about both investor and consumer responses to negative environmental reports, the finding that multinational and

[7] Cohen (1999) provides a more detailed overview of this literature.

domestic private firms were more responsive to the information disclosure than publicly held firms suggests that investors were the more influential market channel in that case. Foulon, Lanoie, and Laplante (2002) consider the effect of information disclosure along with traditional enforcement methods (inspections and fines) on firms in the Canadian pulp and paper industry. They find that being placed on a list of noncompliant firms led firms to improve their environmental performance beyond what would have been expected from the traditional enforcement methods. In this case, the information disclosure could result in pressure from markets (investors and consumers) as well as from the community at large, both of which ultimately influence firm behavior.

Although to our knowledge no papers have directly estimated the role that consumers play in affecting environmental compliance, several have considered the impact of consumers on environmental performance more generally. For example, Arora and Cason (1996) examine participation in EPA's voluntary pollution reduction program known as 33/50 and find that participation rates in the program are greater in industries with greater consumer contact. Similarly, Anton, Deltas and Khanna (2004) find that firms in closer contacts with consumers are more likely to be more environmentally proactive and adopt environmental management systems. We hope to add to the empirical literature on the ability of markets to increase environmental performance by focusing more directly on the role that consumers play in improving environmental compliance.

3. Background on Hazardous Waste Management

Hazardous waste is any discarded material that exhibits a hazardous characteristic (that is, is ignitable, corrosive, reactive, or toxic) or is specifically listed by the EPA as hazardous

waste. Once hazardous waste is generated it must be managed in accordance with federal regulations. Under these regulations, waste can be stored only in approved tanks, containers, or buildings and cannot be stored indefinitely. Ultimately, the waste must be treated either to remove the constituents which render it hazardous or to immobilize the hazardous constituents so that they will not be released to the environment. After treatment the waste either must be disposed in approved units such as landfills or injection wells or it may no longer be subject to regulation, depending on the type of waste. Generators can choose to treat and dispose their waste themselves or they can send their waste off site for management. The majority of hazardous waste generators (over 95 percent) send waste off-site for treatment, although less than five percent of waste is sent off site.[8]

There are many different hazardous waste treatment methods such as combustion, biological treatment, chemical precipitation, or metals recovery, and the type of treatment required depends on the characteristics of the waste.[9] Commercial hazardous waste management facilities may specialize in one or more of these technologies. Most commercial facilities will

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[8] Most of the large hazardous waste generators manage their waste on-site. For example, the top 50 generators (representing less than half of one percent of large quantity generators) account for 40 percent of hazardous waste (measured by weight), almost all of which is managed on-site.

[9] Most waste must be treated so that each hazardous constituent in the waste is below a specified concentration level. However, for some wastes EPA has prescribed specific treatment methods that must be used. The treatment requirements for hazardous waste are collectively referred to as the Land Disposal Restrictions (LDRs) because waste must meet the LDR standards prior to being placed in or on the land (40 CFR Part 268).

accept waste from any hazardous waste generator provided that the waste meets its chemical and physical specifications.[10] However, a small subset of commercial facilities known as captive facilities only accept waste from designated facilities, usually facilities owned by the same parent company.

To comply with EPA's hazardous waste regulations facilities must build, operate and maintain management systems in accordance with requirements; obtain the necessary permits for such systems; institute good housekeeping practices; keep records and file reports on waste management activities; and train personnel both in day-to-day operations and for emergencies. EPA enforces the regulations primarily through facility inspections, although violations which result in damage to human health or the environment are sometimes self-reported or reported by third parties. Once a violation is discovered, the appropriate enforcement agency can initiate administrative, civil, or criminal actions, all of which can include penalty provisions.

4. Empirical Analysis

The purpose of this analysis is to determine whether consumers of hazardous waste management services are affected by managers' environmental performance – specifically their compliance with hazardous waste regulations – and in turn whether this affects the compliance behavior of hazardous waste managers. To answer the first question, we look at changes in the quantity of waste received by commercial hazardous waste managers to determine whether

[10] Specifications will vary across treatment technologies and depend on both the technical and regulatory parameters under which the system can operate.

noncompliance results in a decrease in the quantity of waste managed.[11] To answer the second question we look at managers' compliance behavior to determine whether market size and competition affect the compliance of commercial firms. In particular, market competition should serve as a good proxy for the ability of consumers to exert pressure on managers because the more competitive a market, the more choices available to consumers and the stronger the ability of consumers to influence firm behavior. Additionally, we believe that using both market size and competition will focus on consumers as the source of pressure rather than investors, as one of the primary concerns of investors – future liability – is not affected by the level of market competition.[12]

4.1 Effect of Compliance on Consumer Demand

If consumers care about compliance, then a poor compliance history should decrease the quantity of waste sent to a hazardous waste management facility, *ceteris paribus*. To test this assumption, we look at changes in the quantity of waste received by commercial hazardous

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[11] Alternatively, we could have examined the location choice of hazardous waste generators to determine whether compliance history affects the generator's choice. However, there are over 600,000 hazardous waste generators so we chose to focus on the supply side rather than the demand side to reduce the data requirements of the analysis.

[12] Of course, if investors also care about environmental performance as a way to increase sales to green consumers, market competition could affect investor pressure. This magnifies the role that consumers play in affecting firm environmental performance because they can exert pressure directly as well as indirectly through investors.

waste managers to determine whether noncompliance results in a decrease in the quantity of waste managed. Ideally we would also control for all the other attributes of hazardous waste management that a facility offers. Unfortunately, one of the primary attributes – the price of waste management services – is not available. Additionally, even if it were available, there is no one measure of price at a hazardous waste management facility as the price of services would depend on the hazardous characteristics of the waste managed. Thus to the extent that facilities may decrease price to offset a poor compliance record, the results of this analysis will be biased downward.

Data on the quantity of waste received at management facilities is collected by EPA every odd year through the Biennial Reporting Survey (BRS). For this analysis we examine the change in the quantity of waste managed at commercial facilities for two time periods, between 1997 and 1999 and between 1993 and 1999. In 1999, there were 420 commercial hazardous waste management facilities that accepted waste from offsite generators.[13] Of those, 336 were operating in 1997 and 289 were operating in 1993. For each set of facilities we calculated the percent change in the quantity of waste managed between the beginning and end of the relevant time period.[14] We then ran series of simple linear regressions of the percent change as a function of facility and market characteristics, as well as a number of variables designed to capture the

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[13] This figure does not include 25 federal facilities that accepted waste from other federal hazardous waste generators because federal facilities should not be subject to consumer or market pressure.

[14] We also examined the absolute change in the quantity of waste managed (measured in tons) but found that the percent change performed better in our regressions.

type of information that consumers could obtain about a facility's compliance history. Table 1 presents a summary of the data used in these regressions. As shown, a number of facilities significantly increased the quantity of waste managed in percentage terms, and a number of facilities decreased to almost nothing. The largest absolute increase in quantity during either period was approximately 800,000 tons and the largest absolute decrease was over 1 million tons.

The results of the regressions are presented in Table 2. We included a number of facility characteristics as controls in the regression. The first is the dummy variable *Captive* which is equal to one if the facility only takes waste from other facilities owned by the same parent company. The second is the variable *Permitted* which indicates whether the facility operates a waste management system that must be permitted by EPA prior to operation. Note that the coefficients on these two variables are not significant in any of the regressions. Next we included *Total Waste Managed* which measures the log of the total quantity (in tons) of waste managed (both waste received from off-site and waste generated on-site) at the facility in 1999.[15] The coefficient on this variable is positive in all of the regressions, although it is only significant for the 1997 to 1999 period. This suggests that there are economies of scale in waste management, as demand appears to be concentrating at larger facilities. The next three variables measure the complexity and type of waste management services offered at the facility: *Number of Waste Management Systems* measures the number of different types of waste management offered by the facility and *Combustion* and *Land Disposal* are dummy variables indicating whether the

[15] Because the size of the commercial facilities varies between 1 and 300 million tons, the log of tons managed performs significantly better than tons.

facility operates combustion or land disposal facilities, respectively. None of the coefficients on these variables are significant in any of the regressions.

The next set of variables capture differences in the markets in which the facilities are located. Because hazardous waste transport is relatively expensive, markets for waste management are regional, and market size and competition vary significantly across facilities.[16] Because there is no obvious market definition for hazardous waste facilities, we defined a facility's market to be a circle with a radius of 100 miles centered on the facility in question.[17] The first market variable is *Market Size* which is the log of the tons of hazardous waste being sent off-site by large quantity generators located in the market.[18] We also included *Change in Market Size* for the relative period.[19] While the coefficients on *Market Size* are not significant in

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[16] Alberini and Bartholomew (1999) show that shipping costs are a significant determinant in the choice of management facilities.

[17] We also considered markets with radii of 250, 500, and 1000 miles, but the 100 mile definition provided the strongest results.

[18] These variables were calculated for each facility using data from the 1993, 1997, and 1999 BRS. We could only include waste generated at "large quantity generators", i.e., those facilities that generate over 1,000 kilograms of hazardous waste a month, because smaller facilities are not required to participate in the BRS. Both management facilities and generators were located using latitude and longitude supplied in EPA's RCRAInfo database, or if that information was missing, using the latitude and longitude measure for the centroid of the zipcode in which the facility was located.

[19] *Change in Market Size* is measured in thousands of tons as some markets decreased in size.

any of the regressions, the coefficients on *Change in Market Size* are significant for the 1997 to 1999 regressions, although the negative sign is the opposite of what might be expected. In general, an increase in market size should lead to an increase in the quantity of waste managed at neighboring facilities. One possible explanation for this perverse result could be that in some markets, regulations or treatment requirements may have become more strict and in response, facilities who had previously been managing waste on-site began to send waste off-site to another less stringent market for management.

Number of Competitors measures the number of commercial hazardous waste facilities in the market, normalized by market size. The number of competitors is normalized because a market with ten competitors may actually be less competitive than a market with two competitors if demand in the first market is significantly higher than demand in the second. The regression also includes *Change in Number of Competitors* which measures the absolute change in the number of competitors in the market. None of the coefficients on *Number of Competitors* are significant in any of the regressions. The coefficients on *Change in Number of Competitors* are significant for the 1997 to 1999 regressions, although the positive sign is the opposite of what might be expected as an increase in competition should lead to a decrease in quantity managed, *ceteris paribus*. However, if changes in regulations lead commercial firms to cluster in less stringent locations or conversely to leave more stringent locations, one might see such a direct relationship. The final market variable is the interaction term *Change in Market Size*Change in Number of Competitors*, although none of the coefficients on this variable are significant.

Because of the complexity of hazardous waste regulations there is no simple measure of compliance. There are approximately 40 "areas of violation" which roughly correspond to the subparts of the Code of Federal Regulations for hazardous waste. Within each area, there are

numerous specific violations that could occur and the severity of each violation can vary. Therefore we used a number of different variables to measure compliance. The first regression for the 1997 to 1999 period, reported in the first column of Table 2, includes a dummy variable *Noncompliant* which is equal to 1 if the facility was found to have at least one hazardous waste violation in 1998.[20] As expected, the coefficient on this variable is negative and significant indicating that consumers do appear to respond negatively to facility noncompliance. Next we added the variable *Compliant* which is equal to 1 if the facility was inspected and found to be in compliance with all hazardous waste regulations. (If a facility was not inspected, there would be no information on the facility's compliance for 1998.) The coefficient on *Compliant* is negative, the opposite of what one might expect, although it is not significant. Thus there is no evidence that positive information increases demand, although it may be the case that one clean inspection report alone does not count as a good record.

The third specification for the 1997-1999 period includes the dummy variable *Noncompliant* along with *Number of Violations* which counts the number of detected violations at the facility in 1998, and while both of the coefficients on these variables are negative as expected, neither is significant. The last specification for the 1997-1999 period contains both *Noncompliant* and *Penalties Assessed for Violations* which measures the total amount of penalties (in thousands of dollars) assessed for violations detected in 1998. The coefficients on

[20] Data on enforcement and compliance were obtained from EPA's RCRAInfo Database. We only looked at violation history for 1998 because violations in 1997 could have affected demand in 1997 and violations in 1999 could have taken place after the waste was sent to the facility.

both of these variables are negative as expected, although only the coefficient on *Noncompliant* is significant.

For the 1993 to 1999 period, we looked at violation history for 1994 through 1998 and considered two specifications, one with *Number of Violations* and one with *Penalties Assessed for Violations*. However, neither of the coefficients were significant, and only the coefficient on *Number of Violations* had the expected negative sign. It may be that over a longer time period, changes in regulatory requirements and economic conditions outweigh the effects of poor compliance history on facility demand.

As discussed at the beginning of this section, we cannot obtain data on the price of waste management services at these facilities. If facilities decrease price to offset a poor compliance record, then our results will be biased downward. Given that we do find some evidence that hazardous waste generators respond to negative compliance information, it does appear that consumers may be able to exert pressure on waste management facilities to increase environmental compliance. Therefore the next step is to examine facilities' compliance behavior to see whether we can find evidence that consumers can serve as an informal enforcement mechanism.

4.2 Effect of Markets on Compliance

As discussed in Section 4.1, hazardous waste regulations are quite complex and there is no one obvious way to measure of compliance. For the purposes of this analysis, we consider a facility to be out of compliance if one or more violation of hazardous waste regulations is detected at the facility. Specifically, the dependent variable in this analysis is a binary variable equal to 1 if there is any detected hazardous waste violation at the waste management facility

during 1999. Because violations are only detected during the course of a facility inspection, if a facility is not inspected there is no data on whether the facility is in compliance. Thus our analysis must control for this censoring of data by using data on whether or not a facility has been inspected. In addition, compliance and inspections are jointly determined. That is, a regulator's decision to inspect a particular facility depends in part on the likelihood that the facility will be noncompliant and the facility's decision to comply depends in part on the likelihood of inspection. The censored bivariate probit model developed by Greene (1992) accounts for both of these factors. The censored bivariate probit uses maximum likelihood to estimate a probit model with sample selection where the selection equation and the underlying equation of interest may have correlated errors.

More specifically, both the probability of a violation and the probability of an inspection are modeled as latent variables, $Y_{1i}^{*} = x_{1i}\beta_1 + \varepsilon_{1i}$ and $Y_{2i}^{*} = x_{2i}\beta_2 + \varepsilon_{2i}$, respectively. Let Y_{1i} and Y_{2i} be the observable binary variables associated with these two latent variables. Since regulators target facilities that are likely to be in violation for inspections, the error terms ε_{1i} and ε_{2i} should be positively correlated. Therefore, we can express the likelihood of observing a detected violation (Y_{1i}=Y_{2i}=1) as :

$$L_{Y_{1i}=1,Y_{2i}=1} = \sum_{Y_{1i}=1,Y_{2i}=1} \log \Phi_2\left[x_1\beta_1, x_2\beta_2, \rho\right]$$

where Φ_2 is the bivariate normal cumulative distribution function and ρ is the covariance between ε_{1i} and ε_{2i}. Similarly, the likelihood of inspecting a non-violator (Y_{1i} = 0, Y_{2i} = 1) is:

$$L_{Y_{1i}=0,Y_{2i}=1} = \sum_{Y_{1i}=0,Y_{2i}=1} \log \Phi_2\left[-x_1\beta_1, x_2\beta_2, -\rho\right].$$

Finally, if a facility is not inspected, whether the facility is in violation is unknown. Thus the maximum likelihood function for the censored bivariate probit can be expressed as:

$$L = L_{Y_{1i}=0,Y_{2i}=1} + L_{Y_{1i}=1,Y_{2i}=1} + L_{Y_{2i}=0} = \sum_{Y_{1i}=1,Y_{2i}=1} \log \Phi_2\left[x_1\beta_1, x_2\beta_2, \rho\right] + \sum_{Y_{1i}=0,Y_{2i}=1} \log \Phi_2\left[-x_1\beta_1, x_2\beta_2, -\rho\right] + \sum_{Y_{2i}=0} \log\left(1 - \Phi\left[x_2\beta_2\right]\right)$$

As discussed in Poirier (1980) the bivariate probit model is identified if there is at least one variable that affects whether the facility will be inspected but does not affect whether the facility violates the regulations, as well as at least one variable that affects whether the facility violates the regulations but does not affect whether the facility will be inspected.

The results of the censored bivariate probit are reported in Table 3. Following other empirical analyses of compliance (see, for example Helland (1998), Foulon, Lanoie, and Laplante (2002), and Stafford (2002)) we included a number of facility characteristics (e.g., the quantity of waste managed at the facility, the number and types of technologies at each facility, past compliance history) and state characteristics (e.g., liability regimes, total enforcement effort) as explanatory variables.[21] The first five facility variables are identical to the variables used in the analysis described in Section 4.1. *Captive* is omitted from the Inspection equation to identify the model, but in the Violation equation the coefficient on *Captive* is negative and significant indicating that captive facilities are less likely to violate hazardous waste regulations than other

[21] Data on facility characteristics was obtained from both RCRAInfo and the 1999 Biennial Reporting System (BRS) database. Data on state liability regimes come from analyses of state Superfund Programs conducted by both the EPA and the Environmental Law Institute. The remaining state variables were derived from RCRAInfo and BRS data.

commercial facilities.[22] *Permitted* facilities are more likely to be inspected than other facilities, although they are not more likely to violate regulations. Since large complex facilities pose more of a potential danger to the environment, we expected the coefficients on *Total Waste Managed*, *Combustion*, and *Land Disposal* in the Inspection equation to be positive, which they are although none are significant. It is not obvious what the sign of the coefficients on these variables should be in the Violation equation, as increased probability of inspection at large complex facilities might or might not outweigh the increased costs of compliance (and thus the benefit from noncompliance). Additionally, none of those coefficients are significant.

To control for past compliance and enforcement history, we included an additional three facility variables. *Inspected 98* and *Violated 98* indicate whether the facility was inspected or violated in 1998, respectively, and *Past Violations* measures the number of violations at the facility between 1994 and 1998. The coefficients on all of these variables are positive in both equations, although neither the coefficient on *Inspected 98* in the Violation equation or the coefficient on *Violated 98* in the Inspection equation are significant. Clearly there are some unobserved characteristics of facilities that EPA targets for inspection, as well as some characteristics that make the facility more likely to violation. However, even though facilities with significant past violations are much more likely to be inspected, they continue to violate at a higher rate than other facilities. Perhaps it takes time to correct violations (for example, new technologies may have to be installed) so that past violations may in part determine current violations.

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[22] When *Captive* was included in a probit regression of the Inspection equation alone, it was not significant.

The next set of variables measure state characteristics, as most hazardous waste regulations are enforced at the state level. *State Violations 98* measures the total number of violations detected in the state in the previous year normalized by the gross state product. Because data on the past level of state violations will not generally be common knowledge to facilities, it should not affect the facility's violation decision and is omitted from the Violation equation to identify the model. The coefficient on *State Violations 98* has the expected negative sign in the Inspection equation, since higher violations last year will require more followup inspections this year and will decrease the enforcement resources available for other inspections. However, it is not significant. *State Inspections* measures the total number of inspections conducted in the state normalized by the gross state product. The higher the level of state inspections, the more likely a facility is to be inspected, and thus, the less likely it should be to violate. Both of the coefficients on *State Inspections* have the expected signs, although only the coefficient in the Inspection equation is significant. We also include the variable *Strict Liability* in the regression to control for states that have a strict liability regime for environmental accidents. The coefficient on *Strict Liabiltiy* is negative and significant in the Inspection equation, but it is not significant in the Violation equation.

Finally, we include two variables to measure market competition, *Market Size* (measured as the log of tons of waste generated within 100 miles of the facility) and *Number of Competitors* (normalized by the total size in the market in thousands of tons). Since a facility's market is defined for the purposes of this analysis as a circle with a radius of 100 miles centered on the facility, neither of these variables should affect the probability of inspection, and neither of the coefficients in the Inspection equation are significant. However, if consumers do exert informal enforcement pressure, both market size and market competition should affect a facility's

compliance behavior. First consider market size. If the market is large, facilities will have less need to compete through good compliance records. However, while the coefficient on *Market Size* is positive, it is not significant. Next consider *Number of Competitors*. The more competitors there are in a market, the more choices there are for consumers and thus the easier it is to exert pressure on managers. The coefficient on *Number of Competitors* in the Violation equation does have the anticipated negative sign and is significant. This suggests that market competition can provide additional incentives for compliance at commercial facilities.

To get a better sense of the effect of these explanatory variables on the probability of inspections and compliance, Table 4 reports the change in the probability (in percentage points) of a representative facility being inpected or violating the regulations that would result from various changes in the explanatory variables. Table 4 also shows the results for 3 additional market definitions (250, 500, and 1000 mile radii) to determine how sensitive the results are to our market definition. Note that the representative commercial facility which has the mean values for continuous explanatory variables and the median values for discrete explanatory variables, has an inspection probability of 89 percent and a violation probability ranging from 41 to 44 percent. Captive facilities have violation probabilities approximately 20 percentage points lower at approximately 21 percent. For the most part, the magnitudes and significance of the non-market explanatory variables are consistent across the different market definitions.

Now consider the competition variables. Note that market size does not have a significant effect on the probability of violation, regardless of market definition. However, the coefficients on size are generally positive, as we expected. Additionally, size does have a significant and negative effect on inspection probability for markets of 500 miles, and the sign of the coefficient on size in consistently negative in the Inspection equation. If large markets

increase regulators' workloads, market size might decrease inspection probability. The number of competitors in the market does significantly decrease the probability of violation when markets are defined as 100 miles, and the effect is quantitatively quite large. An increase in the number of competitors by one standard deviation, that is increasing the number of competitors per 10,000 tons of waste from 1.03 to 5.04, decreases the probability of violation from 41% to 7%. While the coefficients on number of competitors are not significant for markets of 250 and 1000 miles, these coefficients are also negative, although the quantitative effect is also much smaller. Thus it appears that local competition can have a significant positive impact on compliance, but the impact decreases as the geographic scope of the market grows. In terms of the effect of competition on inspections, it does appear that in more competitive markets, the probability of inspection may be lower (although the effect is statistically significant only for a 500 mile market radius). This could be due to the fact that regulators recognize, to some extent, the positive effect that competition can have on compliance incentives. Finally, note that the correlation coefficient for the two equations, ρ, is positive as expected and statistically significant.

As a final step in the analysis, we compare the compliance behavior of commercial waste management facilities to that of on-site waste management facilities. The universe for this final analysis includes all non-federal hazardous waste management facilities in the continental U.S. in 1999.[23] As in the commercial facility analysis, we conduct a censored bivariate probit

[23] Federal facilities are excluded because the impact of penalties on federal facilities is not the same as the impact on for-profit companies, and thus compliance behavior will be different. Additionally there are no federal commercial facilities.

analysis. However, since market characteristics should not affect on-site facilities, we exclude those variables from the regression. We also add a dummy variable *Commercial* that indicates whether the facility is commercial. Table 5 presents the results of this analysis. Note that commercial facilities are both more likely to be inspected and more likely to violate the regulations than on-site facilities. While this may be contrary to initial expectations given the fact that commercial facilities are subject to external pressure from consumers and on-site facilities are not, there are two possible explanations for this result. First, because on-site managers are solely responsible for any environmental damages resulting from the mismanagement of hazardous waste, they may be more compliant with hazardous waste regulations. Second, a reputation for environmental compliance may also be important to on-site generators whose investors or customers would be leery of a company with a poor environmental record. This second explanation is consistent with the finding that captive facilities are significantly less likely to violate regulations. Like on-site managers, owners of captive facilities are also unable to spread liability to third parties. In addition, only large firms are likely to find it profitable to operate captive facilities, and firms with "deep-pockets" may have higher incentives to avoid environmental liability.

We also included one additional variable, *State Management Facilities*, which measures the total number of management facilities in the state. One might expect that being in a state with a large hazardous waste management sector would increase the workload on regulators and thus decrease the probability of inspection at any one facility, which is consistent with the negative and significant coefficient in the Inspection equation. However, the negative coefficient in the Violation equation appears inconsistent with this lower probability of inspection. It could be the

case that states with a larger number of management facilities provide more outreach to facilities, thus decreasing violations.

Finally, to get a better sense of the size of the effect the explanatory variables have on both inspections and violations, Table 6 reports the change in the probability (in percentage points) of a representative facility being inpected or violating the regulations that would result from various changes in the explanatory variables. This representative facility has the mean values for continuous explanatory variables and the median values for discrete explanatory variables. The probability of an inspection at this facility is 29 percent and the probability of a violation is 19 percent. If the facility were commercial, the probability of inspection would increase to 41 percent and the probability of violation to 30 percent. However, if the facility were captive, the probability of violation would decrease to 16 percent.[24]

5. Summary and Conclusions

This paper examines the role that consumers can play in encouraging environmental compliance by analyzing whether the demand for hazardous waste management services depends on a facility's compliance record and in turn, whether this affects compliance at hazardous waste management facilities. The hazardous waste management industry provides a unique opportunity to study this issue because hazardous waste generators – the consumers in this market – are liable for any damages the result from mismanagement of their waste and thus have a vested interest in the environmental performance of hazardous waste management facilities. To assess the effect of past compliance on consumer behavior, we look at changes in the quantity

[24] Since all captive facilities are also commercial, the probability is 19% + 11% – 14% = 16%.

of waste managed by commercial hazardous waste management facilities over two time periods, 1997 to 1999 and 1993 to 1999. For the 1997-1999 period, we find that past noncompliance does decrease the quantity of waste sent to a facility. However, for the 1993 to 1999 period, we do not find any significant decrease associated with poor compliance history. If facilities decrease the price of their services to offset a poor compliance record, our results would be biased downward. Alternatively, it may be that over a long time period, changes in regulatory requirements and economic conditions outweigh the effects of poor compliance.

Given that we do find some evidence that hazardous waste generators respond to negative compliance information, we examine the extent to which facilities' compliance behavior is influenced by market size and market competition. Market competition in particular should serve as a good proxy for the ability of consumers to exert pressure on managers because the more competitive a market, the more choices available to consumers and the stronger the ability of consumers to influence firm behavior. Although we do not find any evidence that market size affects compliance behavior, we do find that local competition serves to increase hazardous waste compliance. However, as competition becomes less localized, it has a smaller, if any, effect on compliance. While regulators may be changing inspection targeting somewhat in response to local competition, it appears that there is more room to use local competition as an effective substitute for enforcement resources.

Finally, regardless of the pressures exerted by consumers to comply, commercial hazardous waste managers are more likely to violate hazardous waste regulations than on-site managers. This can be explained in part by the fact that on-site managers are solely responsible for any environmental damages that results from mismanagement while commercial facilities may be able to share liability with the original generators of the waste that they manage. In

addition, since hazardous waste management is not the primary business for on-site managers, a poor environmental record may be more detrimental to on-site managers than commercial managers. Captive hazardous waste managers, that is firms that manage hazardous waste for other facilities owned by the same company, are even less likely to violate than on-site managers.

Table 1: Data Used in the Analysis of the Change in the Quantity of Waste Managed

Period of Analysis	**1997 to 1999**			**1993 to 1999**		
Number of Observations	336			289		
Variables	Min	Max	Mean	Min	Max	Mean
Percent Change in Demand	-0.99	4098.10	20.34	-0.99	6027.25	25.97
Captive	0	1	0.04	0	1	0.02
Permitted	0	1	0.69	0	1	0.76
Total Waste Managed (Log of Tons)	-0.29	19.53	8.59	-2.12	19.53	8.91
Number of Waste Management Systems	1	15	2.43	1	15	2.54
Combustion	0	1	0.33	0	1	0.34
Land Disposal	0	1	0.29	0	1	0.31
Market Size (Log of Tons)	4.98	16.36	12.21	5.61	16.36	12.29
Change in Market Size (Thousand Tons)	-38.23	154.70	12.03	-337.84	579.08	-17.41
Number of Competitors (Per Million Tons)	0.001	6.82	0.10	0.001	3.64	0.09
Change in Number of Competitors	-10	4	-1.53	-4	8	1.89
Change in Market Size x Change in Number of Competitors	-389.32	72.70	-16.77	-853.71	4550	90.48
Noncompliant	0	1	0.48	--	--	--
Compliant	0	1	0.35	--	--	--
Number of Violations	0	44	3.01	0	129	16.44
Penalties Assessed for Violations (in Ten Thousand $)	0	48.80	0.71	0	234	35.81

Table 2: Change in Quantity of Waste Managed at Commercial Hazardous Waste Facilities

Percent Change in Quantity Managed	**1997 to 1999 (N= 336)**				**1993 to 1999 (N= 289)**	
Captive	-22.26 (70.92)	-24.50 (71.15)	-22.69 (70.18)	-22.58 (71.05)	-25.08 (140.50)	-22.11 (140.20)
Permitted	-12.81 (31.08)	-9.41 (31.62)	-11.98 (31.20)	-11.92 (31.08)	45.71 (53.34)	45.82 (53.47)
Total Waste Managed	10.67** (4.85)	11.03** (4.91)	10.71** (4.88)	10.64** (4.86)	4.13 (7.82)	3.54 (7.87)
Number of Waste Management Systems	1.31 (6.16)	1.60 (6.19)	1.30 (6.17)	1.28 (6.17)	-0.80 (9.55)	-0.82 (9.55)
Combustion	27.12 (30.63)	26.85 (30.67)	27.07 (30.68)	27.37 (30.71)	-39.72 (50.36)	-41.67 (50.25)
Land Disposal	14.92 (32.44)	13.96 (32.54)	14.77 (32.53)	15.08 (32.51)	-28.34 (50.73)	-28.82 (50.78)
Market Size	15.74 (13.79)	15.32 (13.83)	15.74 (13.81)	15.82 (13.82)	-18.00 (22.53)	-19.26 (22.14)
Change in Market Size	-0.11* (0.06)	-0.11* (0.06)	-0.11* (0.06)	-0.11* (0.06)	0.01 (0.41)	0.10 (0.41)
Number of Competitors	0.01 (0.04)	0.01 (0.04)	0.01 (0.04)	0.01 (0.04)	-0.05 (0.10)	-0.05 (0.10)
Change in Number of Competitors	9.22* (5.23)	9.18* (5.24)	9.15* (5.27)	9.22* (5.24)	7.40 (10.32)	8.56 (9.82)
Change in Market Size x Change in Number of Competitors	-0.02 (0.02)	-0.02 (0.02)	-0.02 (0.02)	-0.02 (0.02)	0.001 (0.01)	0.001 (0.01)
Noncompliant	-48.20* (27.41)	-63.61 (41.46)	-46.76 (31.41)	-47.61* (27.63)		
Compliant		-20.73 (41.80)				
Number of Violations			-0.25 (2.62)		-0.46 (1.15)	
Penalties Assessed for Violations				-0.61 (3.37)		0.04 (0.13)
Constant Term	-225.67 (163.28)	-210.58 (166.58)	-225.99 (163.57)	-226.43 (163.58)	200.17 (266.58)	210.92 (263.95)

**Significant at 95%; *Significant at 90%.

Table 3: Censored Bivariate Probit Results for Commercial Facilities

		Inspection Equation		Violation Equation	
Variable	**Mean**	Coefficient	(Std. Error)	Coefficient	(Std. Error)
Captive	0.04			-0.58*	(0.34)
Permitted	0.61	0.64**	(0.18)	0.07	(0.17)
Total Waste Managed	7.89	0.03	(0.03)	0.02	(0.02)
Combustion	0.31	0.05	(0.21)	-0.05	(0.17)
Land Disposal	0.27	0.16	(0.22)	0.04	(0.17)
Inspected 98	0.78	1.11**	(0.20)	0.37	(0.30)
Violated 98	0.45	0.15	(0.22)	0.38**	(0.16)
Past Violations	13.63	0.02**	(0.01)	0.02**	(0.005)
State Violations 98	0.35	-0.39	(0.34)		
State Inspections	0.31	0.80*	(0.44)	-0.07	(0.34)
Strict Liability	0.84	-0.67**	(0.29)	-0.01	(0.21)
Market Size	12.24	-0.05	(0.06)	0.03	(0.07)
Number of Competitors	1.03	-0.02	(0.02)	-0.33*	(0.18)
Constant		0.11	(0.75)	-1.05	(1.14)
ρ		0.98**	(0.13)		

**Significant at 95%; *Significant at 90%.

Table 4: Factors that Affect the Probability of Inspection and Violation at Commercial Facilities

	Inspection Probability				Violation Probability			
Market Size	100	250	500	1000	100	250	500	1000
Representative Facility	89%	89%	89%	89%	41%	44%	44%	44%
Captive	NA	NA	NA	NA	**-20%**	**-22%**	**-23%**	**-23%**
Permitted	**+8%**	**+8%**	**+8%**	**+8%**	+3%	+2%	+4%	+2%
Increase Waste Managed by one std. dev.	+2%	+2%	+2%	+2%	+2%	+1%	+2%	+2%
Combustion	+1%	+1%	+0%	+0%	-2%	+0%	-1%	+0%
Land Disposal	+3%	+2%	+1%	+2%	+2%	+0%	+1%	-1%
Inspected Last Year	**+10%**	**+10%**	**+10%**	**+10%**	+15%	+7%	**+13%**	+6%
Violated Last Year	+3%	+3%	+4%	+3%	**+15%**	**+16%**	**+16%**	**+16%**
Increase Past Viol. by one std. dev.	**+5%**	**+5%**	**+5%**	**+4%**	**+13%**	**+14%**	**+15%**	**+16%**
Increase State Viol. by one std. dev.	-2%	-2%	-2%	-2%	NA	NA	NA	NA
Increase State Inspec. by one std. dev.	**-4%**	**-4%**	-3%	-3%	+1%	+1%	+0%	+1%
No Strict Liability Regime	**+8%**	**+8%**	**+8%**	**+8%**	+0%	+1%	+0%	+2%
Increase Size by one std. dev.	-2%	-1%	**-6%**	-12%	+2%	+3%	+2%	-9%
Increase No. of Comp. by one std. dev.	-2%	-1%	**-8%**	-14%	**-34%**	-4%	+0%	-11%

Changes are in percentage points. Statistically significant changes in bold.

Table 5: Censored Bivariate Probit Results for All Management Facilities

		Inspection Equation		Violation Equation	
Variable	**Mean**	Coefficient	(Std. Error)	Coefficient	(Std. Error)
Commercial	0.12	0.33**	(0.09)	0.36**	(0.09)
Captive	0.008			-0.71**	(0.28)
Permitted	0.15	0.56**	(0.08)	0.27**	(0.08)
Total Waste Managed	6.52	0.02**	(0.01)	0.01*	(0.01)
Combustion	0.07	0.36**	(0.11)	0.24**	(0.10)
Land Disposal	0.37	-0.04	(0.05)	-0.13**	(0.06)
$Inspected_{-1}$	0.41	0.57**	(0.06)	-0.05	(0.08)
$Violated_{-1}$	0.21	-0.17**	(0.07)	0.11	(0.08)
Past Violations	4.98	0.03**	(0.003)	0.03**	(0.003)
$State\ Violations_{-1}$	0.33	-0.72**	(0.12)		
State Inspections	0.30	1.17**	(0.15)	0.38**	(0.13)
Strict Liability	0.86	-0.08	(0.07)	-0.04	(0.07)
State Management Facilities	72.50	-0.003**	(0.0004)	-0.001*	(0.0006)
Constant	1.00			-1.07	(0.12)
ρ		0.97**	(0.05)		

**Significant at 95%; *Significant at 90%.

Table 6: Factors that Affect the Probability of Inspection and Violation at All Management Facilities

	Inspection Probability	**Violation Probability**
Representative Facility	29%	19%
Commercial	**+ 12%**	**+ 11%**
Captive	NA	**- 14%**
Permitted	**+ 21%**	**+ 8%**
Increase Total Waste Managed by one std. dev.	**+ 3%**	**+ 2%**
Combustion	**+ 13%**	**+ 7%**
Land Disposal	- 1%	**- 3%**
Inspected Last Year	**+ 22%**	- 1%
Violated Last Year	**- 6%**	+ 3%
Increase Past Violations by one std. dev.	**+ 10%**	**+ 8%**
Increase State Violations by one std. dev.	**- 6%**	NA
Increase State Inspections by one std. dev.	**+ 10%**	**+ 2%**
No Strict Liability Regime	+ 3%	+ 1%
Increase State Mgmt. Fac. by one std. dev.	**- 6%**	**- 2%**

Changes are in percentage points. Statistically significant changes in bold.

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