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# IS THERE A GREEN LINK? A PANEL DATA VALUE EVENT STUDY OF THE RELATIONSHIP BETWEEN CAPITAL MARKETS AND TOXIC RELEASES <sup>1</sup>

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## Abstract

This paper attempts to look at the effectiveness of public provision of pollution information in providing incentives for firms to control pollution. This is achieved by examining the effect of release of pollution information on the market value of firms. The paper conducts a value event study using the U.S Environmental Protection Agency's Toxic Release Inventory Program as the basis for its analysis. The paper uses a Seemingly Unrelated Regressions (SUR) approach with a dummy for the event date to conduct this value event study. The advantage of using the SUR approach as opposed to methods used in similar studies done before is that it explicitly incorporates both the contemporaneous correlation of returns and the inter-temporal correlation of the estimated abnormal returns when testing the null hypothesis that the event has no impact. We conclude that there are significant negative abnormal returns on the day of the release of the pollution information for all the seven releases put together. But, there are no significant negative abnormal returns for each of the seven releases when we incorporate the contemporaneous correlation of the returns and inter-temporal correlation of the estimated abnormal returns. In addition, this negative effect peters away as the length of the event period is extended to include the four days after the release of the information as well.

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## **I Introduction**

“ I am committed to the effective implementation of this law [EPCRA] because Community Right-to-Know protections provide a basic informational tool to encourage informed community-based environmental decision making and provide a strong incentive for businesses to find their own ways of preventing pollution.”

— President Bill Clinton

In the third wave of environmental policy framework the traditional players – the state and the factory are replaced by a regulatory triangle. In this approach regulators are not the only source of pressure on plants to improve environmental performance. The market and the community also play an important role. This alternative to the traditional theories links the plant, the state, the community and the market. Thus with multiple agents and multiple incentives the regulator’s role no longer needs to be confined to producing, monitoring and enforcing rules and standards. Instead, regulators can use non-traditional programs that harness the power of markets and communities. One such non-traditional program relates to the public release of pollution information of firms as a way of controlling pollution. We focus our attention on the Toxic Release Inventory Program ( TRI ) and the effect of the providing this information to investors.

Investors scrutinize environmental performance. In the capital markets shareholders may invest in “green” firms because they might be of the view that environmentally cleaner firms have more efficient production techniques or face fewer clean up costs and will thus be more profitable. Thus public certification of good or bad environmental performance can translate into large expected gains or losses. Thus a reaction from investors would be the first step in testing whether the new policy is effective in regulating pollution. The policy would be effective if there

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and Peter Parks. The remaining errors in the paper are of course my own responsibility.

is reaction from the investors to the release of pollution information and this in turn leads to a decrease in future pollution levels. The new environmental policy framework realizes the importance of the market as a regulatory mechanism and uses innovative methods to use this phenomenon as a means of pollution control.

The key features required for effective pollution control in this new paradigm are:

a) Informational Intensity: Markets and communities need timely and accurate information to access the environmental performance of factories.

b) Information Leveraging: Activities by environmental agencies that influence polluters indirectly may be as important as direct enforcement. These include educating communities, publicly disclosing factory ratings and training environmental personnel in polluting factories.

c) Adaptation: Regulators should tighten existing regulations and simultaneously minimize disruption for investors. This can be done with transparent adjustment rules, linked to publicly available data.

Since the core of the whole new approach relies on information provision, the new approach has been called the information strategy for pollution control. While information strategies have become common in natural resource settings, they are less familiar in a pollution control context. But the number of applications of information strategies to the pollution context is increasing all over the world.<sup>2</sup> This paper uses the publicly available data provided by the TRI to test the success of the Information Strategy in terms of its effect on the investors.<sup>3</sup>

The paper provides empirical evidence that the release of the TRI led to negative stock market reaction. The four major findings of the paper are : i) the effects on the stock market were

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<sup>2</sup> See Tietenberg ( 1997 ) for some selected functioning programs.

<sup>3</sup> See Kennedy, Laplante and Maxwell ( 1994 ) for a theoretical discussion about informational strategies

significant on the day of the release for each of the years 1989 – 1995, ii) The overall effect on all the firms over this entire period is negative as well on the day of the release, iii) 19% of the firms had significant negative stock returns for the entire period on the day of the TRI release. But, there were also some firms that were rewarded by the market possibly for their pollution abatement activities. 4% of the firms had significant positive stock returns for this period on the day of the TRI release and iv) Changes in stack air releases & underground injections, debt equity ratios and industry effects are significant determinants of abnormal returns.

Section II discusses the previous literature in this field and how our attempt differs from the existing works. Section III presents the econometric modeling used to generate the results. Section IV describes the data used by us. Section V provides an analysis of our results and Section VI concludes.

## **II Literature**

There are numerous studies that relate the environment to the various indicators of the financial position of the firms. These can be classified into studies that use information about individual firms and studies that analyze deliberate provision of information to the markets. The latter kind of studies can be quantified as collective information studies and our study also falls into that category. The earliest study in this category that empirically tested the relationship between financial performance and environmental performance was by Shane and Spicer ( 1983 ). These used studies conducted by the Council of Economic Priorities of firms' performance in four industries, namely paper, power, steel and oil, to analyze the reaction of investors to the release of the results of those studies. They find that firms' market value is adversely affected by the release of the pollution information. They also find that firms identified as serious polluters

suffered greater loss in market value than those with a better ranking. In the context of the TRI the first study was done by Hamilton ( 1995 ). He examines whether the TRI when released for the first time in June 1989 were news to journalists and investors. He uses the CRSP data to calculate abnormal returns using the market model event study approach. <sup>4</sup> His results indicate that investors found this pollution information of interest and stockholders in firms reporting TRI pollution figures experienced negative, statistically significant abnormal returns upon the first release of the information. Konar and Cohen ( 1997a ) use the TRI data to test whether or not significant stock price reductions translate into significant decreases in toxic emissions. They look at the change in toxic emissions between 1989 and 1992 that resulted from a change in the stock prices in 1989. They conclude that media attention and resultant stock price effects have more of an effect on subsequent firm behavior than simply being known as the largest emitters. Konar and Cohen ( 1997b ) explores the factors that both explain differences across firms in their initial toxic emissions and in the reductions beyond any legally required levels subsequent to availability of public information on TRI. They look at the change in toxic emissions between 1989 and 1992. They find that the largest firms are most likely to reduce emissions subsequent to the new information being made public. They also find that financial ability plays an important role in emission levels. On the other hand, they also find that firms who advertise more heavily to consumers or had significant negative media attention concerning their emission levels reduced their emissions more than average after controlling for firm size. Lanoie et al. ( 1997 ) use data from British Columbia that provides information on firms that are not complying with the environmental standards and firms that are of concern to the Ministry of Environment, British Columbia ( Canada ). They look at the time period from 1990 to 1992

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<sup>4</sup> See Brown and Warner ( 1980 and 1985 ), MacKinlay ( 1997 ) and Peterson ( 1989 ) for

when the lists of firms were released every six months. This paper concludes that large polluters are affected more significantly from such information releases than small polluters. The yearly provision of the TRI has been used by Khanna et al. ( 1997 ) to conduct a panel data analysis of how repeated public disclosure of environmental information adversely affects the market value of firms in the chemicals industry. They use the TRI for the years 1987-1992, COMPUSTAT, SETS and CRSP databases. They also look at how the change in the market value leads to subsequent changes in the firms' pollution levels. They show that firms incur statistically significant negative stock market returns during the one day periods following the disclosure of the TRI in the years 1990 - 1994. These losses have significant negative impact on on-site toxic releases and a significant positive impact on wastes transferred off-site for recycling and treatment, but their impact on total toxic wastes generated by these firms is negligible.

One of the ways in which our paper is different from all the above mentioned papers is that apart from Khanna et al ( 1997 ) and Lanoie et al ( 1997 ) none of the other studies look at the effects of repeated provision of pollution information and all of them use cross section analysis to explain the determinants of the abnormal returns. Our paper is different from Lanoie et al ( 1997 ) as it explicitly uses the panel data properties provided by the firm specific environmental and financial data in analyzing the distribution of abnormal returns. In addition our paper uses U.S data rather than Canadian data. The U.S data is much better as the sample has 165 firms as opposed to 19 firms in the Canadian data. The U.S data as opposed to the Canadian data also contains financial and pollution information at the firm level. Since all the abnormal returns cannot be explained away by just the pollution information the existence of firm specific variables becomes essential in explaining the factors changing the market value of firms. The

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detailed discussions on event studies.

explicit use of the panel data properties improves the efficiency of econometric estimates and overcomes the difficulties of making inferences about the dynamics of change from cross-sectional evidence.<sup>5</sup> Our paper is different from Khanna et al ( 1997 ) paper as it does not restrict its attention to the firms in the chemical industry and thus is able to present the industry effects when looking at the factors affecting the change in the dollar value of abnormal returns.<sup>6</sup> The use of economy wide data attains significance as the firms in the chemical industry are known to be heavy polluters whose relative pollution contribution has not decreased significantly. Thus the reaction of the market to the pollution by these large polluters may not provide a complete description of the underlying associations. Our paper however does not look at the effects of the investors' reaction on future pollution levels.

In addition our paper is also different from the above mentioned papers relating to TRI as the estimation and testing of the significance of abnormal returns is done using the Seemingly Unrelated Regressions ( SUR ) framework with a dummy for the event date as opposed to the traditional variants of the returns procedure used by these studies. The traditional event studies examine average or cumulative average residuals or forecast errors generated from a fair return generating model such as the market model. The use of the SUR framework becomes essential as the complete overlap of the event windows or total clustering of the included securities leads to non zero covariances / correlations of returns across securities. This correlation of the returns equation arises from the fact that there are common factors that affect the returns of the firms. These common factors could include factors like the general health of the economy as well as factors specific to an industry. Thus, the distributional results presented by the previous TRI

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<sup>5</sup> Chapter 1 of Hsiao ( 1986 ) deals with the advantages that panel data possesses over cross-section and time series data.

<sup>6</sup> Table 2 provides the distribution of the firms in our sample across industries.



studies for the aggregated abnormal returns are no longer applicable.<sup>7</sup> In addition even if the true abnormal returns are serially uncorrelated the estimated abnormal returns are not. Thus, the variances used in these studies in their test procedures for testing cumulative abnormal returns are underestimated leading to an upward bias in the significance tests.<sup>8</sup> The SUR approach explicitly incorporates both the contemporaneous correlation of returns and the inter-temporal correlation of the estimated abnormal returns when testing the null hypothesis that the event has no impact. This approach also provides a simple framework for us to test the significance of abnormal returns to individual firms as well test the joint significance of the abnormal returns to all firms for a given event. This attains importance as the nature of the firm affects the reaction from the capital markets. Firms in industries that produce secondary products are likely to be affected more than firms in industries that produce primary products. The approach also provides a framework for efficiently using the available data when we deal with multiple announcement events. This is done by presenting the details about the abnormal returns at the firm level for each one of the announcement dates. This disaggregation becomes important as the firms are subject to differential effects across each cross section as well as across the time periods.<sup>9</sup>

### **III Method of Study**

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<sup>7</sup> See Bernard ( 1987 ) for a discussion on the problems related to clustering.

<sup>8</sup> See Salinger ( 1992 ) for the details about the underestimation of variances due to serial correlation of the estimated abnormal returns and due to the contemporaneous correlation of residuals.

<sup>9</sup> The approach that we are following is similar to the one used by Schipper and Thomas ( 1983 ) and the exact distributions of the test statistics are based on Schipper and Thomas ( 1985). Also, see Salkever ( 1976 ) for a discussion of this prediction method.

The analysis of the effect of the announcements on the investors is done using the stock market data. We estimate abnormal stock returns using the value event study methodology. The value event study can be used to analyze the effects on investors using the Efficient Markets Hypothesis. This hypothesis claims that security prices fully reflect the present discounted value of all future cash flows due to all of the assets of the firm using all available information and adjusting immediately to new information. Therefore, the effect of release of pollution information on the future cash flows for a given firm should be reflected in the firm's security price at the time the pollution information was released.

In the case of value event studies, the appraisal of the event's impact on the market value of a firm requires a measure of the abnormal return. The abnormal return is the actual ex post return of the security over the event window minus the normal return of the firm over the event window. The normal return is defined as the expected return without conditioning on the event taking place. For firm  $i$  and event date  $t$  the abnormal return is normally measured as :

$$AR_{it} = R_{it} - E(R_{it}|X_t) \quad (1)$$

where  $AR_{it}$ ,  $R_{it}$ , and  $E(R_{it}|X_t)$  are the abnormal, actual and normal returns respectively for time period  $t$ .  $X_t$  is the conditioning information for the normal return model. In the standard fair generating models for conducting event studies there are two common choices for modeling the normal return: a) the constant mean return model where  $X_t$  is a constant and b) the market model where  $X_t$  is the market return.<sup>10</sup> Most studies estimate the abnormal returns as the prediction error of the market model. Abnormal returns are estimated for each observation within an 'event

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<sup>10</sup> In a test of market efficiency, as opposed to a value event study, abnormal returns are defined as the difference between the actual and the ex ante required return.

window' that includes the observations corresponding to the days when new information was learned.<sup>11</sup>

However, the abnormal return for firm  $j$  in this paper is calculated by estimating the following equation for firm  $j$ :

$$\mathbf{r}_j = \alpha_j + \beta_j \mathbf{r}_m + \delta_K \boldsymbol{\mu}_{jK} + \boldsymbol{\varepsilon}_j \quad (2)$$

where

$\mathbf{r}_j$  = the  $T \times 1$  time-series vector of returns to security  $j$ .

$\mathbf{r}_m$  = the  $T \times 1$  time-series vector of realized returns to the market portfolio, in our case the value weighted CRSP index.

$\alpha_j$  = an intercept coefficient.

$\beta_j$  = systematic risk of security  $j$ .

$\boldsymbol{\mu}_{jK}$  = the  $K \times 1$  vector of event parameters multiplying the toxic release variables.

$\delta_K$  = a  $T \times K$  matrix of toxic release variables, with one column for each release of the toxic inventory. Each column contains ones and zeroes to identify time periods in which toxic releases were not announced (zeroes) and the time periods in which the toxic inventories were made public and the corresponding event periods (ones).

$\boldsymbol{\varepsilon}_j$  = a  $T \times 1$  vector of error terms assumed to be serially independent, independent of the market return and toxic release variables, and identically distributed normally.

The estimated coefficient on the toxic release variables represents the abnormal return for firm  $j$  over each event period. Assuming efficient capital markets, an individual abnormal return represents an unbiased estimate of the change in the expected value of future net cash flows to the security.

Under the hypothesis that the toxic release announcements had no impact on the security prices, the toxic release variables parameters are equal to zero. To test the joint impact of the

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<sup>11</sup> The regression run to estimate the abnormal return using the market model is  $R_{it} = \alpha + \beta R_t^m$ , where  $R^m$  is the market return. Abnormal returns are calculated as  $AR_{it} =$

toxic inventory release on the sample of firms, the abnormal returns for all of the  $J$  firms are estimated simultaneously within a system of seemingly unrelated regressions for each event. We consider the following system of equations for the  $J$  firms of the form :

$$\mathbf{R} = \mathbf{X}\Gamma + \mathbf{E} \quad (3)$$

where

$$\mathbf{R} = \begin{bmatrix} \mathbf{r}_1 \\ \cdot \\ \cdot \\ \mathbf{r}_J \end{bmatrix} \quad \mathbf{X} = \begin{bmatrix} \bar{\mathbf{X}} & & \mathbf{0} \\ & \cdot & \\ \mathbf{0} & & \bar{\mathbf{X}} \end{bmatrix} \quad \bar{\mathbf{X}} = [\mathbf{1} \quad \mathbf{r}_m \quad \boldsymbol{\delta}_k]$$

$$\mathbf{E} = \begin{bmatrix} \boldsymbol{\varepsilon}_1 \\ \cdot \\ \cdot \\ \boldsymbol{\varepsilon}_J \end{bmatrix} \quad \Gamma = \begin{bmatrix} \alpha_1 \\ \beta_1 \\ \mu_{1k} \\ \cdot \\ \cdot \\ \alpha_J \\ \beta_J \\ \mu_{Jk} \end{bmatrix}$$

Following Theil ( 1971 ), within this system it is assumed that the disturbances within each equation are independent and identically distributed, but that the contemporaneous disturbances may be correlated across the firms. In addition, the variances are allowed to differ across the firms. The contemporaneous covariance matrix is represented by  $\boldsymbol{\Sigma}_{J \times J}$ . Thus, the error term matrix  $\mathbf{E}$  has covariance matrix of  $\boldsymbol{\Sigma} \otimes \mathbf{I}$ , where  $\mathbf{I}$  is a  $T \times T$  identity matrix.

The estimation procedure follows that of Zellner's ( 1962 ) SUR for the case of identical regressors described by Theil ( 1971, pg 309 ). If  $\boldsymbol{\Sigma}$  is known, the GLS estimate is the maximum likelihood estimate and is BLUE. When  $\boldsymbol{\Sigma}$  is replaced by the OLS residual covariance matrix, the

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$$R_{it} - \hat{R}_{it} = R_{it} - \hat{\alpha} - \hat{\beta} R^m_{it}.$$

joint GLS estimate of  $\Gamma$  is consistent and asymptotically efficient. But, given that we have identical regressors, OLS estimation provides identical parameter estimates to GLS.

Within this framework, we test four hypotheses concerning the  $\mu_{jk}$  parameters. The first is whether the sum, across the firms for all the event periods, of the event parameters for the toxic inventory releases equals zero.

$$H_0: \sum_{k=1}^K \sum_{j=1}^J \mu_{jk} = 0, \quad (4)$$

where  $k$  denotes a release of the toxic inventory and  $j$  denotes a firm. A test of the sum of event parameters across firms is in the spirit of traditional event studies where analysis is performed on the cross sectional sum or average residuals from the unconditional return generating process.

The second hypothesis that we test is whether the sum, across the firms, of the event parameters for a toxic inventory release equals zero.

$$H_0: \sum_{j=1}^J \mu_{jk} = 0, \quad (5)$$

where  $k$  denotes a release of the toxic inventory and  $j$  denotes a firm. The sum of parameters reflects a total, sample wide influence of the regulatory changes, analogous to the portfolio or sample abnormal returns computed in the previous event studies does in this stream.

The third hypothesis that we test is whether the sum, across the releases, of the event parameters for each firm is equals zero.

$$H_0: \sum_{k=1}^K \mu_{jk} = 0, \quad (6)$$

where  $k$  denotes a release of the toxic inventory and  $j$  denotes a firm.

The last hypothesis that we test is whether, for a particular regulatory change all the individual  $\mu_{jk}$  parameters across the sample of firms are equal to zero.

$$H_0: \mu_{jk} = 0 \quad \forall j, k, \quad (7)$$

where  $k$  denotes a release of the toxic inventory and  $j$  denotes a firm.

This test is more likely to reject the null hypothesis of no influence than the tests on the sum of parameters if the toxic release affected only a few firms, or influenced some firms positively and others negatively, or firms had negative returns in a few years and positive in others, thus canceling each other in the sum.<sup>12</sup>

These tests can be written in the form of a linear constraint:

$$\mathbf{a} - \mathbf{A}\boldsymbol{\gamma} = 0 \quad (8)$$

For the first hypothesis ( given by (4) )  $\mathbf{a} = 0$  and  $\mathbf{A}$  is a row vector having  $J \times K$  ones corresponding to the  $J \times K$  estimates of  $\mu_{jk}$  in  $\boldsymbol{\gamma}$ . For the second hypothesis ( given by (5) )  $\mathbf{a} = 0$  and  $\mathbf{A}$  is a row vector having  $J$  ones corresponding to the  $J$  estimates of  $\mu_{jk}$  in  $\boldsymbol{\gamma}$  and zeroes everywhere else. For the third hypothesis ( given by (6) )  $\mathbf{a}$  is a column vector of zeroes of length  $J$  and  $\mathbf{A}$  is a matrix  $J$  rows. Each row of  $\mathbf{A}$  contains  $K$  ones multiplying the  $K$  estimates of  $\mu_{jk}$  in  $\boldsymbol{\gamma}$  and zeroes everywhere else. For the last hypothesis ( given by (7) )  $\mathbf{a}$  is a column vector of zeroes of length  $J$  and  $\mathbf{A}$  is a matrix of  $J$  rows. Each row of  $\mathbf{A}$  contains a single one multiplying an individual  $\mu_{jk}$  and zeroes multiplying the rest of  $\boldsymbol{\gamma}$ .

Since the tests are joint across all the firms, efficient use of the data involves exploiting the cross sectional covariances among of returns across the  $J$  firms as well as the intertemporal correlation of the estimated abnormal returns through the estimated matrix of residuals. The exact quadratic form used to test the null hypothesis is:

$$\{(\mathbf{a} - \mathbf{A}\boldsymbol{\gamma})'[\mathbf{A}(\mathbf{X}'(\boldsymbol{\Sigma}^{-1} \otimes \mathbf{I})\mathbf{X})^{-1}\mathbf{A}']^{-1}(\mathbf{a} - \mathbf{A}\boldsymbol{\gamma}) / \mathbf{e}'(\boldsymbol{\Sigma}^{-1} \otimes \mathbf{I})\mathbf{e}\} \times \{(TJ - S)/q\} \quad (9)$$

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<sup>12</sup> Firms have positive ( negative ) abnormal returns if their pollution levels are lower ( higher ) than public expectation.

Under the null hypothesis, and assuming normality of residuals, the statistic given by (9) is distributed  $F(q, TJ - S)$ , where  $q$  is the number of restrictions,  $T$  is the number of time series observations for each firm,  $J$  is the number of firms and  $S$  is the total number of the regressors in the whole model.

In addition to the above mentioned F test for testing cumulative abnormal returns the testing of significance of the individual firms' abnormal returns was done using the standard t-test for testing significance of coefficients.<sup>13</sup> A non-parametric sign test was also used to test the significance of the cumulative abnormal returns.

The calculation of the sign test statistic requires the knowledge of the number of cases where the abnormal returns are negative,  $x$ , and the total number of cases,  $n$ . The null hypothesis to test negative abnormal returns is  $H_0: p \leq 0.5$  and the alternative is  $H_A: p > 0.5$  where  $p = \text{prob}[\text{Cumulative Abnormal Return} \leq 0]$ . The test statistic  $z$  is given by:

$$z = \frac{x - 0.5n}{0.5 n^{1/2}} \sim N(0,1) \quad (10)$$

This distributional result is asymptotic. For a test of size  $(1 - \alpha)$ , the  $H_0$  is rejected if  $z > \Phi^{-1}(\alpha)$ . A weakness of the sign test is that it may not be well specified if the distribution of abnormal returns is skewed. But we looked at the skewness of the abnormal returns and could conclude the abnormal returns were not skewed. Thus the sign test we are using is well specified.

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<sup>13</sup> The t-test that tests for negative abnormal returns has the null hypothesis as  $H_0: \text{Abnormal Return}_{it} = 0$  and the alternative as  $H_A: \text{Abnormal Return}_{it} < 0$  where  $i$  denotes the firm and  $t$  denotes the year. For the F test the null hypothesis is  $H_0: \text{Cumulative abnormal return} = 0$  and the alternative is  $H_A: \text{Cumulative abnormal return} \neq 0$ .

The determinants of the abnormal returns were estimated using panel data analysis. A firm's equation at a point in time for the random effects panel data analysis model with time specific and firm specific effects can be written as:

$$y_{it} = \mu + \beta'x_{it} + \varepsilon_{it}, \quad i = 1, \dots, N, \quad t = 1, \dots, T, \quad (11)$$

where

$$\varepsilon_{it} = \delta_i + \gamma_t + \eta_{it}, \quad E\delta_i = E\gamma_t = E\eta_{it} = 0, \quad E\delta_i\gamma_t = E\delta_i\eta_{it} = E\gamma_t\eta_{it} = 0,$$

$$\begin{aligned} E\delta_i\delta_j &= \sigma_\delta^2 && \text{if } i = j, \\ &= 0 && \text{if } i \neq j, \end{aligned}$$

$$\begin{aligned} E\gamma_t\gamma_s &= \sigma_\gamma^2 && \text{if } t = s, \\ &= 0 && \text{if } t \neq s, \end{aligned}$$

$$\begin{aligned} E\eta_{it}\eta_{js} &= \sigma_\eta^2 && \text{if } i = j, t = s, \\ &= 0 && \text{otherwise,} \end{aligned}$$

and

$$E(\delta_i x_{it}') = E(\gamma_t x_{it}') = E(\eta_{it} x_{it}') = \mathbf{0}.$$

The classical regression model without time or firm specific effects and the fixed effects models can be written as above after the making the required changes. In case of the classical regression model given that there are no time or firm specific effects and thus  $\delta_i = \gamma_t = 0$ . In case of the fixed effects model with time specific and firm specific effects the effects are incorporated in the intercept term and are not treated as random implying  $\mu = \alpha_i + \lambda_t$  and  $\delta_i = \gamma_t = 0$ .

The efficient estimator for the classical regression model and the fixed effects model is the ordinary least squares estimator. The efficient estimator for the random effects model is feasible generalized least squares estimator. The choice between the fixed effects and the classical regression model is based on the likelihood ratio ( LR ) F test that are used to test for



linear restrictions. The choice between using the classical regression model and the random effects model is based on the Breusch-Pagan ( 1980 ) Lagrangian Multiplier ( LM ) test that tests for heteroscedasticity of the error term. The choice between the fixed effects and random effects model is made using Hausman's ( 1978 ) chi-square specification test. The details of the estimation procedures and the tests are provided in Hsiao ( 1986 ) and Green ( 1993 ).

#### **IV Data Description**

We use four sources of data for our study – the Toxic Release Inventory, the Site Enforcement Tracking System ( SETS )<sup>14</sup>, the Center for Research in Security Prices ( CRSP ) database and the Standard and Poor's COMPUSTAT database.

The Toxic Release Inventory Program ( TRI ) was enacted by the U.S Congress in January 1986 as a part of the Environmental Protection and Community Right to Know Act ( EPCRA ).<sup>15</sup> The TRI provides an annual measure of toxic emissions and wastes generated in the U.S. It is available for EPA and individuals to analyze industries' progress reducing toxic chemical wastes. It is designed to provide information to the public on releases and transfers of toxic substances into the environment. Most of the substances involved are not themselves subject to release standards. The TRI provides information about releases and transfers of toxic

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<sup>14</sup> SETS provides a list of sites of SUPERFUND sites at which a company is listed as a potentially responsible party. The number of SUPERFUND sites for the years 1987-94 will be an indicator of the extent to which investors have prior information about a company's environmental performance.

<sup>15</sup> A toxic gas escaped from a Union Carbide chemical plant in Bhopal, India, in 1984. More than 2,500 people died. A similar incident also occurred in West Virginia. As a result of these and other accidents, more than 30 states now have laws that provide workers and residents with access to information about hazardous substances in their workplaces and communities.

chemicals from manufacturing facilities.<sup>16</sup> The EPA does not use the information contained in the TRI to penalize companies for pollution violations. But the EPA can use the data to verify if releases comply with a company's permits for air, waste and water. The EPA also uses TRI data to track industries' progress reducing toxic chemical releases and wastes. For the companies that do not report toxic releases or fail to report properly the EPA may assess civil penalties for EPCRA Section 313 violations. Any company owner or operator who violates the law is liable for up to \$25,000 a day for each violation. In addition, private citizens may file lawsuits to force a company to obey the law. Facilities must report their releases of a toxic chemical to TRI if they fulfill four criteria:

- 1.They must be a manufacturing facility ( primary SIC code in 20 –39 );
- 2.They must have the equivalent of 10 full-time workers;
- 3.They must either manufacture or process more than 25,000 lbs. of the chemical or use more than 10,000 lbs. during the year;
- 4.The chemical must be on the TRI list of 350 specific toxic chemicals or chemical categories.

Therefore, not all, or even most, pollution is reported in TRI. However, TRI does have certain advantages:

- a. It is multi-media. Facilities must report the amounts they release to air, land, water, and underground separately, and must report how much they send off-site;
- b. All quantities are reported in pounds. This is an advantage compared to databases like PCS, which often report releases as concentrations, or other databases which report releases by volume of waste. These measures are often impossible to convert into pounds;

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<sup>16</sup> Look at the appendix for the TRI definitions of releases and transfers.

c. It is congressionally mandated to be publicly available, by electronic and other means, to everyone. This means that it's relatively easy to obtain TRI data and that the data is well-known, becoming a national "yardstick" for measuring progress in pollution and waste generation.

The TRI data is reported by individual facilities, who send their reports to Federal EPA every year. These reports are filled out on a form called "Form R". EPA takes these forms and converts them into an electronic database. Reporting of emissions or transfers of listed chemicals is accomplished annually with a lag of two years. Thus, the first TRI data released in 1989 reflected releases and transfers in the reporting year 1987.

This information allows businesses and communities to assess progress made at reducing toxic chemical use and production. Investors use TRI as a signal of firm's efficiency in production. A firm having higher emissions per dollar revenue may be wasting resources that end up as pollutants. This may also reflect the fact the firms might have an increased risk of an environmental accident leading to higher expected future costs. They may also be influenced by the fact that high TRI polluters though meeting the legal standards may be targeted by the government for inspections in other areas resulting in higher penalties and increased cost of pollution abatement equipment.

We look only at firms that are traded on the New York or American Stock Exchange that had valid daily returns and value weighted returns, TRI information and firm specific information. The data was created by first looking at the firms in that were used in the study done by Hamilton ( 1995 ). Thus we started out the 436 firms he had in his study as our firm population. These were the firms that has valid stock prices and were not subject to confounding events in the year 1989 when the TRI was made public for the first time. The firms were

matched across the three databases using the stock ticker symbols, CUSIP numbers and Dun and Bradstreet numbers. Since TRI gives pollution at the facility level, the facility level pollution information was aggregated to the parent company level using the Dun and Bradstreet number of the parent company.<sup>17</sup> The data on the returns came for the CRSP database. The share price of the firm as well as the number of shares outstanding for the firm on the day prior to the release of the TRI each year was also obtained from the CRSP data. The firm specific firm characteristics were obtained from the primary file of the Annual COMPUSTAT database. The number of firms with complete data was 165 for the years 1989 to 1995. The analysis will thus be done using a balanced panel of 165 firms. The estimation period for the abnormal returns is the working days starting June 15, 1988 and extending to April 7, 1995. Thus the number of days the returns were observed for each firm was 1724. This resulted in a total of 284,460 observations for estimating the SUR model.<sup>18</sup> The panel data analysis looks at the 165 firms with yearly data for the reporting years 1987–93 for all the variables but the years 1989–95 for the abnormal returns. Therefore the number of observations for conducting the panel data analysis is 1155.

The firms in our sample account for 51% of the total TRI releases, 60% of the total TRI off-site transfers and 53% of the sum of TRI releases and transfers for the reporting year 1988. They also account for 32% of the total TRI releases, 20% of the total TRI off-site transfers and 30% of the sum of TRI releases and transfers for the reporting year 1993. This reflects the fact that publicly traded firms on an average decreased their pollution levels more than their counterpart private firms. Thus, the firms in our sample are very different from the firms in

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<sup>17</sup> The TRI was read off the web page of the RIGHT-TO-KNOW information page maintained by the EPA. The address of the web site is [http://www.rtk.net/tri\\_par.html](http://www.rtk.net/tri_par.html)

<sup>18</sup> Changing the estimation period did not affect the basic results of the paper.

Khanna et al ( 1997 ) which exhibit only a 2.2% decrease in their relative contribution to TRI releases and transfers in the period 1988 – 1992.

## **V Results**

Table 1 presents the descriptive statistics and we see among other things a big fall in the total TRI releases and transfers of the firms in our sample. But there are increases in the total transfers. Total air releases contribute the most to the TRI releases followed by underground injections, land releases and water releases. These sample results correspond to the pattern followed by the firms in the TRI.

Table 2 looks at how our sample of firms compares with the firms in the TRI. We over sample the pollution by the firms that produce transportation equipment. The SIC codes 21, 23, 27 and 31 have no representation in our sample. As with the TRI firms in the chemical industry account for the bulk of the pollution. In our sample firms in the chemical industry account for 47% of the pollution though constituting only 18% of the firms in the sample.

The results that were generated in Table 3 show that the cumulative abnormal returns for all the firms over the whole time span are negative and significant on the day of the release and on the DAY 0 – 1 event period. Thus we can conclude that the release of the TRI for the time period 1989-95 led to a significant negative reaction on the part of the investors. But this effect tends to decrease as we increase the length of the event study. The market punishes the firms immediately but there is little continuity in the market reaction when we look the overall impact of the TRI. The results in this table provide evidence of the overall effectiveness of the TRI and have to our knowledge not been calculated by any other studies. They provide ample support to our hypothesis that TRI has a significant net impact on the value of capital invested in firms.

However, it should be kept in mind that absence of significance of the returns for the Day 0-4 event window does not imply that the stock market did not react to news learned from TRI during this event window. But rather that this news was not significant enough, relative to other new information, to have a predominant impact on the stock market return to the securities. This holds true for the results that are outlined further on in the paper. It should also be kept in mind that though the overall effect may be negative there may be differences in the effect on individual firms at a point in time as well as over the entire time span.

The results generated in Table 4 which looks at the effect of each individual TRI release supports our previous results that there were significant negative effects on the market value of firms. But again the intensity of this effect wears down as we increase the length of the event window. The largest effect was for the DAY 0 event period in the year 1991 with the cumulative abnormal return being  $-0.5569$ . The smallest negative return was for the DAY 0 event period in the year 1992 with the cumulative abnormal return being  $-0.1080$ . 1989 suffers the largest hit for the DAY 0-1 and DAY 0-4 event periods. The abnormal returns are actually positive for the Day 0-4 event period for the years 1992, 1993 and 1995. The cumulative abnormal returns for the sample firms support the results in Hamilton ( 1995 ) and Cohen and Konar ( 1997a ) in terms of the significance of the cumulative abnormal returns. But, they are different from the results in the two papers as the absolute value of our cumulative abnormal returns decreases with an increase in the size of the event window. In contrast to Khanna et al ( 1997 ) we find significant abnormal returns for the year 1989 while the returns are not significant in 1992. In addition, in our paper the negative effect on the firms becomes lower with an increase in the event window whereas the opposite is the case in Khanna et al ( 1997 ). The results in Khanna et al ( 1997 ) may be result of the fact that they are looking at firms that are known to be heavy polluters who do not

decrease their relative pollution levels and thus the market punishes them for longer periods than the firms in our sample.<sup>19</sup>

The conclusion that can be drawn from the above results is that the release of TRI does lead to ‘abnormal’ stock behavior during the event windows for the firms in the sample. This result is also supported by our results in Table 7 where the number of firms with significant negative ( positive ) cumulative abnormal returns for the entire time span for the DAY 0 event period is 31 ( 7 ). The fact that the release of the TRI is the primary cause of the negative abnormal returns and that it comes as unexpected information can be inferred from looking at the cumulative abnormal returns for the trading day prior to the release day. Only for the year 1992 do we get negative and significant cumulative abnormal returns for all the firms on DAY –1 ( Table 4 ).

The results in Table 5 suggest that though the overall effect on the firms in our sample is negative there are a substantial number of firms that are rewarded by the market. The firms that improve their environmental performance could be the ones that are rewarded by the market. We will examine this relationship when we look at the determinants of the abnormal returns. We can also see this from Table 6 where for the year 1995 the number of firms having statistically significant punishments and rewards is the same. This can also be seen from Table 8 where for the years 1991 and 1994 though we found significant negative cumulative abnormal returns ( Table 4 ) the mean dollar value of abnormal losses is actually positive. This could reflect the fact that firms with a higher ( lower ) security price and/or larger ( fewer ) number of shares outstanding are the ones that are being rewarded ( punished ).

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<sup>19</sup> The firms in the chemical industry contributed to 54% of the TRI releases and transfers in 1989. They are the most polluting industry and have contributed to the major proportion of the TRI releases and transfers over the years.

There is no evidence to suggest that repeated provision of information leads to a fall in the effectiveness of information provision as a policy instrument or that new information is not provided by a new release of the TRI. This can be seen from Table 6 where the number of firms with significant abnormal returns was the most in 1994 and there is no drop in the number of firms with significant returns over the whole time period. This evidence can also be gathered from Table 4 where the DAY 0 event period always shows significant abnormal returns except for the year 1992 and the absolute value of the cumulative abnormal returns is the highest in 1994. This evidence supports Khanna et al ( 1997 ) but contradicts Lanoie et.al ( 1997 ) who conclude that successive appearances on the list of Canadian polluters does not provide significant new information and that the information has an once-for-all effect. Thus our results again support the hypothesis that the TRI as a tool for pollution control can be effective as can be seen from the persistent response of the investors.

We look to Table 9 to explain the proximate causes of the abnormal returns. It should be mentioned that PAPER, CHEM, PRIMET, FABMET, TRANS and ELEC are dummy variables that equal 1 if the firms are in the paper, chemicals, primary metals, fabricated metals, transportation equipment manufacturing and electrical equipment manufacturing industry respectively and zero otherwise. These industries are the ones that contribute the most on an average to the releases and transfers in the TRI.

Model I of the Table 9 uses only the pollution variables as the explanatory variables for the abnormal returns. This model was estimated using a random effects model with firm specific constants that are randomly distributed across cross-sectional units and time specific constants that are randomly distributed across the time periods. The model choice was based on the appraisal of the LM, LR and chi-square tests. The model suggests that, without controlling for



industry or firm specific non-pollution variables, there are significant differences in the effect of changes in pollution levels, across the firms as well as across the time periods, on abnormal returns. However, these differences are random and cannot be attributed to any specific firm or time period. In this model increases ( decreases ) in the stack air releases result in significant negative ( positive ) reaction from the market.

Model II introduces the firm specific non-pollution variables into the panel data analysis. The appropriate tests reveal that the appropriate model in this case is the random effects model with just firm specific effects that are randomly distributed across the cross-sectional units. Thus, the addition of the new variables results in the time varying effects going away. This implies that the abnormal returns can be explained by firm specific variables and that there are no time specific effects. This adds value to our argument that there was no decrease in the effectiveness of the TRI over time. The striking feature of this model is the negative relation between the debt equity ratio and the abnormal returns. This is because a higher debt equity ratio implies that the firm is more risky and may not be willing to undertake costly expenditures to prevent pollution in the future. The other firm specific variables like sales and the number of employees are not significant determinants of the market reaction. This result supports Hamilton ( 1995 ) but not Khanna et al ( 1997 ). As hypothesized before an increase in the market value or a proxy of market size of the firm leads to positive though not significant reaction from the market. This could be the case as larger firms are considered financially better off. The financial muscle would enable them to undertake the required investments to tackle the pollution problems. It is also interesting to see that firms with a higher share price are the ones that are affected more by the market reaction while the opposite is true for firms with larger number of shares outstanding.

As observed in the previous model as well increases ( decreases ) in the stack air releases result in significant negative ( positive ) reaction from the market.

The panel data analysis in Table 9 suggests that there are significant industry effects. This can be seen from Model III where firms in industries manufacturing transportation equipment and electronic equipment receive significantly greater negative abnormal returns. Thus, the firms in those industries are penalized more than the firms in other industries. The chemical industry contributes most to the TRI transfers and releases but firms in this industry they are actually rewarded by the market relative to firms in the other industries as the coefficient in the regression is positive though not significant. This result supports the findings of Hamilton ( 1995 ) and Cohen and Konar ( 1997a ) which found that being known as the largest emitters alone does not lead to a negative reaction from the market.<sup>20</sup> The addition of the industry effects leads to the changes in underground injection also becoming a significant explanatory factor along with the stack air emissions. As with stack air emissions increases ( decreases ) in the underground injections result in significant negative ( positive ) reaction from the market. The other results are the similar to those obtained in Model II. This model introduces time invariant regressors in the form of the dummies for the industries and thus cannot be estimated by a fixed effects model. This is because the fixed effects estimator requires that there be within firm variation in all the variables for at least some firms. Given a choice between the classical regression model and the random effects the classical regression model was chosen by using the LM test. This choice corresponds to the choice made by Khanna et al ( 1997 ).

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<sup>20</sup> Results not reported here also suggest that the absolute levels of TRI releases or off-site transfers have no significant effect on the abnormal returns. This result supports the conclusion in Hamilton ( 1995 ) but contradicts that in Lanoie et al ( 1997 ) and Khanna et al ( 1997 ).

The number of superfund sites which provides prior information about the pollution levels of the firms leads to an increase in the abnormal returns though not being significant in any of the models. This implies that firms known as serious polluters are not penalized by the market as the release of the TRI provides little new information about these firms.

Table 10 performs the same analysis as done in Table 9 but it breaks down the analysis by the sectors that are the most polluting. This is important to overcome the multicollinearity that might exist between the industrial sectors and media of releases or off-site transfers. The estimation procedure in all the regressions was chosen after the relevant tests to be the classical regression model. This is as expected as in Model III of Table 9 the classical regression model was the choice once industry effects were also taken into consideration. This adds value to our argument that the effects of the TRI persist over the releases and do not have a tendency to become less effective over time.

The firms in the fabricated metal industry are the ones whose abnormal returns can be best explained. For these firms changes in fugitive air releases have significant negative impact. The higher the price of the shares of a firm in this industry the more noticeable it becomes and is thus penalized significantly by the market. Since this industry has the largest off-site transfers (which includes recycling) it has been significantly rewarded for its efforts to recycle. In this case superfund sites provide prior information to the investors who do not penalize firms with greater number of known superfund sites. These are the firms that the market had punished when their superfund information was made public and the TRI in this case does not provide any new negative information. The same is true for the firms that produce electrical equipment where the coefficient for the superfund variable is positive and significant.

For both the chemical and paper industries, underground injections have a significant negative impact. In addition to this, sales have a significant negative impact on the chemical industries while the number of employees has a significant positive impact. The greater the number of employees the greater is the caution adopted by firms to avoid health damages. This results in the firms with more employees actually being rewarded by the market.

The results of Table 10 are in stark contrast the results the results from Table 9. Apart from underground injections none of the other variables were significant for the pooled regression in Table 9. Also, the variables that are significant in pooled regressions namely stack air pollution and debt equity ratio are not significant at the individual industry level. Thus the effects at the industry level are rather different than the overall effects for the firms in the sample.

The fabricated metal industry is penalized the most for its fugitive air releases, land releases and underground injections, the transportation industry for its stack air releases, and the primary metal industries for its water releases.

Table 11 looks at the \$ value of abnormal returns to see if there were firm specific, time specific or any industry effects. Model 1 and Model 2 were estimated using the fixed effects model with both time specific and firm specific effects. Model 3 was however estimated using the classical regression model. Thus again this choice of estimation method points in the right direction for the long run effectiveness of the TRI as a tool of pollution control.

In Model 2, higher sales lead to a significant negative impact on the value of abnormal returns. In Model 3, stack air releases have a significant negative impact on the value of abnormal returns. A 1000 pound increase in stack air releases leads to a 0.0042 million decrease in the value of the firm. This is similar to what we saw in table 9 where they have a significant

negative impact on abnormal returns. In addition, the number of employees leads to a positive impact. An increase of 1000 employees leads to a 0.41 million increase in the value of abnormal returns. The reason for the positive impact of employees is that firms become more careful about handling their wastes with more employees at work. The more the number of superfund sites, the greater will the clean up cost for a given amount of pollution and thus result in the investors penalizing firms with more superfund sites. An additional superfund site leads to fall in market value by 1.43 million on the average.

Stack air releases lead to the greatest fall in market value, followed by land releases, off-site transfers, underground injections, surface water releases and fugitive air releases ( which have a positive but insignificant impact). Thus firms is they want to minimize the damage from the penalties imposed by the TRI should cut back on stack air pollution. However whether this is the right choice depends on the abatement costs. If the abatement cost are higher than the loss in market value then it would be better to get a negative hit rather than invest in expensive technology to cut back stack air pollution. Since we do not have data about abatement costs all we can conclude is that the abatement costs for decreasing stack air pollution by 1000 pounds should be greater 0.0042 million for the firm not to cut back on its stack air pollution. In case the firms do not contribute to stack air pollution they would have to cut back on their pollution by other media and off-site transfers depending on the relationship between abatement cost and the fall in market value. The coefficients we have in Table 11 will give us the upper limits for the abatement costs beyond which the firms will not cut back on pollution by various media and off-site transfers.

An unit increase in the debt equity ratio leads to a fall in the market value for a firm on the average by 4.53 million after controlling for the level of pollution.

The firms in the transportation industry have a 34.37 loss in market value on the average relative to other industries. The other most polluting industries do not suffer a fall in market value. Thus, being known as the largest polluters need not lead to punishment from the market. For the electrical equipment industry significant lower abnormal returns ( from table 9 ) do not translate to lower market value. This reinforces our view that firms with a greater market value are penalized less or actually rewarded by the market.

Table 12 provides the breakdown of the \$ value of abnormal returns by the most polluting industrial sectors. For the transportation industry surface water releases lead to a significant negative impact with each 1000 additional pounds leading to a 0.65 million decrease in value on an average. Fugitive air releases lead to significant negative impact (0.19 million) for the firms in the electrical industry. Off-site transfers have the opposite effect on the transportation ( negative ) and electrical ( positive ) industry. This could be a reflection of the fact that the electrical industry recycles a lot and is thus rewarded by the market while the transportation sector disposes its waste rather than recycling it. Of course as pointed before this could also be the result of the firms being penalized (rewarded ) in the electrical (transportation) industry have a lower ( higher) market value.

The electrical industry has the largest hit in value due to fugitive air releases, the primary metals industry due to stack air releases and land releases, the transportation industry due to water releases, and the paper industry due to underground injections.

As seen in the case of abnormal returns the industry effects are rather different from the overall effect on the sample. None of the effects that are significant at the sample level are significant at the industry level and vice versa.

## **V Conclusions**

The paper tries to evaluate the effectiveness of the informational strategy to control pollution. This policy involves attempts to increase the availability of information on pollution as its basis for controlling pollution. This paper tests the effectiveness of one such policy pursued by the EPA namely the TRI program. The results show that the TRI has been providing useful information to the investors and its release does provide an incentive for the market to punish the recalcitrant polluters. This effect is best demonstrated by the significant negative effect that the release of each year's TRI has on the market value of firms. But, at the same time there are some environmentally firms that tend to benefit from the release of the information. Thus, the market rewards the good performers though it punishes the bad performers more severely. This conclusion that the TRI has proved to be a successful policy tool attains importance due to the fact that the traditional approaches have proved to be too costly and the market-based approaches have not fully solved the pollution problems. It is also shown that there are differential impacts across the various industries of both the abnormal returns and its dollar value.

But, the results in our paper stand apart from the results in the previous literature because of the fact that we use the SUR model with dummy variables for the event date to generate our abnormal returns. This enables us to simultaneously test significance of the policy tool at the firm and sample level over the entire period unlike the previous studies that conduct the tests only at the sample level and at a point in time. In addition the models used in the previous literature on this subject examine average or cumulative average residuals or forecast errors generated from a fair return-generating model such as the market model. The use of forecast errors as the abnormal returns leads to serial correlation of the abnormal returns. Thus the variances used by the previous studies in testing for the significance of the cumulative abnormal

returns are underestimated. Also, the fact that we have total clustering of event windows leads to correlation of the returns across the securities. This correlation in the disturbance terms of the returns equation arises from the fact that these disturbances include factors that are common to all firms. These common factors could include factors like the general health of the economy as well as factors specific to an industry. This is ignored by the previous literature and thus the distributional results presented for aggregated abnormal returns in those papers are not applicable to the problem in our hands. Therefore our paper, by getting over these problems with the previous approaches, presents much better estimates of the abnormal returns and their significance.

The future research in this field would involve tests to see if the reaction by the market forces the firms to change their pollution patterns in the future. Since TRI releases and transfers have fallen over the years attempts could also be made to look at the distribution of pollution by firms across its facilities as well as the distribution of pollution across firms. These would have to be done to check whether the decreases in pollution levels caused by the market reaction leads to a cost effective allocation of pollution.

**Table 1 : Descriptive Statistics of the Sample Firms <sup>a</sup>**

	<b>1987</b>	<b>1988</b>	<b>1989</b>	<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>
Sales ( in \$ millions )	6196.67 (13282.55)	7088.67 (15405.83)	7487.98 (16053.69)	8038.63 (17107.17)	7918.66 (16691.06)	8176.78 (17483.27)	8313.90 (17860.13)
Employees ( in thousands)	44.47 (85.27)	45.02 (83.27)	45.79 (84.01)	45.34 (83.54)	43.92 (82.58)	42.59 (80.68)	41.39 (78.42)
Price of share :	39.21	38.03	39.86	32.93	39.96	36.09	39.35



Fiscal year – close ( in \$ )	(26.89)	(23.10)	(23.69)	(21.78)	(26.75)	(20.39)	(22.35)
Common Shares Outstanding ( in millions )	92.58 (164.34)	96.57 (163.82)	101.18 (167.02)	114.86 (183.83)	120.89 (192.55)	139.95 (221.34)	143.76 (224.62)
Market value of Stock – fiscal year end ( in \$ millions )	4119.60 (8442.88)	4316.49 (8882.38)	4970.08 (9719.77)	4766.57 (9726.1)	5961.60 (11872.65)	6095.17 (11837.5)	6823.16 (12935.92)
Debt-Equity Ratio	0.48 (0.78)	0.47 (1.69)	0.70 (0.94)	0.68 (0.86)	0.65 (0.74)	0.85 (1.45)	0.73 (1.36)
Fugitive Air Releases *	1483.73 (4296.15)	1482.31 (4189.74)	1368.64 (3968.11)	1157.56 (3444.54)	1057.59 (3376.48)	839.22 (2126.31)	557.18 (1167.49)
Stack Air Releases *	2799.79 (7166.23)	2772.29 (6553.85)	2812.74 (6445.10)	2426.73 (5591.83)	2233.11 (5376.92)	2018.67 (5152.23)	1630.76 (3814.32)
Water Releases *	8898.28 (32728.87)	163.53 (659.29)	163.42 (718.82)	143.59 (577.86)	112.41 (451.86)	106.82 (441.44)	89.09 (366.83)
Land Releases *	1356.68 (6931.47)	1332.33 (7144.99)	844.15 (5416.73)	870.87 (6105.74)	889.87 (6039.59)	705.24 (5239.15)	629.59 (4248.74)
Underground Releases *	12433.62 (121409.86)	3325.88 (27444.38)	3206.70 (26881.29)	1809.41 (14904.08)	1732.11 (15414.33)	1756.99 (16102.85)	1536.89 (13949.08)
Total On-Site Releases *	17695.83 (56419.41)	9076.35 (34529.36)	8395.57 (32925.34)	6408.18 (21431.22)	6025.08 (21769.22)	5426.99 (21755.53)	4443.52 (17570.61)
Total Off-Site Transfers *	4479.95 (10569.14)	3806.49 (11542.37)	2334.04 (6352.95)	1952.07 (5551.37)	4653.14 (10366.11)	5625.70 (13864.04)	5365.09 (13454.97)
Total On-Site Releases and Off-Site Transfers *	22169.36 (63927.22)	12882.85 (41403.82)	10597.69 (37246.86)	8360.24 (25240.18)	10791.32 (29238.25)	11052.69 (30849.02)	9808.61 (26850.28)
Number of Superfund Sites	3.92 (7.26)	4.40 (7.84)	5.36 (9.13)	6.28 (10.75)	6.78 11.47	(7.52) (12.56)	7.87 (13.04)

<sup>a</sup> The numbers in the parenthesis are the Standard Deviations; \* In thousands of pounds.

**Table 2: Distribution of Firms and Pollution across Industries**

Type of Industry	Number of	Total Releases	Total Releases
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	firms in our Sample	and Transfers in our Sample	and Transfers in the TRI data
FOOD	5%	0.39%	1.23%
TOBACCO	0%	0%	0.08%
TEXTILE	1%	0.13%	0.71%
APPAREL	0%	0%	0.03%
LUMBER	1%	0.12%	0.57%
FURNITURE	2%	1.77%	1.04%
PAPER	5%	7.67%	5.09%
PRINT	0%	0%	0.89%
CHEMICAL	18%	46.76%	42.26%
PETROLEUM	3%	2.51%	5.16%
RUBBER	4%	0.85%	2.99%
LEATHER	0%	0%	0.42%
STONE/GLASS	1%	0.34%	0.78%
PRIMARY METALS	6%	13.16%	16.03%
FABRICATED METALS	4%	1.51%	4.35%
INDUSTRIAL EQUIPMENT	15%	1.68%	1.23%
ELECTRICAL EQUIPMENT	14%	4.97%	3.87%
TRANSPORTATION	10%	12.71%	4.36%
WATCH/PHOTO	9%	5.4%	1.01%
MISC INDUSTRIES	1%	0.01%	0.57%

**Table 3**

<b>CUMULATIVE ABNORMAL RETURNS FOR THE SAMPLE FIRMS FOR EACH EVENT PERIOD FROM 1989 - 1995</b>				
	DAY 0	DAY 0 - 1	DAY 0 - 4	DAY -1
Cumulative Abnormal Returns	-2.3494 **/^^	-1.9051 **/^^	-0.1917	-0.5258

\*\*Statistically significant at 5% using the F test, ^^ Statistically significant at 5% using the sign test.

**Table 4**

<b>CUMULATIVE ABNORMAL RETURNS FOR THE SAMPLE FIRMS IN EACH YEAR</b>				
	DAY 0	DAY 0 - 1	DAY 0 - 4	DAY -1
1989	-0.3941 *	-0.3069	-0.2489 *	0.0337
1990	-0.3957 *	-0.1487	-0.0982	-0.1363

1991	-0.5569 **	-0.1698 *	-0.1611 *	0.00649
1992	-0.1080	-0.0537	0.1075	-0.3039 *
1993	-0.2375 **	-0.2903 ***	0.0730	0.1947
1994	-0.5392 **	-0.7275 *	-0.1738	-0.4323
1995	-0.1178 ***	-0.2078 *	0.3099	0.1119

\*Statistically significant at 10% , \*\*Statistically significant at 5% and \*\*\* Statistically significant at 1% using the sign test. None of the above values are significant if we use the F test.

**Table 5**

NUMBER OF FIRMS WITH POSITIVE AND NEGATIVE ABNORMAL RETURNS <sup>a</sup>								
		1989	1990	1991	1992	1993	1994	1995
DAY 1	Negative	102	99	97	87	94	97	91
	Positive	62	66	68	78	71	68	74
DAY 0 – 1	Negative	87	87	92	82	92	102	101
	Positive	78	78	73	83	73	63	64
DAY 0 – 4	Negative	108	88	98	84	79	89	70
	Positive	67	77	67	81	86	76	95
DAY - 1	Negative	91	92	75	100	82	89	79
	Positive	74	73	90	65	83	76	86

<sup>a</sup> The is one firm with a zero value for abnormal returns for the year 1989 for the DAY 0 event window.

**Table 6**

NUMBER OF FIRMS WITH SIGNIFICANT ABNORMAL RETURNS <sup>a</sup>								
		1989	1990	1991	1992	1993	1994	1995
DAY 0	Negative	13	9	16	11	14	27	11
	Positive	8	5	13	11	8	21	11
DAY 0 – 1	Negative	8	6	17	15	10	35	8
	Positive	8	5	16	19	11	15	11
DAY 0 – 4	Negative	11	6	14	14	8	15	7
	Positive	9	4	16	18	9	12	28
DAY - 1	Negative	3	7	15	18	3	13	10
	Positive	6	8	14	15	12	11	13

<sup>a</sup> Significant at the 10% significance level or higher using the t-test for the coefficients in the SUR model.

**Table 7**

<b>NUMBER OF FIRMS WITH SIGNIFICANT CUMULATIVE ABNORMAL RETURNS OVER THE ENTIRE TIME PERIOD <sup>a</sup></b>							
DAY 0		DAY 0 – 1		DAY 0 - 5		DAY - 1	
Negative	Positive	Negative	Positive	Negative	Positive	Negative	Positive
31	7	15	9	13	3	12	8

<sup>a</sup> Significant at the 10% significance level or higher using the sign test.

**Table 8 : Mean \$ Value of Abnormal Returns ( in millions ) <sup>a</sup>**

	All firms	Firms with Negative Returns	Firms with Positive Returns
1989	- 2.7949	-31.3944	43.5088
1990	-0.8445	-38.2972	55.3344
1991	9.4139	-36.0766	74.3048
1992	-4.2096	-83.648	84.3951
1993	-14.5441	-75.6472	66.3528
1994	11.3527	-95.0478	163.1301
1995	-14.1335	-89.3593	78.3738

<sup>a</sup>The dollar value of abnormal return is calculated by multiplying the abnormal return on Day 0 by the price on Day –1 and the number of shares outstanding on Day 0.

**Table 9 : Panel Data Analysis of the Abnormal Returns <sup>a</sup>**

Variable	Model I	MODEL II	MODEL III
Fugitive Air Releases <sup>#</sup>	8.33E-02 (0.1646)	6.35E-02 (0.1637)	7.86E-02 (0.1601)
Stack Air Releases <sup>#</sup>	-0.2743** (0.1571)	-0.2619387** (0.1569)	-0.2245* (0.1518)
Surface Water Releases <sup>#</sup>	3.93E-02 (8.46E-02)	2.36E-02 (8.57E-02)	1.56E-02 (8.29E-02)
Land Releases <sup>#</sup>	5.39E-02 (7.62E-02)	5.55E-02 (7.63E-02)	6.30E-02 (7.44E-02)
Underground Injections <sup>#</sup>	-7.26E-02 (0.1031)	-7.07E-02 (0.1044)	-0.1311* (0.1014)
Off Site Transfers <sup>#</sup>	-4.70E-02 (0.1809)	-4.24E-02 (0.1782)	-3.16E-02 (0.1726)
Superfund Sites	7.85E-02 (0.1302)	9.56E-02 (0.1325)	9.30E-02 (0.1239)
Sales ( in \$ millions )		-3.61E-05 (8.92E-05)	-1.67E-05 (8.23E-05)
Employees ( in thousands )		-1.66E-04 (1.46E-02)	5.90E-03 (1.33E-02)
Debt Equity ratio		-1.0166** (0.4815)	-1.0289** (0.4719)
Price of Share: Fiscal year close ( in \$ )		-2.32E-02 (3.25E-02)	-2.53E-02 (3.13E-02)
Common Shares Outstanding ( in millions )		3.46E-03 (8.08E-03)	2.79E-03 (7.74E-03)
Market value of Stock – fiscal year end ( in \$ millions )		8.49E-05 (1.54E-04)	4.82E-05 (1.48E-04)
PAPER			-1.8540 (2.7107)
CHEM			1.0882 (1.6608)
PRIMET			-1.1806 (2.5237)
FABMET			1.5494 (2.8176)
TRANS			-4.1908** (2.0925)
ELEC			-2.7720* (1.716)
Constant	3.07E-02 (2.5362)	0.9602 (2.5977)	0.5922 (2.5391)
R <sup>2</sup>	0.11	0.13	0.19

<sup>a</sup> The dependent variable in the regressions is the abnormal return on the first day the TRI data was made public multiplied by a 1000 , standard errors in parenthesis; <sup>#</sup> logarithm of pounds ; \*Statistically significant at 10% , \*\*Statistically significant at 5% and \*\*\* Statistically significant at 1%

**TABLE 10 : Abnormal Returns Analysis Across the Most Polluting Industries**

Variable	Paper	Chemical	Primary Metal	Fabricated Metal	Transport	Electrical
Fugitive Air Releases #	1.2856 (3.5547)	-0.3249 (0.5233)	-0.4453 (1.7277)	-11.4326*** (3.7171)	1.9592 (1.8156)	0.6875 (0.4546)
Stack Air Releases #	1.4990 (4.2956)	-0.2752 (0.4802)	-0.2701 (0.5112)	3.0215 (3.3323)	-0.7375 (2.6497)	-0.1781 (0.4638)
Surface Water Releases #	-0.2809 (0.5296)	0.0480 (0.1977)	-0.2965 (0.5377)	0.6447 (0.5041)	-0.0086 (0.3647)	-0.0508 (0.2489)
Land Releases #	0.4379 (0.4202)	0.2613 (0.1628)	-0.1378 (0.3747)	-0.3244 (0.3426)	-0.0465 (0.2848)	-0.2417 (0.2077)
Underground Injections #	-1.2531* (0.6898)	-0.2527* (0.1475)	0.2899 (0.3124)	-3.3903 (2.19)	-0.6469 (0.9458)	-0.4426 (1.5845)
Off Site Transfers #	0.2938 (1.8528)	0.2376 (0.3932)	0.8353 (1.3238)	3.2118*** (0.9926)	-2.0192 (1.7091)	-0.6985 (0.5359)
Superfund Sites	0.3071 (0.8428)	0.1225 (0.4143)	-0.6044 (1.1153)	1.9743* (1.0416)	-1.0002 (0.7449)	0.6442** (0.3164)
Sales ( in \$ millions )	0.0017 (0.0029)	-0.0008* (0.0004)	0.0029 (0.0059)	0.01061 (0.0096)	0.0002 (0.0003)	-0.0009 (0.0011)
Employees ( in thousands )	-0.3649 (0.5368)	0.2391* (0.1305)	-0.2589 (0.8595)	-0.6686 (0.6031)	-0.0253 (0.0386)	0.0731 (0.1032)
Debt Equity ratio	-5.7384 (7.5993)	3.0189 (2.2541)	-1.4036 (2.2999)	-8.1325 (5.2113)	-0.1273 (0.9615)	-1.9544 (1.5349)
Price of Share: Fiscal year close ( in \$ )	-0.3449 (0.3887)	0.0089 (0.0715)	0.1072 (0.2925)	-0.7025* (0.4275)	-0.0591 (0.1415)	-0.0143 (0.0948)
Common Shares Outstanding ( in millions )	-0.0719 (0.2563)	0.0082 (0.0160)	0.0343 (0.1553)	-0.9601 (0.8324)	-0.0033 (0.0388)	0.0188 (0.0330)
Market value of Stock – fiscal year end ( in \$ millions )	0.0022 (0.0047)	-0.0001 (0.0003)	-0.0024 (0.0056)	0.01334 (0.0201)	0.0004 (0.0009)	0.0003 (0.0004)
Constant	-41.592 (65.992)	-2.2285 (5.4749)	-3.7055 (23.499)	71.0116 (43.741)	11.1339 (28.675)	-6.9413 (12.801)
R <sup>2</sup>	0.26	0.06	0.05	0.51	0.05	0.11
N	56	217	70	49	119	154

# logarithm of thousands of pounds; \* = significant at 10%, \*\* = significant at 5%, \*\*\* = significant at 1%

Table 11: Explanation for \$ value of Abnormal Returns

Variable	Model 1	Model 2	Model 3
Fugitive Air Releases #	-0.0020 (0.0052)	-0.0022 (0.0052)	0.0013 (0.0026)
Stack Air Releases #	0.0004 (0.0046)	0.0006 (0.0046)	-0.0042** (0.0021)
Surface Water Releases #	-0.0000 (0.0003)	-0.0000 (0.0003)	-0.0000 (0.0002)
Land Releases #	-0.0024 (0.0040)	-0.0019 (0.0041)	-0.0005 (0.0011)
Underground Injections #	0.0000 (0.0008)	0.0001 (0.0008)	0.0000 (0.0004)
Off Site Transfers #	0.0002 (0.0010)	0.0003 (0.0010)	-0.0004 (0.0007)
Superfund Sites	-3.2926 (2.9318)	-1.1069 (3.0888)	-1.4342** (0.7024)
Sales ( in \$ millions )		-0.0109*** (0.0034)	-0.0004 (0.0007)
Employees ( in thousands )		-0.5832 (0.7320)	0.4099*** (0.1511)
Debt Equity ratio		-2.1779 (6.6971)	-4.5252 (5.2538)
PAPER			11.4386 (32.694)
CHEM			17.2485 (17.969)
PRIMET			15.8855 (29.286)
FABMET			8.7564 (31.164)
TRANS			-34.3703 (22.201)
ELEC			5.8056 (19.278)
Constant	19.85577 (23.445)	115.432*** (42.474)	2.0586 (10.391)
R <sup>2</sup>	0.13	0.14	0.21

# in thousands of pounds; \* = significant at 10%, \*\* = significant at 5%, \*\*\* = significant at 1%

**TABLE 12 : \$ Value of Abnormal Returns Across the Most Polluting Industries**

Variable	Paper	Chemical	Primary Metal	Fabricated Metal	Transport	Electrical
Fugitive Air Releases #	0.0016 (0.0111)	0.0017 (0.0131)	-0.0027 (0.0048)	-0.0019 (0.0089)	-0.0178 (0.0212)	-0.1973** (0.0951)
Stack Air Releases #	0.0028 (0.0024)	0.0015 (0.0068)	-0.0011 (0.0027)	-0.0002 (0.0052)	0.0102 (0.0085)	0.0658 (0.0448)
Surface Water Releases #	-0.0002 (0.0003)	0.0003 (0.0008)	0.0002 (0.0009)	0.0431 (0.0807)	-0.6549*** (0.1926)	-0.1594 (0.2768)
Land Releases #	0.0060 (0.0069)	0.0019 (0.0097)	-0.0000 (0.0002)	0.2082 (0.2049)	0.0250 (0.0161)	0.0066 (0.0640)
Underground Injections #	-0.2976 (0.6202)	-0.0005 (0.0009)	0.0013 (0.0028)	-1052.396 (2478.7)	0.5618 (3.8716)	3943.444 (6332.2)
Off Site Transfers #	0.0008 (0.0023)	0.0004 (0.0021)	0.0000 (0.0002)	-0.0000 (0.0009)	-0.0055** (0.0024)	0.0324*** (0.0124)
Superfund Sites	-1.8053 (3.3726)	-1.5536 (3.0486)	1.4347 (1.1098)	0.6019 (1.8196)	-4.0393 (3.4397)	-6.8201 (5.5715)
Sales ( in \$ millions )	-0.0144 (0.0145)	-0.0142 (0.0105)	-0.0041 (0.0113)	0.0012 (0.0139)	-0.0042 (0.0030)	-0.0203 (0.0169)
Employees ( in thousands )	0.3815 (2.6422)	3.4411 (2.4883)	0.4260 (1.8476)	-0.1734 (1.0863)	0.9735 (0.7104)	5.4335 (3.5739)
Debt Equity ratio	29.3538 (29.702)	-0.5581 (31.076)	2.5785 (3.2816)	1.3139 (5.7258)	2.7495 (8.9999)	-2.2857 (27.557)
Constant	-0.8509 (32.742)	-8.8332 (49.345)	-5.7854 (15.305)	-5.9584 (12.888)	4.7402 (76.922)	-113.7974 (128.11)
R <sup>2</sup>	0.05	0.04	0.05	0.12	0.17	0.08
N	56	217	70	49	119	154

# in thousands of pounds; \* = significant at 10%, \*\* = significant at 5%, \*\*\* = significant at 1%

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