WHY DO FIRMS STRIVE TO BE GREEN?

EXPLAINING THE ADOPTION OF TOTAL QUALITY

ENVIRONMENTAL MANAGEMENT

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Abstract

Many firms are undertaking environmentally friendly organizational change by applying the philosophy of Total Quality Management with its emphasis on reducing waste and increasing efficiency to improve their management of pollution. This paper investigates the factors that lead to total quality environmental management (TQEM) by large firms. We find that internal considerations stemming from a firm's technical capability, size of operations, and volume of past emissions are positively associated with the TQEM adoption decision. The first two factors are proxies for the firm's costs of adopting TQEM while the third factor is related to the benefits from increasing efficiency and waste reduction, and thus proxies for internally generated demand for TQEM. In contrast, external market and regulatory considerations, such as the desire to improve a firm's image with customers and regulators, earning good-will with regulators and the anticipation of future regulations appear not be associated with the adoption of TQEM. All of the external factors are also better thought of as influencing the firm's benefits from (or demand for) TQEM. Thus, the paper's main conclusion is that the adoption of TQEM is driven mostly by supply-side factors, and that to the extent that demand-side factors are important, they too originate internally within the firm rather than externally from the market and government regulation.

1. Introduction

Corporations today are experiencing increased demands for enhanced social responsibility from investors, activists, regulators and consumers. These demands go beyond product quality, which was the focus of the total quality movement of the 1980s, and now encompass other areas, such as, responsible environmental management. Leading corporations in the U.S. are progressively making organizational changes to integrate the environment into their production decisions and are shifting from a regulatory driven, reactive approach to a proactive and beyond-compliance strategy towards environmental management. Surveys show that during the early 1990's senior management began to increasingly view environmental issues as an important component of their strategic decision making rather than as a matter of regulatory compliance only (Lent and Wells, 1994; Newman and Breeden, 1992). Many large corporations publicly adopted the CERES Principles, a ten-point code of corporate environmental conduct as an environmental mission statement.[1] In 2000, over 50 multinationals signed a global compact to refrain from polluting the environment.[2]

This paradigm shift in corporate environmental strategy is reflected in the fairly widespread application of total quality principles to environmental management, referred to as Total Quality Environmental Management (TQEM).[3] A survey of S&P manufacturing firms in 1995 found that 43% of the firms had adopted TQEM (Florida, 1996). Fundamental to the quality management philosophy is the idea of a systems approach to defect prevention instead of defect detection and continuous progress in improving quality in all aspects of production to

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[1] http://www.ceres.org/ceres/

[2] J. Kahn, "Multinationals Sign U.N. Pact on Rights and Environment, New York Times, 27 July, 2000, pg. A3.

[3] The Global Environmental Management Initiative (GEMI), a coalition of firms formed in 1990 is recognized as the creator of TQEM which embodies 4 key principles: customer identification, continuous improvement, doing the job right first time, and a systems approach (http://www.bsdglobal.com/tools/systems_tqem.asp).

exceed consumer expectations. The view that pollution is a defect of the production process and an indicator of waste has led many firms to apply this philosophy to make organizational changes that will enable them to progressively eliminate waste and increase efficiency.

These proactive efforts at environmental management have occurred while consumer demand for environmentally safe products has been growing, environmental regulations have become more stringent and environmental information about firms is increasingly available in the public domain. The decision of a firm to make environmentally friendly organizational changes could be an outcome of the combined influence of (i) external stakeholder pressures from environmentally aware consumers and public interest groups, (ii) regulatory pressures from environmental agencies, (iii) internal factors which depend on the production related benefits and costs of making such organizational changes and the capabilities of firms to make them. TQEM adoption may lead to production-related benefits because it emphasizes a systems-based approach towards environmental management. This approach focuses on process management to reduce input waste, which is seen as the cause of pollution, and input use while increasing productivity and value-added activities. These benefits together with an enhanced potential to respond to external stakeholder and regulatory pressures constitute the gross gains of TQEM adoption. These factors increase the demand for TQEM by a firm. The adoption of TQEM may also impose production-related and managerial costs, due to a need for process and product modifications, employee training and increased coordination across departments. These supply-side considerations may reduce the internal ability of firms to adopt TQEM.

This study uses a sample of S&P 500 firms over the 1994-1996 period to investigate the extent to which these external pressures and internal capabilities explain the adoption of TQEM. Throughout the study, we carefully distinguish between demand and supply related factors to

obtain a better understanding, at the conceptual level, of the sources of environmentally-related organizational change. We further distinguish between the various components of demand-related factors in order to evaluate whether those of internal origin (i.e., production related benefits) are more important than those of external origin (i.e., those related to stakeholder or regulatory pressure).

Several studies have identified the different elements necessary for effective quality management (see survey in Tari and Sabater, 2004) and shown that quality management strategies are not universally suitable for all firms (Sousa, 2003); instead they are contingent on the organizational context. Other studies have sought to examine the motivations for voluntary adoption of environmental management practices by firms, such as an environmentally responsible plan, ISO 14000 and environmental management systems, defined to include a wide range of practices (Henriques and Sadorsky, 1996; Dasgupta et al., 2000; Khanna and Anton, 2002a, b; Anton et al., 2004). The former two studies find that regulatory pressure was the most important factor in motivating firms to adopt environmentally friendly management practices while the latter two studies find that consumer contact, the threat of liabilities, and the volume of emissions were important in motivating the adoption of environmental management systems. These findings suggest that the motivating factors differ across different types of practices. In contrast to the studies listed above, this paper focuses on TQEM, the most sweeping and costly organizational change related to the environmental performance and one that is at the heart of most environmental management systems. Thus, our paper provides insights on the factors driving environmentally friendly organizational change at the very core level.

3. Conceptual Framework, Data, and Variable Construction

The sample is drawn from 254 firms belonging to the S&P 500 that reported their toxic releases to the Toxics Release Inventory (TRI) at least once over the periods 1989-1991 and 1994-1996. Of these, 184 firms responded to the Investor Research Responsibility Center (IRRC) survey on TQEM adoption at least once over the period 1994-96. To exploit the panel nature of our data by estimating a random-effects probit model, we restricted our sample to the 169 firms that responded at least twice to the IRRC survey. This led to a sample of 474 firms. Firms with missing financial data in the Research Insight Database were dropped. The final sample with complete data consisted of 448 observations. The dependent variable takes the value of 1 if the firm has an active TQEM program during that year, and 0 otherwise. About two-thirds (67.6%) of the observations have active TQEM programs.

With regards to the explanatory variables, we partition them into factors that affect the firm's benefits from TQEM, or demand side factors, and into those that affect the firm's costs of adopting TQEM, or supply-side factors. Demand side factors can be further distinguished into those that are originating externally to the firm, either from the market or from government regulation, and those that are originating internally within the firm and reflect the value of such organizational change in terms of production cost reductions. The supply side factors we consider are proxied by internal firm characteristics. In the remainder of this section, we delineate the set of factors that we consider at the conceptual level and describe the measures we use and the source of the relevant data.

We start by the description of the proxies for demand side, externally-driven, factors. Pressures originating from the market are being facilitated by increasing availability of information about corporate environmental practices and performance through several sources

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and this enables consumers to alter their purchasing decisions, thereby signaling their preferences to corporations.[4] For example, J. D. Powers provides consumer-oriented ratings on products based on corporate performance. Quality in manufacturing and service delivery is also recognized through the Malcolm Baldridge Awards and Total Responsibility Management is recognized through the Corporate Conscience Awards given by Social Accountability International (Waddock et al., 2002). To the extent that the adoption of TQEM contributes to an overall strategy of quality management or is otherwise directly observable by the public, firms that are final good producers and thus more visible to the public, have greater incentives to adopt TQEM. Thus, we construct, based on the firm's four-digit SIC code, the variable *Final Good*, which is equal to 1 for firms that produce final goods and 0 for those that produce intermediate goods.[5]

Firms may also adopt TQEM to signal to regulators that they are making good faith efforts to improve their environmental performance. This may deflect enforcement activity away from such firms, serve to preempt stringent regulations in the future and possibly lower the costs of anticipated compliance by mitigating environmental problems ahead of time. We proxy regulatory enforcement pressure by the variable *Inspections* defined as the number of times a firm was inspected by state and federal environmental agencies to monitor compliance with mandatory regulations. We also include *Civil Penalties* received for noncompliance with

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[4] Several consumer surveys indicate that consumers are more likely to purchase products from companies they perceive as acting responsible (Waddock et al., 2002). The percentage of consumers who bought at least one product that was advertised as "environmentally safe" grew from 22% in 1993 to 52% in 1999 in the US (http://www.commercialdiplomacy.org/ma projects/jahnke.html).

[5] SICs categorized as final goods: 2000, 2030, 2040, 2060, 2080, 2082, 2085, 2090, 2111, 2250, 2253, 2511, 2531, 2621, 2731, 2750, 2771, 2820, 2834, 2840, 2842, 2844, 2851, 2870, 2911, 3011, 3089, 3420, 3430, 3523, 3570, 3571, 3577, 3579, 3630, 3640, 3651, 3661, 3711, 3721, 3841, 3842, 3845, 3861, 3911, 3942, 3944, 3949, 4100, 4813, 4833, 4922, 4953, 5000, 5013, 5094, 5110, 5141, 5160, 5172, 5200, 5331, 5411, 5651, 5661, 5731, 5990, 6159,6331, 7011, 7200, 7370, 7372, 7373, 7510, 8721, 9997.

environmental statutes, such as the Clean Air Act, the Clean Water Act, Toxic Substances Control Act and the Resource Conservation and Recovery Act. Firms with a higher frequency of past inspections and civil penalties may have greater incentives to earn regulator good-will and reduce compliance costs by adopting TQEM. We use as a proxy for environmental liabilities the *Number of Superfund Sites* for which a firm has been listed as a potentially responsible party under the provisions of the Comprehensive Environmental Response, Compensation and Liability Act. This data is obtained from USEPA databases.[6] As a proxy for the anticipated stringency of regulation, we include the volume of *Hazardous Air Pollutants* (HAP) consisting of 189 toxic chemicals listed in Title III of the 1990 Clean Air Act Amendments. These were to be regulated under New Emissions Standards for HAP starting in 2000. We expect that firms with a larger volume of HAP face a greater threat of anticipated HAP regulations. This data is obtained from the TRI which contains facility-level information on releases of chemical-specific toxic pollutants.[7]

We now turn to the discussion of internally-driven demand-side variables, i.e., to variables that proxy for the benefits of TQEM adoption that are driven by considerations internal to the firm. TQEM adoption may yield a competitive advantage through more efficient production processes that generate less pollution. Large toxic releases may signal greater waste

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[6] The Integrated Data for Enforcement Analysis (IDEA) database and Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) of the USEPA provide this data at a sub-facility level or facility level. These were aggregated to get parent company level data.

[7] To match the TRI dataset with the IRRC, unique parent company identifiers used in IRRC are constructed for each facility in the TRI database, and then all chemical and facility level data are aggregated to obtain parent company level data. To match the facilities with their parent companies, the Dun and Bradstreet number is used, in addition, to facility name, location, and SIC code. The ticker symbol, which identifies the parent companies in the Research Insight database is used to match the IRRC data with financial data from Research Insight. Since some parent company names have changed over our study period, Market Insight, a database tool linked with Research Insight was used to trace the parent company's history. The historical information included mergers, acquisitions, changes in names, SIC codes and ticker symbols. The chemicals which have been added or deleted over the period 1989-1996 were dropped due to changes in the reporting requirements by the USEPA to ensure that the change in toxic releases in our sample over time is not due to differences in the chemicals that were required to be reported.

and inefficiency in the use of inputs and their reduction through TQEM is likely to improve firm performance. As our sole proxy for these effects, we use the total volume of a firm's *Toxic Releases*, which we also obtain from the TRI. We should note, however, that with the passage of the Community Right to Know Act in 1986, all manufacturing facilities reports to the TRI are made publicly available. Firms with large toxic releases are likely to be subjected to greater adverse publicity from environmental activists and community groups. Therefore, the volume of toxic releases might also be associated with market pressure. If that were the case, then we would expect that *Toxic Releases* would be a better predictor of TQEM adoption for final goods producers. As we discuss in the results section below, we examine this possibility by looking at the coefficient of the interaction of toxic releases and the final good dummy, and find evidence against it. Thus, the volume of emissions is better thought of as an internal demand-side proxy rather than an external demand-side proxy.

Finally, we discuss factors that are likely to affect the cost of adopting TQEM, i.e., the supply-side variables. Quality management requires sweeping reforms in core organizational features, a capacity to commit, and an innovative, forward looking leadership that is receptive to the frequent changes in products and processes required to achieve continuous improvement (see Powell, 1995). It is therefore not easily imitable and requires firm-specific internal expertise in the form of human capital, R&D capability and other resources. Surveys suggest that firms that are more innovative in general are more likely to adopt TQEM (Florida, 1996). Such firms are already engaged in improving production systems and products and are likely to be more forward looking, resourceful and capable of undertaking organizational change and absorbing associated costs.[8] We proxy innovative capacity by a firm's *R&D Intensity* (measured by the ratio of R&D

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[8] Cohen and Levinthal (1989) assert that R&D benefits firms in two ways: it increases innovative activity within a firm and it increases a firm's capacity to absorb or make productive use of externally available technical knowledge.

expenditures per unit sales). Additionally, larger firms may have a greater capacity to bear the fixed costs of adopting TQEM. We measure size by the volume of *Sales* of a firm. We should also note that external pressures are likely to be greater on larger and more visible firms who are more vulnerable to the negative impacts of a tarnished image and face higher costs due to any inefficiency. However, we examine this possibility using the same approach as with *Toxic Releases*, and find evidence against it (in fact the interaction between *Sales* and *Final Good* is generally not statistically significant and always comes out with the "wrong" sign). Thus, firm size is better thought of as a supply-side proxy.

Data on a firm's *Sales* and its *R&D Intensity* are obtained from the Research Insight database.[9] Two other variables, *Age of Assets* and *Number of Facilities* reporting to TRI are also included to capture internal incentives to adopt TQEM. Age of assets is measured by the ratio of total assets to gross assets and ranges between 0 and 1, with larger values indicating younger, less depreciated assets. The older a firm's equipment, the less costly it is to replace, and the easier it is for firms to adopt new technologies or new systems that constitute TQEM. Older equipment may also be less efficient and more polluting creating a greater need for a firm to adopt a systems approach to environmental management. A larger number of facilities reporting to TRI may imply greater benefits from adopting a systems approach to environmental management at the parent company level, especially if firm-wide coordination is important. On the other hand, firms with more facilities may find it more difficult and costly to monitor and implement a firm-wide organizational change. Thus, the number of facilities is a potentially important supply-side variable, albeit one with an indeterminate sign on a priori grounds. Data on facilities of each parent company is obtained from the TRI. All explanatory variables, except

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[9] The variable *Sales* corresponds to the net sales as reported by Research Insight, while *R&D Intensity* is equal to the ratio of R&D expenditure over net sales.

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for the number of facilities are 5-year lagged values to avoid possible endogeneity bias because the year that a firm first adopts TQEM is not known and could have occurred any time in the recent past.

A description and classification of the variables into one of conceptual categories discussed earlier, along with their summary statistics by TQEM adoption status, is reported in Table 1. It can readily seen that TQEM adopters have substantially higher levels of all variables related to regulatory interaction and pressure. They are also firms with a larger volume of toxic releases and larger in size. Differences in the other variables are relatively smaller. However, many of these measures are correlated with each other. For example, firms with greater regulatory interaction are also firms with a large volume of toxic releases (and are larger in size, too). Therefore, in order to reach any conclusions as to effect of each of these factors on TQEM adoption, one needs to isolate the partial effect of each one of them, which we do below.

4. Results

Before we proceed to a detailed description of the probit estimation results, reported in Table 2, a discussion of two issues is warranted. The first issue involves the choice of specification. A comparison of the standard deviations with the means of the variables and an inspection of the associated (but omitted) histograms shows that all variables, except *AGE*, are non-negative and highly skewed with a long right tail. Moreover, the explanatory variables are also likely to have diminishing marginal impact on the propensity to adopt *TQEM*. Therefore, we use as regressors two standard concave transformations of the independent variables (the square root of the variable and log of the variable plus 1). As discussed below, model selection between

these two transformations and the untransformed model is based on the use of the likelihood as a measure of goodness of fit.

The second issue involves the calculation of the standard errors. The panel data nature of our sample suggests that the standard assumption of i.i.d. disturbances in the latent variable equation may not hold. Rather, disturbances of the same firm may be correlated over time. For this reason, we calculate and report both the standard errors under the i.i.d assumption and the robust standard errors that allow for within firm disturbance correlation across time (non-spherical disturbances do not affect the consistency of the parameter estimates, but only that of the standard errors). The robust standard errors are generally higher than those that assume spherical disturbances. We have also calculated bootstrap standard errors by re-sampling with replacement entire firm histories. The standard errors using this (rather conservative) re-sampling scheme are broadly similar to the robust standard errors and are not reported. We have also estimated random effects probit models that explicitly incorporate disturbance correlation across time for each firm. This estimation procedure involves numerical integration with numerical accuracy that is low for high values of inter-temporal correlation. Standard tests of numerical precision indicate that the parameter estimates are not precise even to one significant digit (though these "pseudo-estimates" are often statistically significant as reported by the econometric software). Given that the problem is lack of numerical precision rather than statistical significance, these results are not interpretable or reportable.

Model I of Table 2 reports the results using the untransformed variables as regressors. Statistical significance is generally low, especially when using robust standard errors: two of the ten explanatory variables, *Toxic Releases* and *Number of Facilities*, are statistically significant and the others are not. As discussed above, we suspect that the low explanatory power of this

specification is to a large extent due to the presence of diminishing marginal effects of the impact of many explanatory variables on the latent variable and to the skewness in the distribution of the explanatory variables. Model II uses the square root of the variables as regressors. The value of the log-likelihood for this model is substantially higher than that of the linear model, using the log-likelihood test statistic as a benchmark for comparison.[10] A firm's *R&D Intensity*, *Toxic Releases* and *Sales* are strongly significant when i.i.d. disturbances are assumed, but *Sales* is no longer significant (barely missing the 10% level) when robust standard errors are used.

Given that none of the market and regulatory pressure attributes and *Age of Assets* are significant either in Model I or Model II, we estimated a parsimonious version of Model II after dropping these variables. The elimination of extraneous variables from a regression model generally increases the precision of the estimates, especially when the number of observations is small and the model is a discrete choice model. Indeed, under this parsimonious specification (Model III), *R&D intensity*, *Toxic Releases* and *Sales* are all statistically significant under both i.i.d. and robust standard errors.[11]

For the purpose of sensitivity analysis, we have re-estimated Models II and III using the log of the variables plus 1 (we add 1 to the variables since many variables take the value of zero in some observations). The likelihood of each of these log-transformed models is lower than those of the corresponding square root transformed models, but substantially higher than the corresponding untransformed models. We report under Model IV the results of the parsimonious

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[10]   Had 0.5 been the likelihood maximizing degree of concavity-inducing transformation of the variables, the log-likelihood ratio test would have easily rejected the null of untransformed variables at the 1% significance level (or lower!). Of course, 0.5 is not the likelihood maximizing exponent, which means that the above test is actually conservative. Because we do not estimate the likelihood maximizing exponent of the variables, we treat the square-root transformation as part of the specification when calculating the standard errors, i.e., the standard errors are conditional on the exponent being equal to 0.5.

[11]   One may have been concerned that the lack of significance in the regulatory variables in Models I and II is due to the positive correlation between them (correlation coefficients are of the order of 0.4). We have estimated models

log-transformed model: These are similar to those of Model III in that *Toxic Releases* and *Sales* are significantly associated with TQEM adoption while the *Number of Facilities* of the firm is not, but differ in that the significance of *R&D Intensity* is weaker under the log specification (it is significant when using the spherical disturbances but marginally fails to meet the 10% significance level when using the robust standard errors). Nevertheless, the square root transformation appears more appropriate than the log of the variable-plus-1 transformation as the log-likelihood of Model III is higher than that of Model IV. In fact, the square root transformation yields higher values of the log-likelihood than the log of the variable-plus-1 transformation for all of the models and their variants.[12]

Finally, we investigated whether the level of toxic emissions is not only a measure of internal demand for TQEM, intended to reduce the cost disposal and increase the efficiency of operations, but is also a proxy of external pressure (as larger polluters may attract more bad publicity). Given that this external pressure would have been stronger for firms that sell directly to consumers, as it would directly impact the demand for their products, we added an interaction between the final good dummy and the level of toxic releases in Model III (the statistically stronger specification). The interaction was not statistically significant (see Model V). All other results were unaffected. The interaction remained not significant if the final goods dummy was also added to this model, and the results are robust to whether one uses levels or logs of the regressors. Therefore, toxic emissions are better thought of as being a proxy for internally generated demand for TQEM rather than as a proxy for market driven pressure. We performed a

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that are intermediate to the full and parsimonious models in which we added only two (at a time) regulatory variables to the parsimonious model. In these variants, the regulatory variables remain not statistically significant.
[12] The use of the log-likelihood as a model selection criterion is appropriate as the dependent variable and regressor sets are the same and the selection is over Box-Cox type transformations of the regressor variables.

similar test for the variable *Sales* and reached the same conclusion (in fact, the interaction of *Sales* with the final dummy was negative, though not statistically significant).

5. Discussion and Conclusions

What drives firms to adopt a pro-active environmentally-friendly management system? Our analysis shows is that internal factors are paramount while external (stakeholder or regulatory) considerations are less, if at all, important. In particular, three variables associated with internal considerations, two of these impacting a firm's costs of undertaking organizational change and one affecting the internal benefits (or demand) for such change, are strongly statistically significant across models. On the supply side, we find that larger firms are more likely to adopt TQEM, possibly because of their greater ability and experience in instituting complex organizational changes. We also find that *R&D Intensity* is a second predictor of TQEM adoption, likely because a management initiative such as TQEM requires sufficient technical capacity for successful implementation. This result is consistent with Florida (1996) who finds that firms with higher R&D in manufacturing are also more likely to be innovative in environmental management. On the benefit or demand side, it is our most robust finding that firms with a high volume of *Toxic Releases* have a higher propensity to adopt TQEM as part of their organizational structure. Though a high volume of emissions may also be associated with pressure from consumers or with regulatory concerns, given the general absence of significance of the purely market pressure or regulatory variables, *Toxic Releases* probably reflect more internal considerations. This assessment is further buttressed by our statistical analysis in the preceding section, in which we report that in all specifications, the t-statistic of the interaction between the final good dummy and *Toxic Releases* is well below 1. Therefore, *Toxic Releases*

largely reflects internal considerations: when firms have a large volume of emissions to dispose, they have greater incentives to find ways to significantly reduce waste in production generation, disposal costs, and future liabilities.

All models estimated here consistently show that market pressures towards final good producers did not significantly motivate the adoption of TQEM. This result differs from those obtained by previous studies which find that final good producers were more likely to participate in voluntary programs established by the US Environmental Protection Agency (USEPA), such as the 33/50 Program (Khanna and Damon, 1999), Green Lights and WasteWise (Videras and Alberini, 2000) and to adopt a larger number of environmentally friendly practices (Khanna and Anton, 2002a).[13] One reason for the stronger incentives for final good producers in previous studies could be that they were examining corporate environmental behavior that would receive considerable public recognition. USEPA programs and Responsible Care published newsletters with the names of participants while environmental management practices such as issuing environmental reports, having environmental policies and internal standards could lead to positive publicity for firms. TQEM, on the other hand, may not directly be visible to the general public, but rather may contribute to overall higher quality management rankings only indirectly.

An equally important contribution of this paper is our finding that the potential cost of compliance with regulation is not a significant determinant of TQEM adoption. While the insignificance of all the cost of compliance variables seems surprising, it may provide support for findings obtained by Lent and Wells (1994) on the trend and pattern of investment in environmental management by firms. It may be the case that among the firms used in this study,

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[13] Anton, Deltas and Khanna (2004) find that the link between final good producers and the adoption of environmentally friendly practices is significantly larger for smaller toxic polluters who would otherwise have had weaker incentives to adopt such practices. More broadly, King and Lenox (2000) find that firms that were more visible or concerned about public image were also found to be more likely to join Responsible Care.

the absence of a significant effect of regulatory compliance cost is a manifestation of a shift in investment priorities from remediation and regulatory compliance towards investments that will both reduce pollution and increase competitive advantage.

To summarize, the adoption of TQEM by S&P 500 firms depends on both the benefits and costs of undergoing such organizational change. However, the benefits appear not to be derived externally, either through the product market or though the interaction with regulators. Rather, they are derived from cost savings from the firm's operations, i.e., they are internally generated. The costs of organizational change are also internally determined. Thus, the adoption of TQEM appears to be primarily determined by factors that originate within the organization.

Table 1. Summary Statistics.

	VARIABLES [a]	All Firms				TQEM Adopters		TQEM non-Adopters	
		mean	standard dev.	min. value	max. value	mean	standard dev.	mean	standard dev.
Demand Side Factors	*Dependent Variable*								
	TQEM	0.676	0.468	0	1	1	0	0	0
	Market Pressure								
	Final Good Industry (as classified in the text)	0.574	0.495	0	1	0.591	0.492	0.538	0.500
	Regulatory Pressure								
	Superfund (number of sites)	49.27	149.93	0	1361	60.52	176.07	25.77	62.80
	Releases of Hazardous Air Pollutants (in million pounds)	2.849	6.704	0	57.971	3.398	7.553	1.700	4.234
	Number of Penalties	0.833	1.814	0	13	0.970	1.979	0.549	1.369
	Number of Inspections	51.87	91.114	0	663	60.74	103.13	33.33	54.33
	Internal Demand-Side Factors								
	Toxic Releases (TRI emissions in million pounds)	13.737	41.100	0	382.882	17.508	48.080	5.857	17.412
Supply Side Factors	*Internal Supply-Side Factors*								
	R&D Intensity (ratio of R&D expenditure over sales)	0.0310	0.0378	0	0.1891	0.0333	0.0371	0.0260	0.0390
	Age of Assets (ratio of total assets over gross assets)	0.766	0.0976	0.466	0.951	0.759	0.0971	0.781	0.0973
	Sales (in billions of dollars)	10.843	18.053	0.163	124.994	12.886	19.935	6.575	12.290
	Number of facilities	16.52	20.47	0	111	16.43	19.53	16.71	22.39

[a] All variables, other than Number of Facilities are 5-year lagged values.
The sample size is equal to 448 observations. The number of TQEM adopters is equal to 303 and the number of TQEM non-adopters is equal to 145.

Table 2. Probit Estimation Results of TQEM Adoption.

	VARIABLES	MODEL I (levels of variables) [a]	MODEL II (square root of variables) [a]	MODEL III (square root of variables, smaller model) [a]	MODEL IV (natural log of variables, smaller model) [a]	MODEL V (square root of variables, final/TRI interaction) [a]
	Constant	0.83 (0.56) (0.82)	0.43 (1.15) (1.58)	-0.29 (0.18)* (0.27)	-0.34 (0.20)* (0.30)	-0.28 (0.18) (0.27)
Demand Side Factors	*Market Pressure* Final good	0.15 (0.15) (0.23)	0.13 (0.16) (0.24)	---	---	---
	Final good * Toxic Releases	---	---	---	---	0.034 (0.054) (0.079)
	Regulatory Pressure Superfund	0.00055 (0.00090) (0.00121)	0.017 (0.020) (0.031)	---	---	---
	Releases of Hazardous Air Pollutants	0.0059 (0.0160) (0.0157)	-0.031 (0.099) (0.113)	---	---	---
	Number of Penalties	0.041 (0.061) (0.064)	0.025 (0.123) (0.128)	---	---	---
	Number of Inspections	0.0018 (0.0016) (0.0024)	0.023 (0.030) (0.043)	---	---	---
	Internal Demand-Side Factors Toxic Releases	0.0059 (0.0038) (0.0033)*	0.096 (0.049)** (0.045)**	0.117 (0.038)*** (0.046)***	0.199 (0.064)*** (0.089)**	0.107 (0.038)*** (0.050)**
Supply Side Factors	*Internal Supply-Side Factors* R&D Intensity	2.77 (1.74) (2.50)	2.00 (0.63)*** (0.94)**	2.00 (0.62)*** (0.93)**	3.87 (1.89)** (2.68)	1.97 (0.62)*** (0.94)**
	Age of Assets	-0.85 (0.75) (1.11)	-0.88 (1.33) (1.86)	---	---	---
	Sales	0.0113 (0.0056)** (0.0101)	0.145 (0.051)*** (0.092)	0.180 (0.044)*** (0.084)**	0.356 (0.075)*** (0.126)***	0.172 (0.046)*** (0.088)**
	Number of facilities	-0.0115 (0.0048)** (0.0067)*	-0.078 (0.048) (0.071)	-0.061 (0.036)* (0.053)	-0.088 (0.074) (0.113)	-0.058 (0.036) (-0.058)
	Log-likelihood	-262.90	-254.79	-256.27	-257.89	-256.07

[a] Values in parentheses are standard errors. The first standard error assumes the disturbance term in the latent variable equation is i.i.d., while the second allows for correlation in the disturbance term across time for each firm.
* Significant at 10%, ** Significant at 5%, *** Significant at 1%. Sample size is equal to 448 observations.

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