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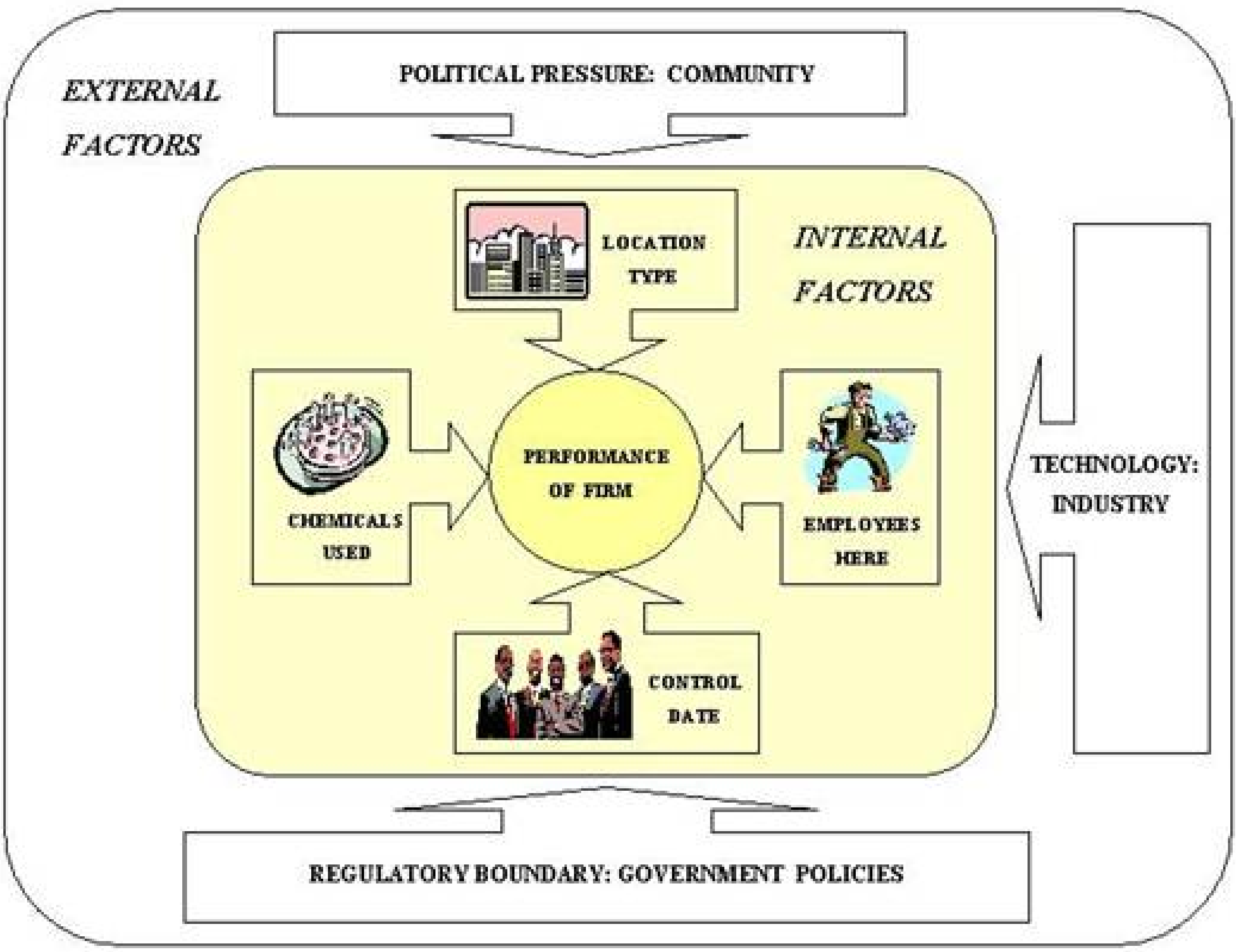
Explanatory Factors For Eco-efficient Behavior of Firms



Seong-Jai Kim

Ph.D. student, Rutgers University

Content

Potential Factors for Eco-efficient Behavior of Firms

I. Introduction

1. Role of Firms in Industrial Ecology

For ages, the society has assumed that chemicals are ¡°safe until proven dangerous,¡± because the basic and adequate information on toxicity and exposures does not exist for the vast majority of chemicals in commerce. It still seems difficult to prove that chemicals used in production processes pose an unreasonable risk to human and the environment (INFORM 1997, 6-7).

Today, we become more and more aware of the environmental unsustainability of the firms¡¯ activities, owing to the scarcity of endowed resources and the remarkable growth of natural resource extraction (Noci and Verganti 1999, 3). Furthermore, the industrial ecology community views our traditional approaches of command-and-control regulation as importantly inefficient and, at times, as counterproductive (Lifset and Graedel 2002, 8). The costs associated with environmental management and, in particular, with the consumption of natural resources and the disposal of waste are continuously increasing (Noci and Verganti 1999, 3-5).

In this respect, business is required to play a special role in industrial ecology (IE). As a locus of technological innovation, business is an important agent for accomplishing environmental goals. Business tries to develop technological innovations aimed at improving the environmental performance of their production processes. This heightened role for business as a positive agent is an active topic of investigation in IE (Lifset and Graedel 2002, 8).

2. Eco-efficiency at the Firm Level

For the environment, the reduction of the absolute impacts through material flows is essential (Bringezu and Moriguchi 2002, 80). Moving from the linear materials flows to cyclic materials flows of ecosystem entails not only closing loops, but using fewer resources to accomplish tasks at all levels of society. (Lifset and Graedel 2002, 8-9).

The quantity of human-induced material flows through the industrial system must be adjusted to adequate levels of sustainable exchange between the economy and the environment (Bringezu and Moriguchi 2002, 79-80). Reducing resource consumption and environmental releases thus translate into a cluster of related concepts: dematerialization and eco-efficiency (Lifset and Graedel 2002, 8-9). The concept of dematerialization refers to the decline of material use per unit of service output, and becomes an important factor in making industrial societies environmentally sustainable (De Bruyn 2002, 209).

Eco-efficiency combines the essential ingredients – economic and environmental improvements – which are necessary for economic prosperity to increase with more efficient use of resources and the prevention of emissions (Verfaillie and Bidwell 2000, 2; UNEP 1998). In cases, eco-efficiency is expressed in the form of a ratio: ¡°output divided by environmental resources (or environmental impact)¡± (Lifset and Graedel 2002, 9), and thus can be a proxy to measure the environmental soundness and sustainability of a firm¡¯ behavior as an important agent in IE.

The concept of eco-efficiency is expected to become a key driver at the firm level, because it helps firms to understand that they can produce better goods and services while using fewer resources and generating less impact, thereby improving both their environmental performance (UNEP 1998). In reality, an increasing number of companies are considering eco-efficiency and environmental issues as a major source of strategic change and competitive advantage (Noci and Verganti 1999, 3-5).

3. Behavior of Firms as an Agent

The special interest of this study is what motivates individual firms and makes them more environmentally friendly and eco-efficient. Of valuable disciplines to explain behavior of firm, economics has been used dominantly in formal systems modeling. Reliance on economics is appropriate where it is reasonable to view decision making as conducted by rational actors, who are well-informed and functioning in an efficient marketplace (Fischhoff and Small 2000, 4).

In reality, rational agents are an ideal type. There are a variety of approaches that attempt, each in its own way, to supplement or move beyond the traditional assumption of rational agent. As one of these disaggregate approaches, agent-based model argues that individual agents have rules of behavior and are explicitly represented. In this approach, no assumptions concerning the attainment of equilibrium are necessary (Axtell 2000, 3-4; Axtell et al. 2002, 10-11).

The typical phenomena studied in IE originate in economic externalities and the departures from socially optimal behavior due to distorted prices, incomplete markets, and imperfect regulations. In this respect, the general problem of agency – the behavior of individuals in the face of imperfect incentives – lies at the core of IE. Agent-based modeling has the potential to provide new insights in treating the incentives that face behaviorally realistic agents, such as firms and consumers, in empirically credible environments (Axtell et al. 2002, 10-11).

Agent-based modeling encourages sophisticated research on behavior of firms, based on both the data of the real world and the advanced computing technologies. Inspired by implications of agent-based modeling, we investigate the actual factors to explain the environmental performance of firms in the state of New Jersey, which adopted pioneering environmental policies earlier than other states. Focusing on the aspects of eco-efficiency, this paper analyzes the determinants of environmental behavior of firms in New Jersey, which annually report their environmental performance to the New Jersey Department of Environmental Protection (NJDEP).

II. Measuring Eco-efficiency and the Data Used

1. Measuring Eco-efficiency

Eco-efficiency is defined as being ¡°achieved by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle, to a level at least in line with the Earth¡¯s estimated carrying capacity.¡± Based on this definition, the World Business Council for Sustainable Development (WBCSD), by whom the concept of eco-efficiency was developed in 1992, identifies the four aspects of eco-efficiency that make it an indispensable strategic element in today¡¯s economy (WBCSD 2001, 5):

> *Dematerialization*: Today¡¯s companies are developing ways of substituting knowledge flows for material flows. One desirable route to dematerialization is product customization: less waste is created when resources a consumer does not want are not produced.
>
> *Closing production loops*: In closed-loop production systems and zero-waste factories, every output is renewable and returned to natural systems as a nutrient or becomes an input for manufacturing process of another product.
>
> *Service extension*: Companies are moving from a supply-driven economy to a demand-driven economy. They are rethinking how they can satisfy demand and are developing customized responses to client needs. In an eco-efficient society, customers are increasingly gaining access to product services by leasing goods, particularly durable goods, rather than buying them outright.
>
> *Functional extension*: Companies are encouraged to manufacture smarter products with diverse and enhanced functionality – and to sell services that enhance the products¡¯ functional value.

The problem we face is that the elements to be included in an eco-efficiency performance profile are a matter of intense debate. In fact, there have been no standard methodology and no agreed, common set of indicators to quantify eco-efficiency (UNEP 1998). Moreover, eco-efficiency is a kind of evolving concept. However, from the discussions of eco-efficiency, we can identify that the essence of eco-efficiency is to brings together the two dimensions of economy and ecology to relate product or service value to environmental influence (Verfaillie and Bidwell 2000, 3; UNEP 1998; Lifset and Graedel 2002, 8-9). Accordingly, eco-efficiency can be represented by the following ratio (Verfaillie and Bidwell 2000, 2-3):

$$\text{Eco-efficiency} = \frac{\text{Product or service value}}{\text{Environmental influence in product/service creation}}$$

A company¡¯s eco-efficient performance profile includes two types of indicators – generally applicable and business specific. A small core of generally applicable indicators, which can be used by virtually all business, will help learning and comparability across time and industrial sectors. At the same time, it is desirable that individual companies develop a fuller description of their environmental performance by adding business specific indicators (Verfaillie and Bidwell 2000, 2-3).

The generally applicable indicators for product/service value are quantity of goods/services provided to customers, or net sales, which are total recorded sales less sales discounts and sales returns and allowances. Those relating to environmental influence are materials consumption, energy consumption, or total waste (Verfaillie and Bidwell 2000, 2-3). The major eco-efficiency indicators of our study – the amount of sales/quantity of chemicals used and the amount of sales/ quantity of non-product outputs – are based on these generally applicable indicators.

2. The Data for Environmental Influence

In order to identify environmental performance of the firms in New Jersey, we use the RPPR database in the period 1995-97, which is now available. Pursuant to the reporting requirements established by the 1984 Worker and Community Right to Know Act and the New Jersey Pollution Prevention Act of 1991, the industrial facilities in New Jersey are required to publicly report comprehensive information related to their use, as well as their wastes, of all toxic chemicals reportable under the federal Toxic Chemical Release Inventory (TRI) reports. Compared with the TRI, the RPPR database contains much more information for each of approximately 650 toxic chemicals and compounds reportable under the TRI (INFORM 2000, 9), including the environmental elements of data for eco-efficiency indicators of firms mentioned above.

In exploring eco-efficiency of firms¡¯ performance, out preferences of the NJ RPPR Database are as follows:

1) Providing the Total Flow of Toxic Chemicals: In revealing the total flow of toxic chemicals into and out of an industrial facility, the RPPR data provide a window into the details of a plant¡¯s manufacturing operations and the underlying reasons for its toxic chemical use and wastes. As Table 1 compares the information reported to the RPPR and TRI databases, the RPPR database provides the more complete picture of the flow of a chemical through a facility (INFORM 2000, 9-10; INFORM 1997, 1-12).[1]

Table 1. Comparison of data elements reported under the RPPR and TRI

	Data Element		Description
	RPPR	TRI	
Reportable Chemicals*	Expanding	Expanding	All toxic chemicals reportable under the TRI
Inputs	Starting Inventory (I_1)	Not reported	Pounds of the chemical stored at the facility at the beginning of the reporting year
	Produced On-site (I_2)	Not reported	Pounds of the chemical manufactured at the facility
	Brought On-site (I_3)	Not reported	Pounds of the chemical transported to the facility from an off-site location by barge, rail, road, or pipeline

Outputs	Consumed (O_1)	Not reported	Pounds of the chemical converted to another chemical through on-site production processes
	Shipped in Product (O_2)	Not reported	Pounds of the chemical transported from the facility in consumer and industrial products
	Nonproduct Output (O_3)	Total Waste	Nonproduct output (NPO) is the term used in the RPPR program to denote total waste.
	- Releases (O_{31})	- Releases	Pounds of the chemical emitted into the air, discharged into ground/ surface water, and disposed of in on-site landfills
	- Transfers (O_{32})	- Transfers	Pounds of the chemical sent off-site for treatment, recycling, incineration, and disposal in landfills
	- Waste management Activities (O_{33})	- Waste management activities	Pounds of the chemical recycled, treated, and incinerated for energy recovery on- and off-site
	Ending Inventory (O_4)	Not reported	Pounds of the chemical stored at the facility at the end of the reporting year
Pollution Prevention Activities*	Recycled On-site (R_1)**	Recycled On-Site**	Pounds of the chemical used that were recycled out of process on-site
	Substance Reduced (R_2)	Not reported	Pounds of material-related change from the previous year to the reporting year
Production Quantity*	Actual Quantity of Products (Q)	Production index	The actual quantity of products a facility manufacture each year

Source: INFORM 2000. This table is different from the original table in the following aspects:

* These three data elements are added for our analysis.

** Recycled On-site (R_1) is classified as intermediate processing of pollution prevention activities.

The information on the lease, transfer, and management of waste – that the TRI provides – is not always the source of a plant¡¯s biggest impacts or the best measure of its overall environmental performance. A fuller picture of material flow accounting, including potentially harmful exposures that can result from the use of toxic chemicals, are gaps in the TRI database that the RPPR database fills (INFORM 2000, 9-10; INFORM 1997, 1-12).

In particular, as data elements for measuring eco-efficiency of firms, the RPPR database identifies information on the quantities of specific chemicals entering the facility, how much is consumed in production processes, and how much the facility leaves as in nonproduct output.

2) Assessing the Efficiency of Industrial Chemical Use: The RPPR data allow a variety of measures of how efficiently a facility uses particular chemicals. From an environmental standpoint, using a chemical more efficiently would mean that ¡°more of the total amount used goes to its intended purpose (such as an ingredient in a product, a processing aid, or a reagent) and less is generated as waste¡± (INFORM 1997, 8). Of the data elements, Shipped in Product (O_2), which are not reported in the TRI, have important implications for assessing the efficiency of chemical use and the improvement of the environmental risk management.

Due to the weakness of quantity of product, whose reason will be explained in the next section, we reserve the first measure, that is, quantity of production per the quantity of chemicals used, for future research. Accordingly, nonproduct output (NPO) per the quantity of chemicals used – which all are uniformly expressed by pounds – is the primary indicator to measure chemical use efficiency as a complementary indicator of eco-efficiency.

3) Evaluating the Reduction of Toxic Chemical Use and Waste at the Source: Reducing the use of toxic chemicals and the generation of waste at an industrial facility is ¡°the most direct way of eliminating human or environmental exposure that might occur during handling, storage, recycling, treatment, disposal, or release to the environment.¡± Only the RPPR requires industrial facilities to report on two kinds of pollution prevention activities; i) any reductions achieved in the use of toxic chemicals (INFORM 1997, 8), or ii) the total quantity of all the reportable substances that was recycled out-of-process on site and then processed or otherwise used again at the facility during the reporting year.

The former refers to the changes in the amount of substance used due to substitution of other non-listed substance, and the latter represents to the process of minimizing the amount of waste to be disposed by reclaiming reusable materials by the removal of contaminants from the substances to allow it to be used again (NJDEP 1997, 16).

Maximizing the use of the RPPR database with these merits, we add two chemical use efficiency indicators; the quantity of chemicals reduced per quantity of chemicals used, and the recycled on-site per quantity of chemicals used.

However, the RPPR database has some methodological challenges, and some of them are common problems raised when considering the use of TRI data.

1) Matching Companies with Other Databases: Since the RPPR reports information on toxic uses and releases at the facility level with CRTK(Community Right to Know) Facility Identification Number, while such databases as the Dun and Bradstreet Million Dollar database or the Standard and Poor¡¯s Compustat database identify companies by the D & B D-U-N-S number or GICS Code assigned to each company respectively. As the TRI database has the D & B number, it can be easily matched with other databases of financial information (Khanna et al. 1998, 249-252).

However, the RPPR database has no specific ID numbers at the level of company that are used as popular primary keys in external databases, and thus causes difficulties in matching it with other databases. Though the firms with these special ID numbers are relatively small, the RPPR database would enhance its usefulness and applicability if it provided more information on firm identity.

2) Inconsistent Nature of the Database: As the advantages of using the TRI includes the fairly uniform reporting by the same facilities for the same pollutants over a relatively long time period (Gerde and Logsdon 2001, 271), so using the RPPR has the same advantages. Furthermore, as mandatory reporting program, the RPPR includes the large number of industries and firms that must report, and adds the breadth for statewide studies.

But, the RPPR is an expanding program, because the federal thresholds of the TRI directly affect the reportable substances by RPPR and because the TRI has increased the coverage of the reporting universe and reported chemicals. Reporting requirements and the lists of toxic chemicals vary from year to year even for the same facility. These changes in reporting requirements, listed chemicals and methods of calculation make longitudinal studies difficult (CEIS 1999, 6; Gerde and Logsdon 2001, 273).

3) Limited Accessibility of the Database: The RPPR database came out of the 1984 Worker and Community Right to Know Act (NJRTK), which was the first law of its kind to require an industrial facility to publicly report the comprehensive flow of chemicals through the facility. However, it is still used infrequently, partly owing to the lack of public awareness of their availability and partly owing to the limited accessibility of the database (INFORM 1997, 7-42).

The first step to avoiding the exposures to toxic chemicals is to identify where and how they are being used. The RPPR data make potential harms of industrial chemical use crosschecked by a wide range of stakeholders – including manufactures, policymakers, workers, health care providers, consumers, and communities in identifying routes of exposures, potential problems caused by these exposures and solution. A excellent research analysis using the RPPR database also points out this problem: if it is made widely available in an accessible, understandable form including the form of dBase files, the RPPR database will be more useful to the public (INFORM 1997, 7).

In fact, sharing and crosschecking the information crucial to human health and the environment is surely the philosophy of creating and developing the RPPR database. Making information on industrial chemical use available for free and with more ease is consistent with the original purpose of the NJRTK Act, that is, to track and crosscheck potential harms of the vast varieties of chemicals by various stakeholders.

4) Accuracy of Data: Another problem about measurement of environmental performance of firms is that the RPPR data are self-reported by the facilities, based on estimates. Despite the guiding instructions to assist facilities in reporting their data on environmental performance data, reporting errors easily occur. According to the TRI data quality site survey by the US Environmental Protection Agency (USEPA), the estimates for on-site releases and off-site transfers were fairly accurate; but there were larger discrepancies in fugitive emission estimates, and various differences in industry vs. surveyor estimates of emissions. As a result, variations between facilities might result from the different estimation methods use by each facility (CEIS 1999, 6-7)

3. The Data for Product Value

Product value can be represented by quantity of products provided to customers or amount of net sales. As mentioned earlier, one of the unique merits in RPPR database is that it provides abundant information on quantity of production. But the problem related to quantity of production is that the quantities have diverse units of measurement, e.g., tons, lbs, or gal, and make it difficult to compare them each other.

Quantity of physical production is well suited in situations characterized by one unique physical production output. The limitation to this type of data is that only comparisons among plants or companies within the same sector can be compared (SPRU et al. 2001). For this reason, we use total sales as an indicator of economic performance instead of quantity of production. In analyzing economic performance of firms, we are primarily based on the Dun & Bradstreet Million Dollar Database and the S&P Compustat financial database.

4. The Final Sample of Firms

Our study maximizes the unique characteristics of the RPPR database, while facing its limitations. Given the strengths and limitations of the RPPR, this analysis depends mainly on two samples of firms: the primary sample of firms for the analysis of eco-efficiency consists of 197 firms that are selected from the three databases – 195 firms commonly matched from the RPPR and D&B Databases and 6 firms from the RPPR and Compustat databases. Only four of 197 firms are common in all the three databases.

The complementary sample for the analysis of trends in environmental performance comprises 371 firms that continued to operate during 1995, 1996, and 1997. This sample is used for the time series analyses of economic and environmental performance of firms, which support and complement our findings of research about the primary sample.

In short, this study is based on these samples, focusing on two major eco-efficiency measures – Sales/ Chemicals used and Sales/Nonproduct Output (NPO), and three complementary indicators of chemical use efficiency, as Table 2 summarizes:

Table 2. Eco-efficiency and chemical use efficiency indicators

Focus	Indicators	Components
Eco-efficiency	Sales/USE	- Total Annual Sales (dollars) - Quantity of chemical used (pounds)*
	Sales/NPO	- Total Annual Sales (dollars) - Quantity of Total NPO (pounds)*
Chemical Use Efficiency	NPO/USE	- Quantity of Total NPO (pounds) - Quantity of chemical used (pounds)*
	RECYC/USE	- Quantity of chemical recycled (pounds) - Quantity of chemical used (pounds)*
	REDU/USE	- Quantity of chemicals reduced (pounds) - Quantity of chemical used (pounds)*

* Quantity of chemical used (pounds)= Total Inputs (I_1+ I_2+ I_3) – Ending Inventory (O_4)

III. Research Hypotheses

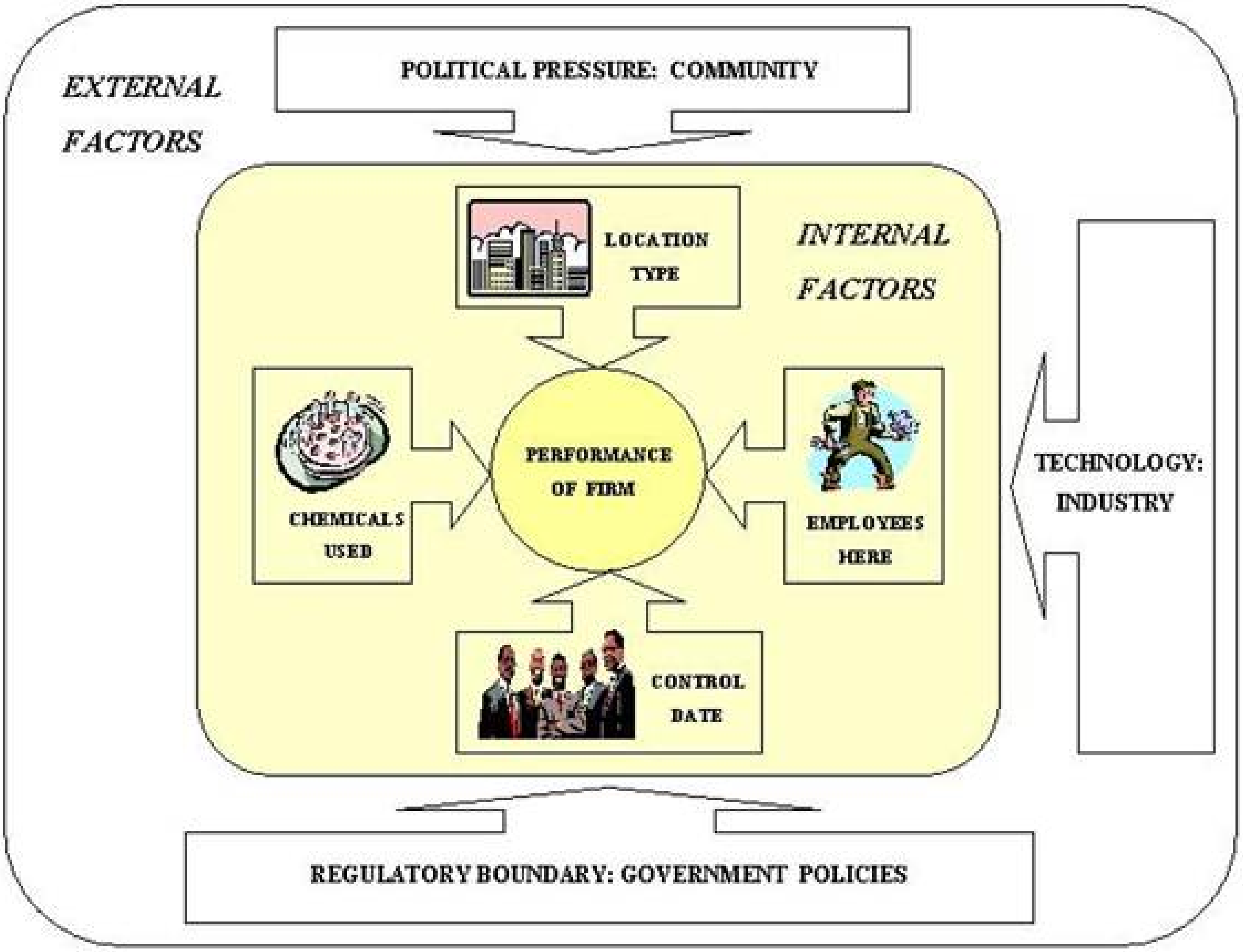
The purpose of this study is to investigate determinants to explain the behavior of firms in the arena of industrial ecology. Generally speaking, behavior of firms might be affected, in large, by two major factors – internal characteristics of firms and external circumstances surrounding the firms. The efficiency of firms in treating environmental issues are basically constrained by the inner factors, such as firm size of employees, organizational type, and technological methods of dealing chemicals, and control date of present owners. Outer and larger boundaries affecting firms are political pressures of neighboring communities, present technology and strategy of the industrial sector that a firm belongs to, and governmental regulation and policies. Figure 1 summarizes the relationship of each factor that our hypotheses are based on.

1. Internal Characteristics of Firm

Firm Size

Larger corporations are at a more advanced stage of economic and environmental management because they have competitive access to more resources. Larger companies have already been using environmental management as an integral part of their strategy for many years, while smaller companies generally have been reported as more reactive to environmental issues (Roy and Vézina 2001, 344).

Figure 1. Theoretical relationship of potential explanatory factors



Some larger firms show more positive attitude – even to a degree of aggressive attitude – towards environmental problems, which is explained by the theory of rent-seeking of firm. In reality, competition is imperfect and information does not flow freely, it may be possible for cost savings to go unexploited. Furthermore, environmental regulation, like tariffs or other government intervention in markets, can create rents or quasi-rents. Accordingly, firms seek these rents as they do others, and can simultaneously reduce their costs and improve their environmental performance, by exploiting the opportunities of environmental free lunches. For example, 3M initiated its ¡°Pollution Prevention Pays,¡± program in 1975, and has succeeded in finding the most costeffective form of regulatory compliance and integrating business and environmental goals while saving money. As a more positive form of corporate strategy, a large firm or an industry initiates environmental regulation to constrain competitor¡¯s behavior (Ochsner et al. 1995, 672; Reinhardt 1999, 11-14).

However, this continues to be debated, as some have found no evidence of firm size affecting the development of environmental management systems in case studies (Klassen and Whybark 1999, 608). A recent study indicates that management¡¯s environmental orientation of US companies has significantly improved during the very last years, and have been proactive and environmentally innovative (Lindell and Karagozoglu. 2001, 38-46).

Today, firms, large and small alike, are facing both challenges and opportunities as they attempt to take advantage of the growing concern for the environment. Firms must continuously maintain and develop resources and competencies that will enable them to sustain their competitive advantage over rivals (Roy and Vézina 2001, 344). Given the contradicted debates about the environmental performances of firms, it is suggested that the size of a firm correlate with environmental performance.

> *Hypothesis 1.1: The environmental performance of firms is related to the firm size represented by employees here.*

Institutional Factors

The theory of the firm is based on the views that ¡°the world does not fit the Panglossian belief that firms always make optimal choices¡± (Porter and van der Linde 2002, 99). Though factors external to firms create incentives and expectations for managers, intra-firm politics influences how managers perceive external pressures and act upon them. The behavioral theory of the firm suggests that managers are boundedly rational under uncertainty and that they have autonomy to interpret the impact of external pressures on the long-term profit and non-profit objectives. Hence, intra-firm dynamics and institutional factors of firms are important in explaining variations in adoption across firms for a given policy or within a firm for a set of similar policies (Prakash 2001, 286-290).

In particular, corporate culture is a crucial factor to affect employee behavior. Under the an open and creative corporate culture, the merging of various backgrounds and talents can bring a technical and regulatory understanding of the necessary chemical use, review current work progress, and propose new projects. The corporate commitment to foster the creativity, empowerment, and commitment of every employee has allowed firms to meet customer needs in a timely, cost efficient and environmentally appropriate manner (Greska and Ford 2000, 314-320). In this regard, the institutional analysis provides insights on the relationship between environmentally-significant behaviors and institutional design issues – contracts, rules, and procedures. (Andrews and Swain 2000, 171-187).

Accordingly, institutional aspects are considered as an important variable to strongly influence environmental performance of firms. Location type – such as single/branch/headquarters mixed with the number of employees – can be an available proxy that represents the institutional factors of firms, because location type is an organizational type of firm and because these elements are often enumerated as a basic physical framework of institution.

> *Hypothesis 1.2: The environmental performance of firms is affected by location type mixed with number of employees as a proxy of institutional factor.*

Number of Chemicals Used

The ideal types of factories in IE are zero-waste factories with closing production loops system. In complementary materials flows of the closed loop system, wastes generated will be likely to decrease remarkably. This expectation makes us pay attention to the chemicals used in a factory. A factory that uses diverse chemicals might have more favorable opportunities to complement each other and reduce the generation of wastes in a bigger closed loop system.

> *Hypothesis 1.3: The number of chemicals used in a facility might complement each other¡¯s consumption, and affect the environmental performance of the facility.*

Ownership Date of the Business

Generally speaking, the advanced manufacturing technologies and newer production equipment – which new firms or new owners usually inaugurate – might offer an excellent opportunity to upgrade related environmental management systems (Klassen and Whybark 1999, 608). The role of technology improvements in these new facilities also weighs heavily in any pollution prevention success (Greska and Ford 2000, 319-320).

The ownership or control date of the business is the date that current management assumed ownership, or majority stock ownership, of a business. In many cases, especially for small businesses, current ownership date and the year the business started are the same (D&B's Million Dollar Database Glossary). Therefore, the owners of recent control might be more sensitive to state-of-the-art technologies and new equipments, as a means of competitive strategy and proactive compliance of existing regulations.

> *Hypothesis 1.4: The control date is related to the environmental performance of the facility through the owners¡¯ considerations of which level of technology to use in the existing regulations.*

2. Circumstances Surrounding Firms

Industry Effects

The industrial organization literature in economics suggests that industry structure can be considered as a determinant of firm performance and firm differences (McGahan 1997, 15-30). According to this logic, greener industries may have higher returns than dirtier industries because of lower compliance and regulatory costs (King and Lenox 2001, 108).

On the other hand, the industrial sectors known as dirtier industry make more proactive approach to environmental risk management. For example, the Chemical Manufacturers Association (CMA) initiates Responsible Care program, which aims to improve the negative public perception of the industry and to distinguish the proactive performances of member companies from the poor performances of other (often smaller) companies (Nash and Ehrenfeld 1996, 18-19).

Recently, the increasing number of companies publishes an environmental or health, safety and environmental (HSE) report. This environmental voluntary reporting practices clearly differs between industrial sectors, with a higher level of reporting in sectors with a (perceived) relatively large environmental impact such as pharmaceuticals, mining, forestry, pulp and paper, and chemicals & synthetics. The relationship between environmental impact of the sector and reporting frequency appears to be clearer (KPMG 1999, 11-15; Kolk et al. 2001, 20-27).

Hypothesis 2.1: The industrial sectors represented by SIC affect the environmental performance of the facility through developing the present level of technology and setting up common strategy towards environmental issues.

Communities

The natural environment and its treatment by firms is an area of increasing stakeholder interest and one of the main issues that motivates stakeholder pressures on firms. Firms exposed to more intense pressures emanating from their surrounding communities will be likely to be more environmentally friendly and meet environmental issues more actively.

Contrary to our expectations, a recent study indicates that stakeholder pressures may be a weak deterrent, at best, of poor environmental performance as evidenced by environmental litigation exposure (Kassinis and Vafeas 2002, 403).

Accordingly, awareness of environmental regulation and pressure from the public and other external stakeholders can be a important topic in analyzing which factor motivates firms to develop a more proactive orientation toward environmental issues (Klassen and Whybark 1999, 608-609).

Hypothesis 2.2: The increasing pressures and environmental concerns of communities are related to the environmental performance of the neighboring facilities dealing with toxics.

Governmental Regulation and Policies

Governmental regulations and policies towards environmental issues might be a strong external factor that affects and direct the behavior of firms. According to the 1984 Worker and Community Right to Know Act, twenty industry sectors, represented by SIC codes 20 through 39, are required to submit materials accounting data to the NJ

DEP. The recent NJ DEP¡¯s report on pollution prevention trends suggests that one possible factor contributing to New Jersey¡¯s superior performance is that facility-level materials accounting data collection has been required in the state since 1987 (Aucott et al. 1996).

Of these SIC codes, five major SIC codes are included in the first group of facilities covered by the New Jersey Pollution Prevention Act of 1991, which required the facilities to prepare pollution prevention plans; SIC 26 facilities manufacture paper and allied products; SIC 29 facilities manufacture chemicals and allied products; SIC 30 includes rubber and miscellaneous plastics products manufacturers; SIC 33 contains primary metals industries; SIC 34 is manufacturers of fabricated metal products, except machinery and transportation equipment.

Most of these facilities have been involved in pollution prevention planning since before the date their plans were due to be completed, July 1, 1994. Information on pollution prevention goals and other information submitted in the Pollution Prevention Plan Summaries are available for analysis for facilities in these five SIC codes, but not for other SIC codes (Aucott et al. 1996). In this respect, we are interested in these five groups for studying the impacts of governmental regulations on behavior of firms.

> *Hypothesis 2.3: The governmental regulation and policies affect the incentives and performances of firms about environmental issues.*

IV. Results

1. Characteristics of Firm:

Firm Size

Table 3.1 shows a tendency that larger firms are relatively more eco-efficient in Sale/Use ratio and Sale/NPO ratio than the small and medium enterprises (SMEs). The Pearson correlation coefficients between the mean of Sale/Use ratio and that of Sale/NPO ratio are 0.872, which is significant at the 0.01 level (2-tailed). These evidences indicate that eco-efficiency of a firm is closely related to the size of the firm represented by the employees here.

Table 3.1. Eco-efficiency by location type and firm size

Employees here	# of firms	% of sample	Total sales	Quantity used	Total NPO	Sale/Use Ratio	Sale/NPO Ratio
1-24	6	3.0	16,682,167	27,797,011	181,258	0.6	92.0
25-49	30	15.2	24,635,000	944,541	147,749	26.1	166.7
50-74	27	13.7	10,148,111	3,375,156	279,012	3.0	36.4
75-99	21	10.7	17,570,524	1,523,962	75,586	11.5	232.5
100-124	26	13.2	122,006,808	3,956,208	212,173	30.8	575.0
125-149	11	5.6	38,033,333	4,101,312	211,465	9.3	179.9
150-199	22	11.2	49,131,500	8,501,216	293,752	5.8	167.3
200-499	25	12.7	137,685,320	2,295,282	1,348,750	60.0	102.1
500-999	14	7.1	474,600,143	1,213,618	206,855	391.1	2,294.4
1000-	15	7.6	302,400,857	1,106,945	551,558	273.2	548.3
Total	197	100.0	105,142,474	3,777,818	374,791	27.8	280.5

* The figures of Total Sales, Quantity Used, and Total NPO are a mean value of each class

In parallel, it is noted that some SMEs are proved to be also eco-efficient in our research.

SMEs whose firm size range are 25-49 accomplished 26.1 of Sale/Use ratio, while those with the range of are 150-199 realized only 5.8 of the ratio. It means that some SMEs also begin to be concerned with environmental issues and actually develop green innovations, including even those that are not directly affected by environmental regulations. ¡°Green product innovation may occur and may also have strategic implications in SMEs.¡± Some SMEs are currently incorporating the environmental factor into their R&D strategy and organization, and have started to exploit this opportunity to develop more environmentally friendly products and technologies (Noci and Verganti 1999, 3-12; Roy and Vézina 2001, 344).

Institutional Factors

The Table 3.2 shows that the subtotals of eco-efficiency indicators of the branch location type as a whole are 97 and 386 respectively, which are greater than those of both single location and headquarters.

Table 3.2. Eco-efficiency by location type and firm size

Location type	Employees here	# of firms	% of sample	Total sales	Quantity used	Total NPO	Sale/Use Ratio	Sale/NPO Ratio
Single Location	1-49	19	9.7	10,120,211	1,327,075	162,919	8	62
	50-99	33	16.9	12,239,061	2,531,787	210,517	5	58
	100-199	22	11.3	23,645,476	2,088,701	123,748	11	191
	200-499	10	5.1	31,434,700	726,726	139,039	43	226
	500-999	1	0.5	54,500,000	50,534	11,255	1,078	4842
	1000+	2	1.0	134,190,500	331,028	32,338	405	4150
	Subtotal	87	44.6	20,115,767	1,870,054	163,578	11	123
Branch location	500-999	9	4.6	75,344,444	1,742,437	308,324	43	244
	1000+	6	3.1	280,166,667	1,444,071	556,555	194	503
	Subtotal	15	7.7	157,273,333	1,623,091	407,616	97	386
Head-quarters	1-49	17	8.7	38,050,529	9,994,345	142,621	4	267
	50-99	15	7.7	15,939,400	2,638,896	144,904	6	110
	100-199	37	19.0	113,855,972	7,812,194	313,046	15	364
	200-499	14	7.2	219,592,214	3,476,416	2,260,122	63	97
	500-999	4	2.1	1,477,950,500	314,546	27,449	4,699	53844
	1000+	6	3.1	456,060,000	1,167,901	811,514	390	562
	Subtotal	93	47.7	178,584,154	5,972,838	567,757	30	315
Total		195	100	105,938,615	3,807,769	375,112	28	282

* The figures of Total Sales, Quantity Used, and Total NPO are a mean value of each class

There can be many potential explanations of this excellent performance of branch organization. A branch organization usually is specialized in certain production process and this specialty contributes to yielding higher gains and enhancing efficiency of production.

In addition, from the dynamic view of properly designed environmental regulations, the firm¡¯s capacity to improve and innovate continually can fully offset the costs of complying with them, and promote both environmentalism and industrial competitiveness (Porter and van der Linde 2002, 97-116). The performance of specialized branch with capacity to positively innovate its production process might be superior to that of other organizational type.

As Table 3.3 shows, the mean and median of Sale/Use ratio and Sale/NPO ratio showed the significant correlation in 1997 respectively. Furthermore, the mean of Sale/Use Ratio and the Sale/NPO Ratio had the significant correlation with their median in 1997. In particular, Table 3.2 shows that, as the firm size increased in the

same location type, the eco-efficiency of firms generally increased in 1997. These evidences imply that
the location type with firm size is significantly related to the economic and environmental performance of firms.

Table 3.3 Pearson correlation coefficients for eco-efficiency indicators by location type and firm size

		Sale/Use Ratio		Sale/NPO Ratio	
		Mean	Median	Mean	Median
Sale/Use Ratio	Mean	1.000	0.872*	0.988*	0.972*
	Median	0.872	1.000	0.796*	0.752*
Sale/NPO Ratio	Mean	0.988*	0.796*	1.000	0.994*
	Median	0.972*	0.752*	0.994*	1.000

* The correlation is significant at the 0.01 level (2-tailed).

Number of Chemicals Used

Table 3.4 provides the trends in chemical use efficiency distribution by the number of chemical used. The NPO/Use ratios showed the similar patterns during 1995, 1996 and 1997, and the Quantity recycled/Use ratios showed the similar patterns during the same period.

Table 3.4. Trends in chemical use efficiency by number of chemicals used

# of chemical	# of firms	% of sample	1995 NPO/Use	1995 Recy/Use	1996 NPO/Use	1996 Recy/Use	1997 NPO/Use	1997 Recy/Use
1	111	29.9	4.0%	0.1%	4.0%	0.1%	3.3%	0.0%
2	84	22.6	8.3%	0.0%	5.0%	0.1%	8.2%	0.4%
3	51	13.7	7.8%	0.6%	6.0%	0.5%	6.7%	0.5%
4	33	8.9	1.6%	0.1%	1.4%	0.1%	2.0%	0.0%
5	23	6.2	7.8%	0.0%	8.4%	0.1%	9.7%	0.2%
6	15	4.0	21.2%	0.1%	17.2%	0.5%	17.4%	0.0%
7	18	4.9	8.2%	1.1%	7.8%	1.2%	7.1%	1.5%
8+	36	9.7	3.8%	0.1%	5.2%	0.2%	3.7%	0.2%
Total	371	100.0	4.4%	0.1%	5.3%	0.2%	4.2%	0.2%

As Table 3.5 shows, the Pearson correlation coefficients also support our observation.

Generally, firms in New Jersey improved their efficiency in using chemicals during the period 1995-97. In particular, firms that used more than six chemicals exerted relatively excellent chemical use efficiency. It is noted that one third of the sample of 371 firms used one chemical and improved their chemical use efficiency in the period 1995-97.

Table 3.5. Pearson correlation coefficients for chemical use efficiency by number of chemicals used

		1995			1996			1997		
		NPO/Use	Recy/Use	Redu/Use	NPO/Use	Recy/Use	Redu/Use	NPO/Use	Recy/Use	Redu/Use
1995	NPO/Use	1.000	0.016	-0.087	0.961*	0.325	-0.060	0.976*	0.010	-0.008
	Recy/Use	0.016	1.000	-0.278	0.035	0.933*	0.119	-0.050	0.935*	0.279
	Redu/Use	-0.087	-0.278	1.000	-0.169	-0.325	0.054	0.028	-0.047	-0.170
1996	NPO/Use	0.961*	0.035	-0.169	1.000	0.356	-0.209	0.948*	0.011	-0.112
	Recy/Use	0.325	0.933*	-0.325	0.356	1.000	-0.081	0.250	0.881*	0.092
	Redu/Use	-0.060	0.119	0.054	-0.209	-0.081	1.000	-0.076	0.052	0.902*
1997	NPO/Use	0.976*	-0.050	0.028	0.948*	0.250	-0.076	1.000	-0.012	-0.045
	Recy/Use	0.010	0.935*	-0.047	0.011	0.881*	0.052	-0.012	1.000	0.091
	Redu/Use	-0.008	0.279	-0.170	-0.112	0.092	0.902*	-0.045	0.091	1.000

* The correlation is significant at the 0.01 level (2-tailed).

Ownership Date of the Business

As Table 3.6 provides the eco-efficiency distribution of 180 firms both by control date and by the firms of mainstream SIC in the same class of control date. The results of our study are contrary to our expectation. The firms of the recent ownership exert relatively poor economic and environmental performance. And the mainstream SIC of the each period of ownership date in New Jersey is chemicals industry.

The results provide two implications: first, the influences of ownership are not significant. The current business practices may explain this result. The current concept of ownership in the US system is too limited, involving just capital, and ownership is largely restricted to outside shareholders (Lindell and Karagozoglu. 2001, 50). Accordingly, the priorities of top management and customers seem to be more influential than those of owners.

The second implication for further research is that industry variable is a good one for analysis of firm performance. An ideal sample of industry has such characteristics as a high degree of variation in environmental management strategies, competitive marketplace, and relatively standardized production technology (Klassen and Whybark 1999, 609). Through the whole period, owners in New Jersey consistently preferred chemicals industries to other manufacturing industries. Chemicals industries might be the popular industries in New Jersey, which need our special attention to case studies of favorable conditions for these industries. The next section explains the more detailed effects of industrial sector on behavior of firms.

Table 3.6. Eco-efficiency by ownership of the business

Control Date	# of firms	% of sample	Total Sales	Quantity Used	Total NPO	Sale/Use Ratio	Sale/NPO Ratio
1874-1949	31	17.2	255,651,900	1,270,391	313,108	201	816
SIC28**	14	45.2	533,223,923	1,680,919	621,250	317	858
SIC34**	4	12.9	16,151,500	123,969	74,175	130	218
1950-1969	30	16.7	36,929,667	5,315,877	196,504	7	188
SIC28**	9	30.0	22,311,111	15,632,033	328,034	1	68
SIC34**	6	20.0	31,958,000	306,662	104,424	104	306
1970-1979	32	17.8	53,019,406	1,523,473	179,711	35	295
SIC28**	9	28.1	141,085,222	2,114,296	62,314	67	2,264
SIC27**	6	18.8	17,055,000	222,584	184,648	77	92
1980-1989	28	15.6	31,777,000	10,668,358	146,286	3	217
SIC28**	14	50.0	33,451,154	8,534,347	245,077	4	136
SIC30**	3	10.7	47,633,333	1,378,637	77,637	35	614
1990-1996	25	13.9	117,080,520	2,830,085	287,712	41	407
SIC28**	11	44.0	197,017,818	4,557,738	511,588	43	385
SIC34**	2	8.0	62,452,500	505,442	125,056	124	499
1997-	34	18.9	112,789,515	2,973,319	1,011,520	38	112
SIC28**	14	41.2	160,725,286	3,198,642	1,006,329	50	160
SIC34**	6	17.6	59,160,000	515,196	455,739	115	130
Total	180	100.0	101,588,215	3,989,825	372,404	25	273

* The figures of Total Sales, Quantity Used, and Total NPO are a mean value of each class
** These mean the first and second large number of firms in each class of control date

2. Industry Effects

There is a significant correlation between eco-efficiency indicators grouped by industrial sectors. Our results indicate that industrial sectors represented by SIC basically restrict the behavior of firms. As table 3.7 and 3.8 show, the Sale/Use ratio and the Sale/NPO ratio showed the significant correlation in 1997. Furthermore, the mean of Sale/Use ratio and the Sale/NPO ratio had the significant correlation with their median in 1997.

Table 3.7. Eco-efficiency of firms grouped by SIC

SIC	# of firms	% of sample	Total Sales	Quantity Used	Total NPO	Sale/Use Ratio	Sale/NPO Ratio
20 Food	6	3.1	102,503,000	131,056	29,824	782	3,437
22 Textile	7	3.6	10,579,143	170,830	87,946	62	120
24 Lumber & wood	2	1.0	19,210,500	1,080,369	650	18	29,555
25 Furniture	1	0.5	138,840,000	10,882	237	12,759	585,823
26 Paper	6	3.1	49,016,667	1,131,721	1,556,348	43	31
27 Printing, publishing	7	3.6	16,047,143	240,071	161,429	67	99
28 Chemicals	74	38.5	201,452,681	5,425,020	514,558	37	392
29 Petroleum refining	2	1.0	31,500,000	1,877,573	348	17	90,647
30 Rubber	14	7.3	42,008,286	585,359	54,923	72	765
31 Leather	1	0.5	23,800,000	224,496	85,420	106	279
32 Stone, clay, glass	5	2.6	62,821,400	174,362	63,013	360	997
33 Primary metal	18	9.4	46,088,889	14,662,352	569,384	3	81
34 Fabricated metal	22	11.5	38,470,048	452,206	285,985	85	135
35 Computer equipment	7	3.6	35,179,714	959,792	109,429	37	321
36 Electronic	9	4.7	37,584,667	1,443,436	196,436	26	191
37 Transportation	5	2.6	99,426,600	2,608,787	509,582	38	195
38 Scientific instruments	4	2.1	157,603,500	252,515	177,999	624	885
39 Miscellaneous	2	1.0	116,646,000	407,668	207,432	286	562
Total	192	100	107,667,772	3,831,105	381,567	28	282

* The figures of Total Sales, Quantity Used, and Total NPO are a mean value of each class

Table 3.8. Pearson correlation coefficients for eco-efficiency indicators by SIC

		Sale/Use Ratio		Sale/NPO Ratio	
		Mean	Median	Mean	Median
Sale/Use Ratio	Mean	1.000	1.000*	0.983*	0.984*
	Median	1.000*	1.000	0.984*	0.985*
Sale/NPO Ratio	Mean	0.983*	0.984*	1.000	1.000*

Median	0.984*	0.985*	1.000*	1.000

* The correlation is significant at the 0.01 level (2-tailed).

The more detailed analysis of chemical use efficiency in the period 1995-97 also supports our findings as Table 3.9 and 3.10 show. The NPO/USE ratios by industrial sectors showed the similar patterns during 1995, 1996 and 1997, and the Quantity Recycled (Out-of Process on Site)/USE ratios by industrial sectors also showed the similar patterns during 1995, 1996 and 1997.

These results provide important implications on the behavior of firms: First, the industrial sector is a determinant to affect the eco-efficiency of firms. Second, the eco-efficiency is a good measure for economic and environmental performance of firms in certain circumstances like grouping firms by SIC codes.

Table 3.9. Trends in chemical use efficiency indicators grouped by SIC

SIC	# of firms	% of sample	1995		1996		1997	
			NPO/Use	Recy/Use	NPO/Use	Recy/Use	NPO/Use	Recy/Use
20 Food	12	3.2	13.40%	1.90%	12.72%	0.74%	16.02%	1.04%
22 Textile	11	3.0	59.00%	3.98%	65.14%	0.70%	55.07%	0.77%
24 Lumber & wood	3	0.8	0.68%	0.00%	0.35%	0.00%	0.23%	0.00%
25 Furniture	1	0.3	100.00%	0.00%	100.00%	0.00%	100.00%	0.00%
27 Printing, publishing	10	2.7	79.83%	0.00%	76.28%	0.51%	75.32%	0.00%
29 Petroleum refining	10	2.7	2.73%	0.00%	4.62%	0.00%	2.95%	0.00%
31 Leather	2	0.5	12.41%	0.00%	15.70%	0.00%	10.10%	0.00%
32 Stone, clay, glass	6	1.6	16.22%	19.80%	20.59%	48.43%	19.17%	21.07%
35 Computer equip	13	3.5	5.06%	0.00%	7.23%	0.00%	7.34%	0.00%
36 Electronic	10	2.7	14.92%	0.00%	2.06%	0.00%	13.62%	0.00%
37 Transportation	4	1.1	20.48%	0.00%	18.86%	0.00%	18.41%	0.00%
38 Scientific instruments	10	2.7	28.78%	0.00%	29.22%	0.00%	26.51%	0.00%
39 Miscellaneous	4	1.1	48.95%	8.45%	21.29%	6.01%	19.43%	9.01%
Subtotal (1)	96	25.9	2.96%	0.02%	4.66%	0.02%	3.14%	0.01%
26 Paper*	12	3.2	151.00%	25.92%	142.42%	0.53%	130.35%	0.65%
28 Chemicals*	159	42.9	7.19%	0.42%	6.40%	0.64%	6.07%	0.65%
30 Rubber*	33	8.9	2.09%	0.51%	1.64%	0.74%	1.74%	0.36%
33 Primary metal*	33	8.9	7.28%	0.16%	6.30%	0.17%	8.01%	0.19%
34 Fabricated metal*	38	10.2	41.55%	0.61%	42.49%	0.71%	40.51%	0.26%
Subtotal (2)	275	74.1	7.74%	0.45%	6.92%	0.60%	6.77%	0.59%
Total	371	100	4.39%	0.15%	5.30%	0.18%	4.21%	0.18%

* The New Jersey Pollution Prevention Act of 1991 (NJPPA) required facilities in the following SIC codes to prepare pollution prevention plans: SIC 26, 28, 30, 33, and 34.

Table 3.10. Pearson correlation coefficients for chemical use efficiency by SIC

		1995			1996			1997		
		NPO/Use	Recy/Use	Redu/Use	NPO/Use	Recy/Use	Redu/Use	NPO/Use	Recy/Use	Redu/Use
1995	NPO/Use	1.000	0.568*	0.665*	0.983*	-0.061	0.285	0.984*	-0.020	0.162
	Recy/Use	0.568	1.000	0.445	0.542	0.580*	-0.104	0.516	0.611*	0.160
	Redu/Use	0.665	0.445	1.000	0.685*	-0.092	0.315	0.647*	-0.078	0.035
1996	NPO/Use	0.983*	0.542	0.685*	1.000	-0.044	0.284	0.994*	-0.048	0.009
	Recy/Use	-0.061	0.580*	-0.092	-0.044	1.000	-0.055	-0.050	0.958*	0.058
	Redu/Use	0.285	-0.104	0.315	0.284	-0.055	1.000	0.306	-0.082	0.130
1997	NPO/Use	0.984*	0.516	0.647*	0.994*	-0.050	0.306	1.000	-0.056	0.006
	Recy/Use	-0.020	0.611*	-0.078	-0.048	0.958*	-0.082	-0.056	1.000	0.330
	Redu/Use	0.162	0.160	0.035	0.009	0.058	0.130	0.006	0.330	1.000

* The correlation is significant at the 0.01 level (2-tailed).

3. Communities

Table 3.11 and 3.12 indicate that there was no significant correlation between the median household income of county and the environmental performance of firms. But, both the NPO/Use ratios by counties and the Quantity Recycled/Use ratios by counties showed the similar patterns during 1995, 1996 and 1997.

Total quantity of NPO means the total of all waste streams generated, including all environmental releases and off-site transfers for energy recovery or recycling, and as (or in) waste for treatment and/or disposal. Because the concept of NPO contains desirable kinds of waste treatments, the neighboring communities might be more sensitive to the net amount of on-site releases that the total NPO generated. Table 3.13 compares the trends in generation of NPO and on-site releases grouped by county.

Table 3.11. Trends in chemical use efficiency indicators grouped by county

County	Median HH Income	# of firms	% of sample	1995 NPO/Use	1995 Recy/Use	1996 NPO/Use	1996 Recy/Use	1997 NPO/Use	1997 Recy/Use
Morris	56,273	23	6.2	9.30%	2.13%	9.47%	3.18%	9.96%	2.16%
Somerset	55,519	16	4.3	3.05%	0.40%	2.49%	1.10%	2.36%	0.34%
Hunterdon	54,628	4	1.1	1.37%	0.01%	0.42%	0.01%	0.91%	0.02%
Bergen	49,249	50	13.5	13.00%	1.66%	11.11%	1.79%	12.32%	3.21%
Sussex	48,823	4	1.1	45.21%	3.89%	40.05%	7.25%	59.84%	3.92%
Monmouth	45,912	11	3.0	5.24%	1.43%	3.19%	0.71%	1.52%	0.02%
Middlesex	45,623	60	16.2	2.39%	0.07%	1.36%	0.01%	2.50%	0.06%
Burlington	42,373	12	3.2	8.90%	0.12%	9.64%	0.22%	6.88%	0.09%

Union	41,791	32	8.6	5.70%	0.08%	5.96%	0.04%	4.69%	0.04%
Mercer	41,227	10	2.7	10.97%	0.94%	7.79%	1.23%	7.52%	1.00%
Warren	39,929	9	2.4	2.27%	1.06%	1.82%	1.69%	2.72%	1.66%
Gloucester	39,387	20	5.4	4.18%	0.00%	7.47%	0.00%	4.22%	0.00%
Passaic	37,596	32	8.6	11.78%	0.45%	12.70%	0.25%	13.21%	1.61%
Camden	36,190	11	3.0	8.76%	0.12%	8.54%	3.83%	10.88%	3.99%
Essex	34,518	53	14.3	8.63%	0.71%	7.83%	0.66%	9.32%	0.53%
Atlantic	33,716	3	0.8	25.89%	0.00%	27.07%	0.00%	26.09%	0.01%
Salem	33,155	5	1.3	12.40%	1.24%	9.44%	2.47%	7.76%	2.19%
Ocean	33,110	1	0.3	1131%	0.00%	826%	0.00%	-5044.%	0.00%
Hudson	30,917	13	3.5	44.14%	0.67%	39.50%	0.51%	48.53%	0.65%
Cumberland	29,985	2	0.5	11.18%	0.00%	15.63%	0.00%	16.17%	0.00%
Total		371	100.0	4.39%	0.15%	5.30%	0.18%	4.21%	0.18%

* The figures of each chemical use efficiency are based on the subtotals of Quantity recycled, Total NPO, and Quantity used, which are grouped by each county.

Table 3.12. Pearson correlation coefficients for chemical use efficiency by county

		Median HH Income	1995 NPO/Use	1995 Recy/Use	1996 NPO/Use	1996 Recy/Use	1997 NPO/Use	1997 Recy/Use
Median HH Income		1.000	-0.253	0.385	-0.260	0.276	0.237	0.150
1995	NPO/Use	-0.253	1.000	-0.156	1.000*	-0.139	-0.998*	-0.170
	Recy/Use	0.385	-0.156	1.000	-0.154	0.836*	0.187	0.662*
1996	NPO/Use	-0.260	1.000*	-0.154	1.000	-0.137	-0.997*	-0.169
	Recy/Use	0.276	-0.139	0.836*	-0.137	1.000	0.169	0.864*
1997	NPO/Use	0.237	-0.998*	0.187	-0.997*	0.169	1.000	0.191
	Recy/Use	0.150	-0.170	0.662*	-0.169	0.864*	0.191	1.000

* The correlation is significant at the 0.01 level (2-tailed).

Because on-site environmental releases means the toxic substances emitted into the air, discharged into ground and surface water, and disposed of in on-site landfills, neighboring communities will be likely to sensitively respond to them. As Table 3.13 shows, though there are some exceptions, in the counties with relatively low median household income, such as Warren, Camden, and Cumberland, larger portion of waste generated was emitted to the environment directly. This implies that the different responses of communities to the treatment of waste might be a factor to affect the behavior of the firms

Table 3.13. Trends in generation of NPO and on-site releases grouped by county

County	Median HH	1995	1997

	Income	NPO	Releases	Release/NPO	NPO	Releases	Release/NPO
Morris	56,273	2,134,343	139,794	9.3%	2,352,154	142,429	6.1%
Somerset	55,519	1,919,542	147,738	7.4%	1,563,110	119,075	7.6%
Hunterdon	54,628	190,948	94,910	76.2%	64,645	47,476	73.4%
Bergen	49,249	7,503,231	841,196	12.2%	7,259,910	640,618	8.8%
Sussex	48,823	424,541	37,003	8.7%	523,577	33,200	6.3%
Monmouth	45,912	7,402,913	39,696	1.0%	2,617,908	50,901	1.9%
Middlesex	45,623	66,907,865	2,967,386	4.3%	67,491,707	2,366,394	3.5%
Burlington	42,373	6,024,601	251,230	4.3%	4,180,379	238,973	5.7%
Union	41,791	27,878,282	1,026,790	3.0%	25,374,434	877,243	3.5%
Mercer	41,227	1,197,357	92,548	8.8%	749,098	59,641	8.0%
Warren	39,929	2,701,303	464,508	23.8%	3,160,721	1,118,637	35.4%
Gloucester	39,387	220,922,624	749,233	0.2%	247,261,880	791,723	0.3%
Passaic	37,596	5,502,912	243,004	3.8%	6,849,109	263,436	3.8%
Camden	36,190	1,639,832	314,057	16.8%	2,082,029	264,705	12.7%
Essex	34,518	22,126,496	863,346	2.5%	24,761,289	736,162	3.0%
Atlantic	33,716	108,248	6,667	6.0%	90,706	6,982	7.7%
Salem	33,155	47,160,080	1,136,393	2.6%	32,206,286	1,103,360	3.4%
Ocean	33,110	120,209	929	1.0%	157,991	1,509	1.0%
Hudson	30,917	8,262,486	71,870	0.9%	8,460,624	91,382	1.1%
Cumberland	29,985	81,860	80,920	93.1%	112,853	94,670	83.9%
Total		430,209,673	9,569,218	1.4%	437,320,410	9,048,516	2.1%

4. Governmental Regulations and Policy

As Table 3.6 shows, the group of industrial sectors regulated by NJPPA was more eco-efficient than that of other sectors outside its regulation. This finding implies that the NJPPA had a positive role in reducing NPO and facilitating pollution prevention activities of firms. A result of recent research is also consistent with our findings, and affirms that those facilities required to prepare pollution prevention plans in New Jersey projected a greater percent decrease in waste generation that those not required to plan (INFORM 1997, 20).

V. Conclusions

Findings

We can draw some helpful implications on the determinants of environmental behavior of firms:

First, the analysis of firm size indicates that larger firms are still in a dominant position to attain high eco-efficiency. In addition, we can recognize that there have been emerging some desirable and innovative changes in economic environmental performance of some pioneering SMEs.

Second, our analysis provides important implications on the effects of industrial sector on behavior of firms. Industry sectors may have the potential of a strong determinant to affect the eco-efficiency of firms, because there is a significant correlation between eco-efficiency indicators that are represented by SIC codes.

Third, the diverse sensitiveness of communities to the environmental performance, e.g., environmental releases, by neighboring firms can be a factor to affect the behavior of the firms. Counties with low median household income tend to tolerate environmental direct releases of neighboring firms more generously.

Finally, the group of industrial sectors regulated by the NJPPA was more eco-efficient than that of other sectors outside its regulation. This finding implies that the NJPPA has played a positive role in reducing NPO and facilitating pollution prevention activities of firms in New Jersey.

Limitations

Despite the insufficiency of data available and the limited number of sample, we confess that our analysis has the following limitations in explaining the behavior of firms:

First, the samples of this study partly represent the whole population of all toxics-generating facilities. The RPPR Database is not representative of all New Jersey toxic waste-generating facilities. Small firms – which are not required to submit the TRI report and do not exceed a 10,000 pounds threshold for manufacture, process, or otherwise use – are exempt. The database also does not cover releases from mobile sources and area (non-point) sources. As a result, on-site and off-site releases reported comprise only a portion of all toxic chemicals released statewide (NJDEP 2001, 9; CEIS 1999, 6-7; Gerde and Logsdon, 2001, 271-273).

This insufficient representation of samples may affect the outcomes of research whose focus is the study of small firms. Furthermore, it is an important weak point that proactive small firms – that show the excellent environmental performances and might be a desirable example of environmental behavior – are excluded from the special interest of this study.

Second, the numerous types of emissions and environmental burdens vary from business to business, and make it difficult to compare the figures of different companies (UNEP 1998). Furthermore, the impacts of environmental releases are not directly and uniformly correlated with exposure rates. The potential risk of toxic chemicals is generally dependent on type of release, environmental conditions, population neighboring the facilities, toxicity of chemical, and the fate of the chemical after release. Accordingly, the information on the effects to human health and the environment is insufficient, and therefore can be used as a starting point to determine exposure or calculate adverse effects to human health and the environment (CEIS 1999, 7; Gerde and Logsdon, 2001, 273).

In short, in parallel with limitations to the data used, this study is not enough to get the full story of what is happening inside a plant. Deeper insight into actual performance can only be gained from detailed surveys or case studies of examples of the RPPR respondents (INFORM 2000, 18-23; Bunge et al. 1996, 14).

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[1] Table 1 is based on the classification of INFORM. The original table of INFORM classifies Recycled On-site as an element of inputs (INFORM 2000, 10). However, this analysis follows the classification by the NJDEP, which computes Total Input by adding starting inventory (I_1), Produced on site (I_2), and Brought On-site (I_3) (NJDEP 2000, 68). In our analysis, Recycling out of process on-site is classified as intermediate processing rather than input processing.