THE EFFECTS OF ISO 14001 ON CORPORATE FINANCIAL AND ENVIRONMENTAL PERFORMANCE

by

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Abstract

The Effects of ISO 14001 on Corporate Financial and Environmental Performance

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Environmental Applied Science and Management, 2005
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The purpose of this study is to examine the effects of ISO 14001 registration on corporate financial and environmental performance. The stock market's reaction to the ISO 14001 registration of a sample of Canadian firms is investigated. An analysis of the overall sample of companies revealed that there were no abnormal stock market returns experienced during a three day event window. However, abnormal returns were experienced when the companies were analyzed individually. The environmental performance component of this study investigated whether ISO 14001 registered facilities experience greater emission reductions than non-registered facilities within the Transportation Equipment Industries sector in Canada. The results of the analysis indicated that there was no difference between facilities that adopted ISO 14001 at different time periods and that the facilities that adopted ISO 14001 experienced an increase in aggregated weighed emissions.

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Acronyms

ATSDR - Agency for Toxic Substances and Disease Registry

CalEPA - California Environmental Protection Agency

CAR - Cumulative Abnormal Return

CER - Council on Economic Priorities

CFMRC - Canadian Financial Markets Research

CHHI - Chronic Human Health Indicators

CSR - Corporate Social Responsibility

EMS - Environmental Management System

EPA - Environmental Protection Agency

GEMI - Global Environmental Management Initiative

HEAST - Health Effects Assessment Tables

IRIS - Environmental Protection Agency's Integrated Risk Information System

ISO - International Organization for Standardization

IUR - Inhalation Unit Risk

GDP - Gross Domestic Product

HRS - Hazard Ranking System

HTP - Human Toxicity Potential

LOAEL - Lowest Observable Adverse Effect Level

MNE - Multi-National Enterprise

NDEMS - National Database on Environmental Management Systems

NOAEL - No-Observable Adverse Effect Level

NPRI - National Pollutant Release Inventory

OPP - Office of Pesticide Programs

OSF - Oral Slope Effect

RfC - Reference Concentration

RfD - Reference Dose

RSEI - Risk-Screening Environmental Indicators

SIC - Standard Industrial Classification

TRI - United States Toxic Release Inventory

WOE - Weight-of-Evidence

1.0 Introduction

Voluntary approaches that attempt to foster environmental sustainability have recently become popular with many businesses and organizations. This growing interest regarding corporate activities surrounding the reduction or elimination of waste products has started to center on corporate environmental management systems (EMS) (Melnyk *et al.*, 2003). EMSs are designed to monitor and reduce an organization's impacts on the environment and they can be registered under the ISO 14001 standard. These standards are intended to act as guidelines to create an environmental policy, objectives, and procedures for any size company, in any industry. As a result of the ability of ISO 14001 to be applied to a variety of organizations, this international standard has become the focus of much attention.

Advocates of the ISO 14001 standard claim that tangible results can be obtained from implementing an ISO 14001 system and that this system has a considerable impact on efforts aimed at protecting the environment. When used correctly, ISO 14001 allows companies to implement a framework for achieving continual improvement and advance towards the ultimate goal of environmental improvement. Supporters of the standard insist that substantial operational, managerial, compliance, and industrial efficiencies can be achieved by using a certified EMS; however, this view is not shared by everyone. Many critics argue that ISO 14001 does not ensure that continual improvements in environmental performance will occur, nor are financial rewards guaranteed. ISO 14001 requires that companies maintain continual improvement regarding the EMS, not in environmental performance. One might assume that by enhancing an EMS, improvements in environmental performance would result, but this is not necessarily assured. Many companies, governments, and other organizations are skeptical regarding the actual impacts that certification has on both environmental and financial performance.

Some critics view environmental management as an activity that is unproductive and is contrary to enhancing profits (Walley and Whitehead, 1994; Palmer *et al.*, 1995). A competing view also exists that shareholder values can and do benefit from implementing environmental management initiatives (Porter, 1991; Schmidheiny and Zorraquin, 1996). A significant quantity of research pertaining to corporate financial outcomes and environmental performance, management, and responsibility has been conducted in the past. The evidence seems to indicate that a positive relationship exists between firm financial performance and various environmental variables; however, evidence also exists that no clear significant relationships could be determined and negative relationships also exist. It is clear that more research needs to be conducted to explore the relationship between environmental management and financial performance outcomes.

Often, an ISO 14001 system or the presence of an EMS tends to be equated with positive environmental performance (Ammenberg and Hjelm, 2002). Rondinelli and Vastag (2000) point out that ISO 14001 certification does not measure the actual environmental performance of a company. ISO 14001 is a process, not a performance standard, which means that it does not guarantee or force companies to be at an optimum environmental performance level. Many investigations have been carried out to establish how EMSs influence environmental performance. From the current literature, it is still questionable what the exact nature of the relationship actually is. Different measures of environmental performance are often used, which makes it increasingly difficult to compare the results of various studies. If the relationship between improved environmental outcomes and ISO 14001 registration could be shown, there would be possible regulatory implications. To help provide information that will form the basis of sound policy and regulations, this analysis will try to further shed light on the relationship that exists between environmental management and performance.

It is apparent that a definite consensus concerning the relationship between environmental management, improved environmental performance, and profitability is lacking. There is also an absence of reliable information regarding the tangible benefits of utilizing an EMS (Melnyk *et al.*, 2003). The clarification of these relationships would allow for increased confidence in ISO 14001 as a tool to decrease toxic emissions (Russo, 2004). Corporate managers and policy analysts would also appreciate information regarding what effect environmental management has on economic outcomes. Empirical evidence regarding the impacts of ISO 14001 would allow various interested parties to determine whether ISO 14001 certification is a suitable method to achieve environmental or financial performance goals.

The purpose of this study is to examine the effects of ISO 14001 registration on corporate financial and environmental performance. Since both of these components are being examined, this study is separated into two major sections. The financial performance aspect of this research paper will investigate the stock market's reaction to the ISO 14001 registration of a sample of Canadian firms. Event study methodology will be used to determine if there is any reaction to ISO 14001 registration during a period of time surrounding the registration. The environmental performance component of this study will encompass the exploration of whether ISO 14001 registered facilities experience greater emission reductions than non-registered facilities within the Transportation Equipment Industries sector in Canada. To do this, weighted emissions of various Canadian companies will be analyzed over time to determine the relationship between ISO 14001 registration and emissions performance. The ramifications of any linkages found between environmental management, environmental performance, and financial outcomes on both corporate decisions and public policy will also be assessed. To adequately examine all of these topics, an understanding of the fundamental aspects of ISO 14001 is necessary.

2.0 Overview of ISO 14001

The ISO 14000 series standards were approved by the International Organization for Standardization (ISO) in September 1996 because of a need for standardization of processes for developing and maintaining environmental management systems (EMS) (Rondinelli and Vastag, 2000). This need was expressed at the 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro (Bansal and Bogner, 2002). ISO is a private (non-governmental) organization that forms a network of the national standards institutes represented by 147 different countries (ISO, 2003). Each country has only one member representative at ISO. There is a Central Secretariat, located in Geneva, Switzerland, that organizes the system (ISO, 2003). The series is divided into six parts, each containing different standards as shown in Table 1 (Delmas, 2002).

Table 1: Six Divisions of the ISO 14000 Series Standards

Classification	ISO Standard
EMSs	14001 and 14004
Environmental Auditing	14010 - 14012
Environmental Labeling	14020 - 14025
Environmental Performance Evaluation	14031
Life Cycle Assessment	14040 - 14043
Environmental Aspects in Product Standards	14060

SOURCE: Delmas, M. 2002. The diffusion of environmental management standards in Europe and in the United States: an institutional perspective. *Policy Sciences*, 35: 91-119.

EMSs are designed to monitor and reduce an organization's impacts on the environment and they can be registered under the ISO 14001 series standard. These standards are intended to act as guidelines to create environmental policy, objectives, and procedures for any sized company, in any industry. For a company to gain ISO 14001 certification, it has to undergo one initial audit and then have five other inspection visits during the three year time period for which the certificate is valid (Delmas, 2002). ISO 14001 can be either self or externally-certified. Organizations that have self-registered ISO 14001 systems may have to face the consequence of their system having less credibility than a system registered by an independent third party (Pollution Probe, 2003).

As of December 2002, there were a total of 49,462 companies registered in 118 countries (ISO, 2003). These companies use this standard as a tool to determine the amount of pollution that is created from different processes, to assess measurable pollution release targets, to ascertain the level at which their goals are being met, and to guarantee that the organization is committed to continuously improving its EMS (Delmas, 2002). The five requirements of the ISO 14001 series standard are shown in Figure 1.

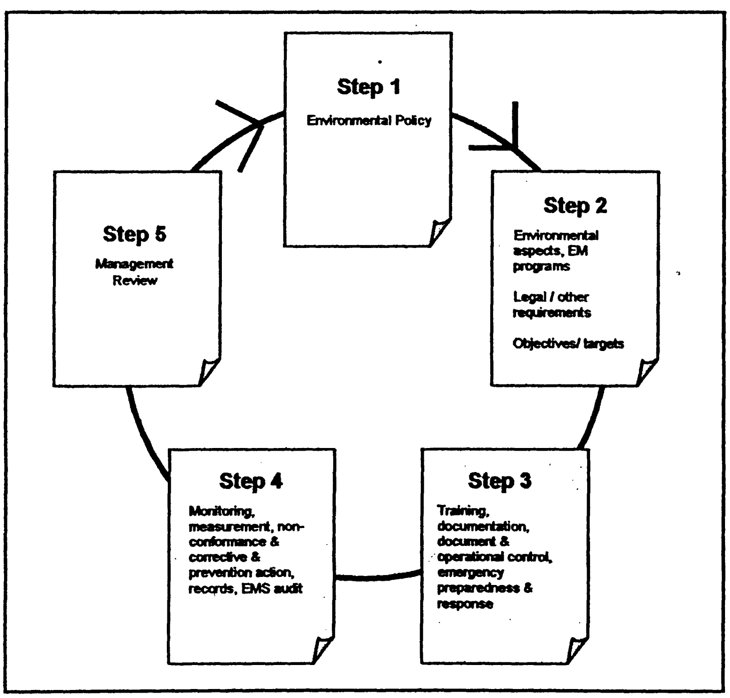

Figure 1: Requirements of the ISO 14001 series standard. Source: Modified from Cheremisinoff, N., and A. Bendavid-Val. 2001. *Green Profits.* Boston, Massachusetts: Oxford.

The first requirement of ISO 14001 involves top management developing an environmental policy and showing a commitment to implementing an EMS. Management must pledge to continue to improve, examine, and extend upon the policy while establishing dedication to preventing pollution. The policy must be documented and communicated to company employees and the public (Woodside *et al.*, 1998).

The second step involved in this process is to develop an implementation plan for the environmental policy. At this stage, a procedure for identifying environmental aspects has to be designed. Environmental aspects are elements of an organization's activities, products, or services that can interact with the environment. Significant environmental aspects must be recognized at this stage using criteria developed by the company. Any pertinent regulatory compliance requirements applicable to the company must also be acknowledged at this point. ISO 14001 also requires that objectives and targets are established and maintained at this stage. These must be consistent with the environmental policy set by the company and they must also account for legal requirements and the views of interested parties. Targets that are set out by the system must be very precise, quantifiable, and achievable within a specified time frame. The company must set these and environmental performance objectives since they are not established by the ISO 14001 system standards (Woodside *et al.*, 1998). The ISO 14001 series relies on the government, where the standards are being applied, to have performance and emission standards that are contained in their own laws and regulations as the minimum level of compliance (Pollution Probe, 2000). After objectives, targets, and legal requirements are set, the company must develop an environmental program to achieve them. The program must outline who is responsible for achieving the objectives and targets, the time frame by which they are to be accomplished, and the means by which they will be realized (Woodside *et al.*, 1998).

The third step involves the implementation of the policy and operation of the EMS under the policy. This part of the process depends heavily on self-enforcement and the leadership abilities of the company's managers (Stenzel, 2000). Also at this stage, the organization must extend the human, physical, and financial resources necessary to implement the policy and maintain the system (Murray, 1999). Appropriate training must be provided for all personnel whose work may impact the environment. To do this, the organization must establish and maintain procedures to ensure that employees are aware of significant environmental impacts and their responsibilities. The standard at this stage also entails that communication, both internally and externally, regarding the significant environmental impacts, is carried out and that a procedure is present to outline how to accomplish effective communication. Another major requirement of this stage is that a process for documenting the core elements of the EMS and their interactions is established. In addition, operations and activities associated with significant environmental aspects must be identified. After identification, the organization must make sure that these operations and activities are carried out under specific conditions set by the company. Emergency preparedness and response must also be accomplished by having the company create procedures to identify the potential for and response to accidents or emergencies and to prevent and mitigate any environmental impacts that may occur from them (Woodside *et al.*, 1998).

Monitoring and measurement devices must be set up and remedial action has to be taken in the fourth step of ISO 14001 (Delmas, 2002; Stenzel, 2000). The standard also specifies that the organization must have a documented procedure for periodically evaluating compliance with relevant environmental legislation and regulations. This does not necessarily require an audit and the evaluation does not have to be performed by an independent person. Environmental audits are also necessary to determine if the EMS conforms to planned arrangements set out for the EMS, including conformance with ISO 14001, and that the system has been correctly implemented and maintained. The standard expects that the organization will institute procedures and programs for EMS auditing. Auditors who are accredited to a register must sporadically inspect the company. These internal EMS audits can be carried out by enterprise personnel, by outside auditors, or by a combination of the two (Woodside *et al.*, 1998).

The final commitment that the standard requires is that management review must be carried out and that the company must be engaged in continually improving the EMS. The review should be conducted at regular intervals to evaluate environmental goals, targets, effectiveness of the EMS, and to make any required alterations or adjustments to the system (Murray, 1999).

2.1 Positive Aspects of ISO 14001

There are many potential benefits associated with the adoption of the ISO 14001 series standards. From a corporate perspective, these advantages could include improving efficiency in areas such as waste management and production due to the auditing process, there could be a decrease in risk of environmental accidents, resulting in lower corporate liability, enhanced public image, and internal cost savings. ISO 14001 certification can also promote higher levels of compliance with statutes and regulations because an organization must review laws and statutes on a regular basis as it prepares its EMS to be ISO 14001 certified (Delmas, 2002; Stenzel, 2000).

ISO 14001 may also be able to achieve public goals in addition to those of the private sector. Public benefit can ultimately result from an increase in the private sector's efficiency. The public can benefit from positive externalities such as enhanced competition among suppliers, diffusion of technology from the upgrading of products or advancing process methods, and improved national competitiveness (Pollution Probe, 2000).

2.2 Limitations of ISO 14001

The first major criticism of ISO 14001 is that it does not outline any minimum regulatory standard (Murray, 1999). ISO 14001 views legal standards as being the minimum performance level that should be achieved. A company will then set its own goals for performance and methods of achieving targets. Concern then exists for companies in countries where the environmental standards are lenient because companies could set their standards below easily achieved levels while still being within the law and all the while advertising that they are ISO 14001 registered (Murray, 1999).

The second major weakness with ISO 14001 is the choice of self certification. Companies have the choice of whether to self-certify their system or have external certifiers. Companies that choose to self-certify may do so out of the fear that information assembled in the certification process could somehow be exposed to the public and be used by regulators or environmental groups to prosecute environmental violations. The problem in choosing not to necessitate third-party certification is that the reliability and trustworthiness of the entire process is questioned (Murray, 1999). Also, by choosing to self-certify, a company decreases the amount of flexibility or favorability it could have hoped to received from regulators. Market pressures may even force companies to forgo the self-certification process and have a third party auditor to verify environmental performance (Murray, 1999).

Confidentiality of the EMS is another problem associated with ISO 14001 certification. Companies are very leery when they are about to become or are in the process of becoming ISO 14001 certified. Companies are very concerned about making themselves open to both civil and criminal litigation and penalties. Confidential and possibly damaging information uncovered by external auditors could be used by environmental groups or the government to expose environmental violators. Companies have been attempting to protect the information that is obtained through ISO 14001 audits with an attorney/client type of privilege (Murray, 1999). The Attorney/Client Privilege is a law that protects communications between attorneys and their clients and keeps them confidential (Stanford University, 2003). The courts have currently been rejecting these attempts since the attorney client privilege is contrary to the spirit of EMS and ISO 14001 standards. EMSs should be company-wide and should be able to be accessed and contributed to by all employees. These standards are not supposed to create any undisclosed documents that are only privy to corporate councils and environmental compliance officers (Murray, 1999).

Although strengths and weaknesses of the ISO 14001 standard are apparent, companies are continuing to implement them for a variety of reasons ranging from being committed to the environment, to hopes of increased profitability, to image enhancement.

Clarification of vague relationships previously presented using mainly anecdotal evidence between ISO 14001 and environmental and financial performance would be appreciated by companies, governmental agencies, and environmental groups.

3.0 ISO 14001 & Financial Performance

3.1 Nature of the Problem

There seem to be two very distinct outlooks regarding the connection between environmental protection and economic outcomes. A more traditional view is that environmental management is an activity that is not productive and is contradictory to increasing profits (Walley and Whitehead, 1994; Palmer *et al.*, 1995). A more modern, alternate view also exists. Supporters of this outlook ascertain that environmental initiatives do not suppress companies' competitiveness and that in some cases shareholder values have benefited from implementing environmental management (Porter, 1991; Schmidheiny and Zorraquin, 1996). A significant quantity of research pertaining to corporate financial outcomes and environmental performance, management, and responsibility has been conducted in the past. The empirical evidence that is available seems to indicate that a positive relationship exists between firm financial performance and various environmental variables; however, evidence also exists where no clear significant relationships could be determined and negative relationships also exist. It is clear that more research needs to be conducted to explore the relationship between environmental management and financial performance outcomes.

3.2 Objective of the Study

The objective of this section of the study is to examine whether companies that invest in ISO 14001 management systems experience superior stock market price returns in reaction to ISO registration. To understand the reasoning for conducting this type of analysis, one must examine both historical and current views of the relationship between environmental management and financial outcomes. It is also important to review the types of research methodologies that are available to examine the stock market reaction to ISO 14001, and why the event study methodology was chosen to carry out this research.

3.3 Literature Review

3.3.1 Introduction

The relationship between environmental management and financial performance is becoming a more prominent topic since more companies are realizing that environmental programs can often make significant differences in profitability and viability (GEMI, 1998b). Another possible reason for this topic's popularity could be because environmental responsibility is becoming a necessary aspect of business today (Melnyk *et al.*, 2003). Two common views are widely held regarding the relationship between environmental protection and economic outcomes in the literature. The traditional perspective, that is still present today, is that environmental management drains resources, is non-productive, is inconsistent with increasing shareholder profits, and conflicts with other business objectives (Walley and Whitehead, 1994; Palmer *et al.*, 1995). An alternate view is that environmental protection does not stifle companies' competitiveness (Porter, 1991) and that in some cases shareholder values have benefited (Schmidheiny and Zorraquin, 1996). Evidence has suggested that environmental management implementation often results in measurable financial improvements (Cohen *et al.*, 1997; Hart and Ahuja, 1996; King and Lennox, 2001; Klassen and McLaughlin, 1996; Konar and Cohen, 2001; White, 1996). Both the traditional perspective and the alternative to it regarding the relationship between environmental management and economic performance will be examined by reviewing the historical context of this subject and by analyzing studies that have been carried out in this and related research areas.

3.3.2 Historical Overview

Over two decades ago, it seemed clear to both academics and those in the manufacturing industry what the relationship was between environmental practices and corporate performance. Pursuing environmental objectives was seen to be against sensible business strategy (Melnyk *et al.*, 2003). According to the traditionalist's view of the corporation as summarized by Pava and Krausz (1996), business managers have a responsibility to owners of the corporation (shareholders) to maximize the value of the firm. This fiduciary duty is seen to be violated if managers decide to embark upon projects that in no way improve the income generating capability of the firm. Previously, investments that attempted to enhance environmental performance were believed to result in diminished quality, escalated costs, and increased lead times. The product of these elements would be overall decreased profits and reduced earnings to stockholders (Melnyk *et al.*, 2003). Over the last twenty years, companies that were confronted with environmental regulations attempted only to achieve compliance and often fought these new rules being forced upon them (Walley and Whitehead, 1994).

In the mid to late 1980s, the environmental movement began to change. Regulations were no longer focused so intently on the specifics of how compliance was achieved, just that results were produced (Walley and Whitehead, 1994). It is during this period that Walley and Whitehead (1994) contend that "win-win" situations existed because the easily made improvements had been completed or the "low hanging fruit" had been harvested. Easily solved problems had been fixed, and companies then would accept the notion that committing to environmental actions would result in financial gains. However, once the straightforward problems were solved, management had difficulty finding more "win-win" solutions (Walley and Whitehead, 1994).

Porter (1995a) challenged this view and the traditional theory regarding environmental protection and financial performance. He claimed that the relationship between economic competitiveness and environmental protection did not have to be a negative one (Porter, 1991). This debate reflected the shift in manufacturer's attitudes regarding environmental responsibility and a movement towards pollution reduction gradually emerged (Melnyk *et al.*, 2003). Porter (1995a) argued that pollution is equal to inefficiency, and is a form of economic waste since resources have been used incompletely or ineffectively. Contrary to the previously held belief, Porter stated that a reduction of pollution or waste would make companies more competitive. Criticisms to Porter's view are prevalent (e.g. Walley and Whitehead, 1994) but supporters of his beliefs also exist (Klassen and McLaughlin, 1996; Leal *et al.*, 2003; Melnyk *et al.*, 2003; Montabon *et al.*, 2000). Walley and Whitehead (1994) argue that environmental costs for companies are increasing and that there is little economic return to show for it. "Win-win" situations regarding environmental protection and financial outcomes are perceived to be few and far between and likely eclipsed by the total cost of a company's environmental initiatives (Walley and Whitehead, 1994).

The debate surrounding this topic continues, but there has been a change in managerial attitudes and perceptions regarding reducing pollution and more effective environmental management. The traditionalist view regarding the negative relationship between economics and the environment still persists, but this view is starting to decline in popularity (Melnyk *et al.*, 2003).

It is imperative to not only review the historical context of this subject, but to examine the current research regarding environmental management and financial performance. According to the EPA (2000), the most noticeable characteristic of this body of research is that there appears to be a positive relationship between the two types of performance. This is in spite of the different variables that are used to measure each type of performance, the date of the study, or the method that is used to test the relationship. The present literature on the subject either focuses on the relationship between environmental and various measures of financial performance, the link relating environmental management and stock price returns, or the connection between corporate social responsibility and financial performance.

3.3.3 Environmental & Financial Performance

Molloy *et al.* (2002) asserts that the literature that analyzes the relationship between environmental and financial performance falls into three distinct categories. The first category includes event studies which examine the relative change in stock prices subsequent to some environmental event using event study methodology (King and Lenox, 2001; Klassen and McLaughlin, 1996). Secondly, some studies fall into the portfolio analysis group which compares stock market returns of portfolios that are generated using environmental performance criteria. The last class of studies includes cross-sectional analyses between environmental performance and firm accounting measures or market value.

3.3.3.1 Financial Event Studies

Event studies examine whether there is a change in stock prices after an environmental event. For example, Hamilton (1995) carried out an event study that investigated whether Toxic Release Inventory (TRI) data released by the EPA in 1987 was considered to be newsworthy by print journalists and investors. The results indicated that the higher the emission figures were for a company's TRI report, the more journalists were prone to write about the company's toxic releases. It was concluded in the study that stockholders in these firms had statistically significant negative returns after the first release of the information by journalists.

Konar and Cohen (1997) also carried out a similar event study, but instead of taking into account how environmental performance influences financial performance, they examined whether a firm's decreasing stock price, due to the TRI data release, equated to a significant reduction in toxic emissions. Forty firms that had the largest number of abnormal returns in 1989, due to the TRI data release to the public, were investigated with respect to their negative abnormal returns and the emissions that ensued after the TRI information release. Firm size was controlled for by using two measures of environmental performance. The first was the absolute level of emissions per thousand dollars in revenue, and the other was the firm's rank (normalized by the number of firms in the industry) within its industry category. Emissions in 1989 were compared to emission levels in 1992 along with average TRI emissions from 1988-1990 and 1991-1992. After the TRI data were released, firms in the study were found to decrease in rank for their industry in terms of TRI per dollar and they also reduced their TRI per dollar of emission. This indicated that firms were becoming relatively "cleaner" for the 1989 and

1992 statistics. Konar and Cohen concluded that new information provided by the TRI data regarding a firm's toxic emissions that had a significant effect on a firm's stock price was likely to induce that firm to significantly decrease subsequent emissions and enhance environmental performance. Therefore, they concluded that providing information to the public regarding firms' emissions may be an effective means of decreasing environmental externalities, which impose costs on society, beyond regulatory standards.

Another study that empirically tested the linkage between financial and environmental performance is a financial event study carried out by Klassen and McLaughlin (1996). The authors believed that the connection between environmental management and financial performance could be investigated by evaluating the literature regarding operations strategy. As seen in Figure 2, environmental management was thought to affect operations strategy since it influences both the structural and infrastructural components such as management systems and product and process

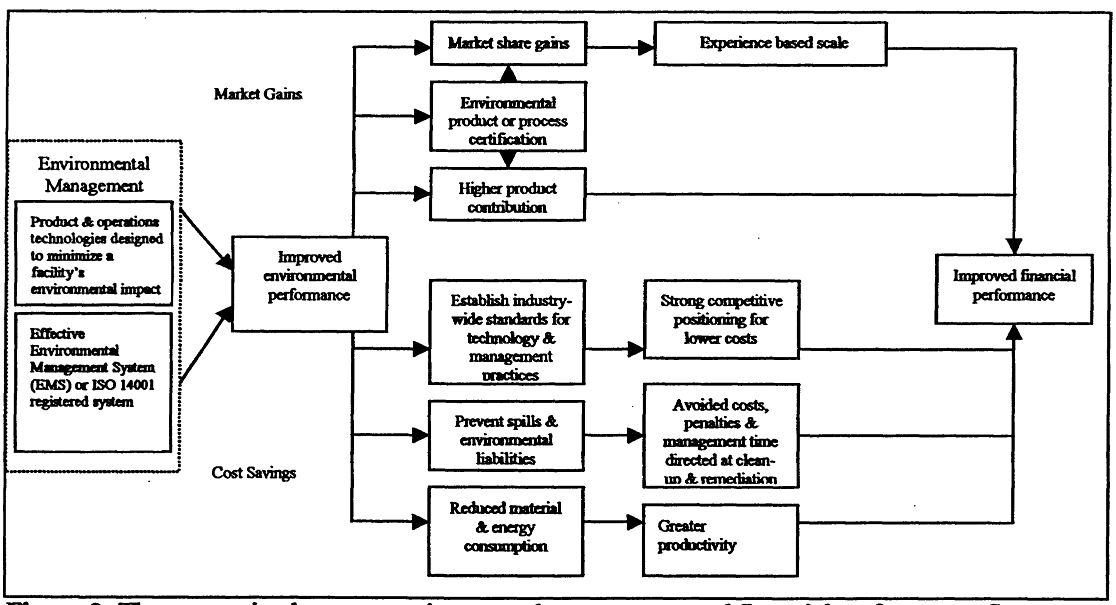

Figure 2: The connection between environmental management and financial performance. Source: Klassen, R.D., and C.P. McLaughlin. 1996. The impact of environmental management on firm performance. *Management Science*, 42 (8): 1202.

technology. Improved environmental performance, along with strong management systems, were hypothesized to have improved financial performance for the firm. Conversely, weak environmental performance was theorized to have a negative effect on firm profitability. The research methodology consisted of using an announcement of an environmental award by a third party as an indicator of strong environmental performance and conversely, the announcement of an environmental crisis as an indicator of weak environmental performance. The sample periods for environmental events were limited to 1985-1991 and crisis to 1989-1990. Three day event periods which captured the financial market's net valuation of the environmental event were employed. This event period consisted of the day before, the day of, and the day after the environmental crisis or award announcement. The results indicated that receiving environmental awards was connected with a statistically significant cumulative abnormal return (CAR) of 0.63 %. The average market valuation of the environmental awards was $80.5 million, which is equal to approximately $0.37 per share. The average CAR that was linked to an environmental crisis event was -0.82 % which resulted in a market valuation of -$390 million or -$0.70 per share. A cross-sectional analysis was also carried out which determined that first time award winners were linked to larger growth in market valuation, and smaller increases were observed for firms in environmentally "dirty" industries.

Other similar studies using event methodology include Jones and Rubin (1999) and Laplante and Lanoie (1994).

3.3.3.2 Financial Portfolio Studies

Within the financial literature, many research papers focus on the investigation of stock market returns in portfolios of companies that are environmentally responsible (King and Lenox, 2001). White (1996) attempted to answer the question "Does it pay to be 'green'?" in his analysis of the relationship between shareholder value and firm reputation. A selection of six publicly traded firms from 1989 – 1992 that were environmentally rated by the Council on Economic Priorities (CEP) had their monthly stock returns analyzed. It was concluded that risk was an important determinant of portfolio return and that greater returns could have been experienced by investors if they had purchased stock from firms that were rated 'green' by the CEP. Another portfolio study was conducted a few years later on by Cohen *et al.* (1997) that produced similar conclusions.

Cohen and his colleagues (1997) constructed two balanced industry portfolios of companies from the Standard and Poor's 500 index. Both accounting and market returns of "high polluters" were compared to "low polluters". Several different measures of environmental performance were taken from government databases from 1987-1989 to rank the firms within each industry. The results indicated that in more than 80 percent of the portfolio comparisons, the "low polluter" portfolio performed better than the "high polluter" portfolio. When the risk adjusted stock returns were examined, approximately 75 percent of the "low polluter" portfolio performed better than the "high polluter" portfolio; however, only 20 percent of these comparisons were statistically significant. The low significance of these results suggested that there was no penalty imposed for investing in companies that have good environmental performance but there were also no premiums experienced either.

3.3.3.3 Cross-Sectional Analyses

Some of the studies regarding environmental and financial performance fall into the cross-sectional analysis category. In this category, standard regression techniques were used to analyze the effects of modifications in pollution emissions on changes in financial performance (King and Lenox, 2001). Hart and Ahuja (1996) established that from 1991 to 1992 emission reductions had a significantly positive influence on lagged values of return on equity. They then concluded that decreased emissions due to pollution prevention (P2) resulted in an increase in the bottom line within one to two years after the P2 measures were put into place. This correlation was found to be significant among firms that were considered to be "high polluters". It was theorized that a decrease in emissions in this group of firms resulted in enhanced financial performance since these companies had more to gain from reducing emissions as compared to firms with initially low amounts of emissions (Molloy *et al.*, 2002).

Russo and Fouts (1997) assert a resource based perspective of firms. They claim that firms with a proactive environmental policy will frequently redesign their production or delivery processes to decrease waste and to become more efficient. Physical resources can become a source of competitive advantage if firms start performing better than competitors with equal assets. Prevention policy ultimately fosters increased employee skills, participation within the firm, and organizational commitment and learning. A policy choice that includes prevention will affect a firm's capability to generate profits.

Analyzing a sample of 243 firms that were environmentally rated by Franklin Research and Development Corporation, and financial data obtained from COMPUSTAT from 1991 to 1992 allowed the authors to conclude that there is a connection between superior economic and environmental performance that strengthens in higher growth industries.

Dowell *et al.* (2000) investigated whether multi-national enterprises (MNEs) investing in developing countries with less rigorous environmental standards experienced a competitive asset or liability when adhering to stringent, global corporate environmental standards. The authors examined a sample of U.S. based MNEs' global environmental standards in relation to their stock market performance. Firms with stricter environmental standards were shown to have higher market values than those firms that were less stringent, or that were located in a country with weakly enforced standards.

Another study, completed by Konar and Cohen (2001) attempted to answer the question "Does the market value firms that have better environmental reputations than those that do not?" The impact of environmental reputation on firm market value was measured by decomposing firm value into tangible and intangible asset valuation. Intangible assets include factors of production that enable a firm to earn profits greater than the returns on tangible assets. Examples of intangible assets are patents, brand names, firm goodwill, and trademarks. After controlling for variables that were typically thought to explain firm level performance, the results indicated that poor environmental performance was negatively correlated with the intangible asset value of firms. In the sample, the average intangible liability was approximately 9 percent or $380 million of the replacement value of tangible assets. It was then concluded that legally released substances had a significant effect on intangible asset value of publicly traded companies.

The severity of these effects was found to vary between industries. Industries that had a history of polluting were found to experience greater losses.

Another major cross-sectional study carried out was by King and Lenox (2001) to attempt to differentiate pollution reduction from other previously unmeasured underlying industry attributes. They analyzed whether the environmental performance of a firm was relative to its given industry and whether firms that operated in "cleaner" industries accounted for linkages between environmental and financial performance. Evidence from the study showed that an association between reduced pollution and improved financial performance existed but the causal direction of the relationship could not be demonstrated. It also could not be sufficiently proven that firms who chose to operate in cleaner industries were linked to better financial performance.

There have been a few studies that focus on the direct effects of environmental management as opposed to the previously mentioned studies regarding environmental performance. A conceptual framework was developed by Feldman *et al.* (1996) that links environmental management systems, environmental performance, environmental signaling, firm risk, and firm value as shown in Figure 3. This model implies that to receive an increase in firm value, there must be improvements that are made to environmental management systems and performance. Feldman *et al.* (1996) claims that by decreasing the amount of environmental risk, a company will in turn decrease its Beta value (measure of a firm's systematic risk), which will result in a lower cost of capital and will ultimately lead to a positive share price increase. Using 330 firms, during two

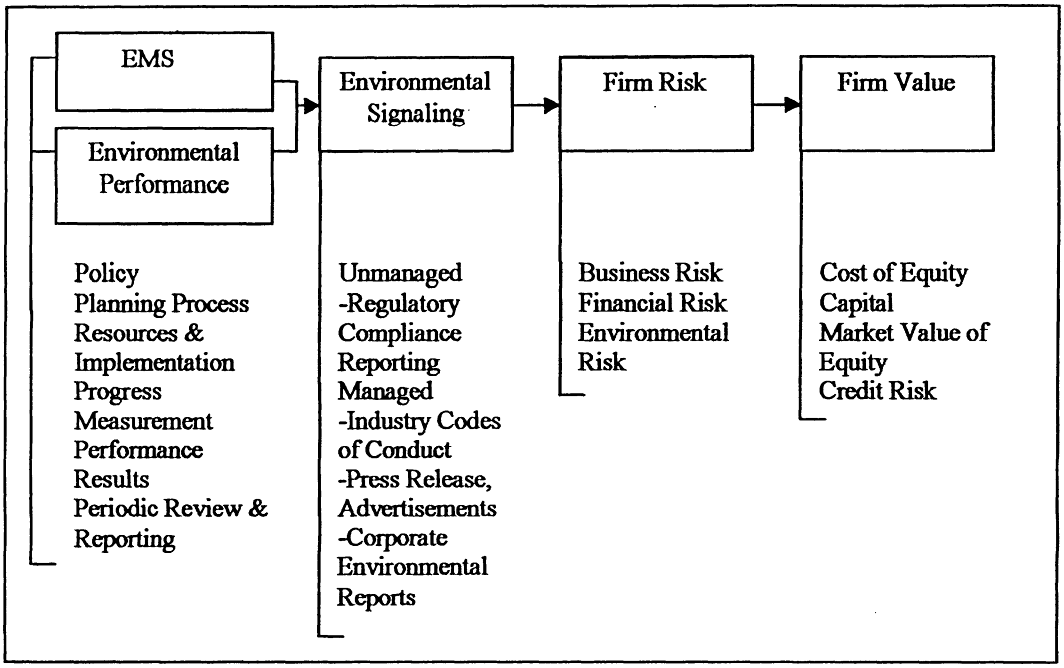

Figure 3: Conceptual Model Linking Corporate Environmental Management and Performance with Firm Value. Source: Feldman, S.J. *et al.* 1996. *Does improving a firm's environmental management system and environmental performance result in a higher stock price?* ICF Kaiser International, Inc.

separate time periods, multiple regression analysis showed the statistical significance of an empirical model developed to estimate whether both environmental management and environmental performance influence a firm's financial risk. It was concluded that as a firm enhances its EMS, the financial risk of that firm will decrease. In addition, as environmental performance gets better, the firm risk will diminish. These results suggest that environmental initiatives result in lower risk levels and also produce an increase in the stock price of public companies.

Thomas (2001) also provided insight regarding the relationship between stock market returns and, more broadly than Feldman *et al.* (1996), an environmental agenda. She attempted to determine if companies that adopted an active environmental agenda experienced superior stock returns. To examine whether an environmental agenda was evidence of superior long run returns, Thomas observed whether companies adopted environmental policies, the presence or absence of an environmental training program, and the number of prosecutions companies received by an environmental standards agency. Survey data from 131 companies, and financial information over the years 1985 to 1997 allowed for regression analysis to be carried out. Adoption of an environmental policy by companies in industries known for being heavy polluters was found to be correlated with superior market returns. Thomas suggests that this implies that it was in both the companies' and shareholders' best interests to have the environmental policy in place. No other significant results were found.

Overall, many of the relationships found within cross-sectional studies seem to support the notion of a positive relationship between economic and environmental performance. One study by Molloy *et al.* (2002) was carried out to test this relationship by using more recent data and also took into account the influence of alternative measures of management. It was found that poor environmental performance displayed a statistically significant positive influence on market returns, with the exception of the response to non-compliance penalties. Molloy *et al.* (2002) claims that this relationship shows that investors view environmental upgrading as being expensive, unless the upgrades are going to be made in reaction to regulations to avoid any fines.

3.3.4 Implications to Firms, Government, and Investors

Correlation between environmental and financial performance may be sufficient for market analysts, who collect figures on environmental performance as sign of future capital market returns, but are not sufficient for policy makers and firm management (Kiernan 1998). Causation needs to be proven to show that improvement in environmental performance pays off (King and Lenox, 2001). Thomas (2001) makes a strong point in that if the stock market reflects the acceptance of an environmental agenda (or an EMS or environmental performance) as a sign of improved future earnings or as an indication of effective management, the government can decrease the amount of its involvement in monitoring firms. Positive stock market returns will be incentive enough for firms to comply and possibly even go beyond compliance. This would be a more cost-effective way for government to achieve its goals by allowing some flexibility to enable companies to meet standards and regulations by relying more on market-based incentives and less on "command-and-control" regimes (Clarke, 1994).

If a causal relationship can be sufficiently shown, it would suggest to firms that environmental management and improved financial performance can be substantiated. Wells (1994) cautions that "we do not need to throw money at every environmental opportunity that comes along," since investments in environmental management are very costly and therefore should be properly evaluated, like all other investments (Feldman *et al.*, 1996). Sound environmental management can lead to decreased risk levels of the firm, which is highly valued by investors and financial markets (Feldman *et al.*, 1996). A lowering of a firm's risk due to short and long term environmental performance is a key factor that investors consider when they are figuring out the amount of return that they need to make a certain investment. Smaller levels of risk translate into lower required returns which result in a decreased cost for investing in the pursuits of the firm (Feldman *et al.*, 1996).

3.3.5 Summary & Criticisms

It has been demonstrated that a significant quantity of research pertaining to corporate financial outcomes and environmental performance, management, and responsibility has been conducted. The empirical evidence seems to indicate that a positive relationship exists between firm financial performance and different environmental variables in most papers that were examined. A few cases exist where no clear significant relationships could be determined (Pava and Krausz, 1996, Thomas, 2001). However, negative relationships were also present (Molloy *et al.*, 2002; Pava and Krausz, 1996; Wagner *et al.*, 2002). There was an indication that the linkages proven in a few cases may or may not be related to the type of industry a firm was in (Hart and Ahuja 1996; King and Lenox, 2001). Certain traditional industry sectors are known to be "dirtier" since they are associated with high pollution levels as compared to other "clean", low pollution intensive industries. Firms operating in "dirty" sectors would have more to gain by introducing environmental management practices. More research needs to be conducted to determine if this phenomenon is actually occurring by controlling for industry type, as opposed to many of the previous studies that did not focus on specific industries. It also has been pointed out by the EPA (2000) that research regarding the connection between financial and environmental performance does not seem to answer the most important questions that are being asked by investors, firms, and policy makers (EPA, 2000). Reed (1998) has outlined the major valid criticisms that are often made regarding the current literature.

According to Reed, most of the research papers do not focus on a specific industry. Analysts that believe that environmental management can enhance a firm's profitability also think that the amount of value added to the firm varies from one industry to another. Reed also points out that a significant number of the studies depend on restricted series of data, have considerable quality problems, and do not attempt to analyze how firms are able to manage environmental challenges and prospects currently and in the future. Studies, such as the one carried out by Cohen *et al.* (1997), that compare firms' performance in stock portfolios of high and low polluters did not adjust for disparities in risk. Lastly, the issue of causation was overlooked in most studies.

This last criticism calls for attention since there are three theories that exist that attempt to clarify the connection between corporate financial and environmental performance (EPA, 2000). The first is that firms that are better managed may naturally have improved environmental performance. Secondly, firms that are not very successful may be less likely to invest money on environmental initiatives than profitable firms and vice versa. Finally, while en route to improving environmental performance, a firm may, in turn, experience better financial performance (EPA, 2000). Each of the theories has not been sufficiently established or rebutted.

3.4 Research Methodology

After a careful review of the literature, the approach that is chosen for this analysis is the event study methodology. It is chosen because ISO 14001 is seen as a signal to the public of a firm's environmental performance and dedication to future performance. If the stock market reacts positively, this may indicate that ISO 14001 is viewed as an event that will provide insight into the willingness of a company to invest in environmental management in the long term (Thomas, 2001). One other similar study regarding ISO 9000 (quality certification) has been carried out by Nicolau and Sellers (2002). This shows that other researchers have also validated this method of analysis for a similar type of ISO certification. Extending upon the ISO 9000 study, and the other event studies that have been presented, this current study will focus on ISO 14001 as the specific type of event and test if there is any abnormal change in stock returns for a sample of companies.

Although all of the criticisms pointed out in the literature review cannot be fully addressed by this study, it is still worthwhile to carry out this exploratory investigation. This research is necessary since there is a void in the research regarding the effects of ISO 14001 on financial performance, especially within the Canadian context. Data regarding ISO 14001 registered companies are restricted to a small number of firms in Canada, since only 1064 companies in Canada were ISO 14001 registered as of 2002 (ISO, 2005). The type of industry can not be controlled for since the analysis is limited by the number of companies that are actually registered and the available stock market data for specific companies. The data are believed to be of high quality and this event study will not be dealing with TRI, or similar data, which will eliminate the errors and problems associated with TRI data. Unfortunately, not all of Reed's criticisms could be adequately addressed; however, it is believed that there is enough of a gap in the knowledge regarding ISO 14001 in the Canadian context to justify carrying out this exploratory analysis. The procedure for the event study is described in further detail below.

A method that allows for the evaluation of the effect that a certain event has on a company's stock price is termed an "event study" (Bodie *et al.*, 1993). Event study methodology has been utilized to examine the stock market's reaction to the adoption of ISO 14001. This method enables the stock price behaviour surrounding the time of the announcement of environmental certification to be analyzed. The stock return was used as a measure of a firm's financial performance since it allows for the analysis of the impact that ISO 14001 certification has on the market value of a firm (Nicolau and Sellers, 2002). The share prices of firms are analyzed to determine if there is a change in the stock return following ISO 14001 registration. If there is a change in the stock return, it can be assumed that the market will reflect a change in net present value of the firm because of the certification (Klassen and McLaughlin, 1996). If the information regarding the ISO 14001 certification reveals an increase in the expected future cash flows, then the firm's stock is currently undervalued in the market (Konar and Cohen, 1997). Investors aware of this will then take advantage and buy stock which will raise the demand for the security. The ISO 14001 certification announcement by the news media is a signal of environmental management and performance of a firm to the market. The market may perceive the ISO 14001 certification as a signal of higher future earnings, resulting in a positive stock price response. In reaction to the new information regarding ISO 14001 registration, investors will reassess the firm's expected future cash flows and ultimately trade the firm's securities in the stock market which affects both stock prices and market returns (Konar and Cohen, 1997). Investors may attribute enhanced future earnings to the possible improvements of the firm's relationships with insurance companies, the elimination of costs associated with conformance to conflicting national standards, the reduction of liability and risk, the process cost savings by reduction of material and energy inputs, and the improved access to capital (Omnex, 2005).

Event study methodology is based on the Efficient Market Theory. This theory is summed up as a market where prices will always fully reflect available information (Campbell *et al.*, 1997). The semistrong-form of the Efficient Market Theory includes all publicly available information that becomes accessible to all market participants and is information that is constantly evaluated and reflected in the price of a stock (Campbell *et al.*, 1997; Klassen and McLaughlin, 1996). Under the assumption that investors conduct themselves in a reasonable manner, it is anticipated that share prices will mirror available information regarding a firm (Nicolau and Sellers, 2002). The Efficient Market Theory is the theoretical basis on which event study methodology and has been developed and improved upon over the years in many studies (Brown and Warner, 1985; McNichols and Dravid, 1990). Applications of event study methodology in various fields are abundant (Campbell *et al.*, 1997). For example, event studies have been employed to evaluate the market assessment of quality awards (Hendricks and Singhal, 1996), stock market performance and environmental awards and crisis (Klassen and McLaughlin, 1996), and the stock market reaction to quality certification (Nicolau and Sellers, 2002). Therefore, it is appropriate to employ event study methodology to analyze the stock market's response to a firm that chooses to adopt the ISO 14001 standard. Stock returns have the tendency to fluctuate with the market, but the onset of an unanticipated event can also have the ability to affect the value of a firm's return (Klassen and McLaughlin, 1996). The objective of this study is to differentiate between returns that are caused by new information regarding a firm obtaining ISO 14001 certification and the normal return of the firm. To accomplish this differentiation between returns, the variation in the share price on the date that the ISO 14001 registration is announced must be compared to the variation in the price of the stock during a period of time without any unexpected events occurring (Nicolau and Sellers, 2002). Therefore, the "event date" is the date that the ISO 14001 certification is made public via a media release, which is typically the date that the market is made aware of the granting of the certificate.

To determine the impact of the event, a measure of abnormal return is required. The Market Model, as shown in Equation 1, is a statistical model that is used to calculate the variation in share prices for any day by linking the return of a stock to the return of the market portfolio (Campbell *et al.*, 1997; Nicolau and Sellers, 2002). An assumption of this model is that a linear relationship exists between the expected return of a stock and the expected return of a market index or portfolio which is also known as the "normal return" (Klassen and McLaughlin, 1996). The normal return is defined as the return that is expected if the event did not occur (Campbell *et al.*, 1997). An ordinary least squares (OLS) method is applied to estimate the parameters over a long estimation period that occurs prior to the event date (Klassen and McLaughlin, 1996). To calculate the normal return, the following equation was used:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \qquad (1)$$

where R_{it} represents the returns of the firm's share i on day t, R_{mt} is the rate of return on the market portfolio or index on day t, ε_{it} is the error term, and α_i and β_i are both calculated parameters, where α_i is the constant term and β_i is the slope. The β_i value measures a firm's systematic risk, which is a measure of a given stock's volatility relative to the overall market. The higher the firm's Beta value, the greater the firm's systematic risk. The market has a Beta value of one and stocks with a Beta value greater than one are more volatile than the market (Feldman *et al.*, 1996). These parameters allow for the calculation of expected returns on the event day and the expected returns over a longer period of time. This period of time is referred to as the event window (Nicolau and Sellers, 2002). Day 0 is the event day, Day -1 is the day prior to the event and Day +1 is the day after the event. Day -1, 0, and +1 are the three days considered in the event window in this study. To calculate the return of the firm's share *i* on day *t*, the following equation was used:

$$R_{it} = (P_t / P_{t-1}) - 1 \qquad (2)$$

where P_t represents the price of an asset of the firm.

To determine the abnormal return (A_{it}) during the event window around the company's public announcement day of an ISO 14001 registration, the following formula was employed:

$$A_{it} = R_{it} - (\alpha_i + \beta_i R_{mt}) \qquad (3)$$

where α_i and β_i were calculated with Equation (1) which regressed R_{it} on R_{mt} over an estimation period which occurred before the event window. The measurement of the independent variable, R_{mt} poses the problem of whether to use a value-weighted or an equal-weighted index, which has been an issue throughout past event studies within the literature. An equal-weighted index is a market index in which all the securities contribute equally to the value of the index (Vanguard, 2005). According to Henderson (1990), the theory of event studies suggests that a value weighted index is more appropriate index since it better reflects the total market performance. A value-weighted index is a stock index in which each stock affects the index in proportion to its market value (Investorwords, 2005). This means that greater value is assigned to the stock of companies that have the highest market capitalization, calculated by multiplying the number of existing shares by their current market price (Investorwords, 2005). It has been shown by Brown and Warner (1980) and expanded upon by Peterson (1989) that an equal-weighted index is more likely to uncover abnormal returns (Henderson, 1990). To solve the issue of whether a value or equal-weighted index should be used, all calculations were first made with the equal weighted index, and again with the value-weighted index. This would ensure that any relationships that may not be as obvious if one index was chosen to be used over the other would be uncovered.

3.4.1 Overall Sample

The methodology for the overall and individual company analysis were derived from Brown and Warner (1980) and Adams *et al.* (1999). The abnormal returns of the entire sample of companies were averaged and the average was then tested to determine its significance. This average, denoted as $\overline{A_t}$, is statistically tested in order to establish whether the event date (and the other days in the event window) has a mean abnormal return equal to zero (H_0: $\overline{A_t} = 0$). The resulting test statistic for event day t is

$$TS_t = \frac{\overline{A_t}}{S_{\overline{A}}} \qquad (4)$$

where

$$S_{\overline{A}} = [(\frac{1}{200-1}) \sum_{t=-209}^{-10} (\overline{A_t} - \overline{A})^2]^{\frac{1}{2}} \qquad (5)$$

and

$$\overline{A} = \frac{1}{200} \sum_{t=-209}^{-10} \overline{A_t} \qquad (6)$$

$$\overline{A_t} = \frac{1}{N_t} \sum_{i=1}^{N_t} A_{it} \qquad (7)$$

3.4.2 Individual Company Sample

A microanalysis allowed for each of the companies' abnormal return on Day -1, 0, and +1 to also be examined. By carrying out this analysis, each company could be analyzed individually to determine which firms were influencing the overall sample the most and which firms affected the sample the least (Adams *et al.*, 1999). Each firm's abnormal returns, A_{it}, on Day -1, 0, and +1 were tested for significance. To do this, the typical daily abnormal return was subtracted from the abnormal return on the event day and was divided by the standard deviation of the estimation period using the following equations:

$$TS_{it} = \frac{(A_{it} - \overline{A_i})}{S_i} \qquad (8)$$

where:

$$S_i = [(\frac{1}{200-1}) \sum_{t=-209}^{-10} (A_{it} - \overline{A_i})^2]^{\frac{1}{2}} \qquad (9)$$

and

$$\overline{A_i} = \frac{1}{200} \sum_{t=-209}^{-10} A_{it} \qquad (10)$$

A parametric test was chosen for the aggregated sample since parametric tests seem to have worked well, in earlier studies, with empirical data.

3.4.3 Description of the Sample

It is necessary to clearly define the environmental event to carry out the described analysis. According to Klassen and McLaughlin (1996) the environmental event has three characteristics which are: defining the event, identifying the day that the event is announced, and discovering which firm is involved with the event. The event date was defined as the date that the ISO 14001 certification was made public via a media release. This type of announcement was chosen since it is the date that the market becomes aware of the ISO 14001 registration, whereas the actual date that the certificate is granted may not be the day that the public became aware that a company was registered. Four comprehensive electronic databases; ABI/Inform Trade and Industry, CBCA Complete, Proquest Canadian Newsstand, and Factiva were searched from the years 1996 (the year that ISO 14001 was created) to December 31, 2002 for ISO 14001 registrations. The search was limited to the end of 2002 since the Canadian Financial Markets Research Centre (CFMRC) stock market data necessary for the analysis was only available until December 31, 2002. The results of this search yielded 57 companies. Of this sample, 20 companies, that had an announcement of ISO 14001 but were not included on the CFMRC company listings of Common or Preferred Equities, were eliminated from the analysis. From the 57 company sample, 12 companies were eliminated because of insufficient or missing stock market values during the specified time period. The result was a sample of 25 news items regarding ISO 14001 registrations. To minimize the presence of any confounding effects during the event period, the aforementioned databases were then searched to see if there were any relevant news releases that would have affected company returns during each event period and one day prior to and subsequent to the event period. Any news items that mentioned a merger, public offer of stock acquisition, changing/firing of a CEO, large purchases of shares, etc. were first analyzed with the full sample and then were removed from the sample to allow for a second analysis absent of confounding events (Klassen and McLaughlin, 1996; Nicolau and Sellers, 2002). Nineteen firms remained after removing firms that experienced confounding circumstances. Table 1 in Appendix A demonstrates the major characteristics of the sample, including a description and the year of the ISO 14001 registration.

The event period consisted of three days in total (-1, 0, +1) which encapsulated the announcement of an ISO 14001 registration's impact on the financial market. Day 0 was the actual announcement day, Day -1 was used to encompass any effect of prior knowledge of the event and the last Day, +1, was used to capture any effect the information had as it became publicly dispersed (Klassen and McLaughlin, 1996). The estimation period was made up of 200 days, starting at Day -209 to Day -10 as seen in Figure 4. To control for "insider trading", which occurs when information regarding the event is leaked before the official public release to a small group of investors, the 10

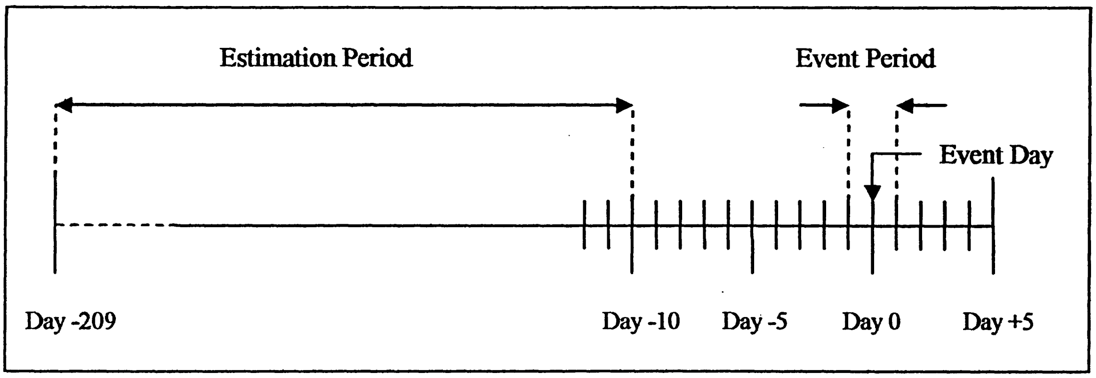

Figure 4. Time Frame for Event Study. Source: Klassen, R.D., and C.P. McLaughlin. 1996. The impact of environmental management on firm performance. *Management Science*, 42 (8): 1206.

days before Day 0 were not included in the estimation period to limit contamination of the estimation period (Klassen and McLaughlin, 1996). The abnormal returns of each company during the event window were calculated and the student's t-test statistic was used to determine the significance of each abnormal return within the event window.

3.5 Results

3.5.1 Overall Sample Results

The mean abnormal returns and their test statistics for both the full sample of companies and for the sample of companies with confounding events removed are shown in Table 2. The highest abnormal returns appear on the day after the announcement (Day +1). However, no significant mean abnormal returns were found on either the announcement day or the day prior to or after the event day. Nevertheless, it is still valuable to review the individual companies' abnormal returns and their significance during the three day event window.

Table 2: Mean Abnormal Returns and t-statistics for Overall Sample of a Stock Price Response to ISO 14001 with and without Confounding Events.

Abnormal Return Model	t = -1	t = 0	t = +1
All Companies			
Equal Weighted Index	-0.0001 (-0.0274)	0.0007 (0.1367)	0.0050 (0.9364)
Value Weighted Index	-0.0010 (-0.1830)	0.0008 (0.1490)	0.0065 (1.2347)
Confounding Events Removed			
Equal Weighted Index	0.0030 (0.4514)	0.0024 (0.3649)	0.0066 (1.0118)
Value Weighted Index	0.0017 (0.2563)	0.0022 (0.3394)	0.0080 (1.2280)

N = 25 for All Companies, N =19 for sample with confounding events removed
No significance found at the two-tailed, 10% critical value, t-statistics are in parentheses

3.5.2 Individual Company Sample Results

In the analysis that was carried out for the entire sample of companies, the mean of all 25 ISO 14001 registered companies on the announcement day was concurrently tested for significance. Conversely, with the individual company sample tests, the entire distribution of companies were individually examined to see how the individual companies influenced the overall results. This set of results is more anecdotal in nature since they cannot be combined into a single test statistic with a p-value or a confidence interval (Adams *et al.*, 1999). Each company's event window (Day -1, 0, +1) abnormal return A_{i-1}, A_{i0}, and A_{i+1} was tested to determine whether it was significantly different from its characteristic daily abnormal return $\overline{A_i}$. Table 3 shows the specific company event-day abnormal returns with t-statistics listed in parentheses. When examining the abnormal returns, it is apparent that 5 out of 25 companies encountered significant positive abnormal returns. Specifically, Abitibi-Consolidated ($p<0.01$), Cameco ($p<0.05$, $p<0.01$), Canfor Corporation ($p<0.05$), Domtar ($p<0.05$), and Weyerhaeuser ($p<0.05$) experienced unusually elevated returns during certain days within the event window. However, 4 companies – Cambior ($p<0.05$), Shell (both the Refinery and Manufacturing centre) ($p<0.05$, $p<0.01$), and Tembec ($p<0.05$) appear to have negative abnormal returns during various days in the event window also.

Table 3: Individual Abnormal Returns and t-statistics for Individual Tests of Stock Price Response to ISO 14001

Company	Index E = Equal Weighted V = Value Weighted	t = -1	t = 0	t = +1
Abitibi-Consolidated$^+$	E	-0.0140 (-0.5016)	-0.0113 (-0.4029)	0.0714 (2.5494)**
	V	-0.0118 (-0.4165)	-0.0134 (-0.4732)	0.0737 (2.6026)***
Abitibi-Consolidated	E	0.0150 (0.4882)	-0.0156 (-0.5056)	-0.0095 (-0.3078)
	V	0.0172 (0.5651)	-0.0106 (-0.3415)	-0.0104 (-0.3345)
Cambior	E	-0.0690 (-2.308)**	0.02574 (0.8579)	0.01412 (0.4695)
	V	-0.0664 (-2.2075)**	0.0258 (0.8556)	0.0102 (0.3346)

Table 3: (Continued) Individual Abnormal Returns and t-statistics for Individual Tests of Stock Price Response to ISO 14001

Company	Index	t = -1	t = 0	t = +1
Cameco	E	0.0266 (1.2110)	-0.0242 (-1.1035)	-0.0056 (-0.2544)
	V	0.0285 (1.3276)	-0.0269 (-1.2543)	-0.0056 (-0.2631)
Cameco	E	0.1008 (4.8458)***	0.0430 (2.0670)**	-0.0342 (-1.6432)
	V	0.1026 (4.9391)**	0.0508 (2.4508)**	-0.0309 (-1.4766)
Canfor Corp.	E	0.0366 (1.2801)	0.0351 (1.2291)	0.0550 (1.9216)*
	V	0.0259 (0.9216)	0.0369 (1.3122)	0.0564 (2.0021)**
Dofasco+	E	0.0108 (0.6414)	-0.0042 (-0.0246)	-0.0211 (-1.2391)
	V	0.0071 (0.4241)	-0.0014 (-0.0800)	-0.0143 (-0.8455)
Domtar	E	0.05745 (0.5059)	0.5605 (-0.0804)	0.5505 (-0.5026)
	V	0.0044 (0.1917)	0.0156 (0.6783)	-0.0315 (-1.3658)
Domtar	E	0.0049 (0.2072)	-0.0179 (0.7571)	-0.0261 (-1.110)
	V	0.0060 (0.2570)	0.0179 (0.7685)	-0.0278 (-1.1970)
Domtar	E	-0.01759 (-0.8685)	0.02691 (1.3319)	0.0460 (2.2780)**
	V	-0.0176 (-0.8713)	0.0186 (0.9205)	0.0432 (2.1434)**
Domtar+	E	0.02312 (1.1531)	(-0.0220) (-1.1092)	0.0205 (1.0241)
	V	0.0252 (1.3318)	-0.0250 (-1.2378)	0.0205 (1.0892)
Interfor	E	-0.0504 (-1.1693)	-0.0216 (-0.4998)	-0.02124 (-0.4917)
	V	-0.0522 (-1.1987)	-0.0076 (-0.1724)	-0.0203 (-0.4648)
IPSCO	E	0.0215 (0.7658)	0.0184 (0.6532)	0.0116 (0.4101)

Table 3: (Continued) Individual Abnormal Returns and t-statistics for Individual Tests of Stock Price Response to ISO 14001

Company	Index	t = -1	t = 0	t = +1
IPSCO continued	V	0.0084 (0.2891)	0.0171 (0.5883)	0.0200 (0.6895)
Nortel Networks	E	-0.0140 (-0.4937)	-0.0241 (-0.8516)	-0.0048 (-0.1625)
	V	-0.0282 (-1.2206)	-0.0397 (-1.7144)	0.0006 (0.0253)
Shell Canada	E	-0.0014 (-0.0575)	0.0299 (1.4362)	-0.0445 (-2.1188)**
	V	0.0030 (0.1524)	0.0292 (1.4006)	-0.0454 (-2.1594)**
Shell Canada+	E	-0.0554 (-2.7673)***	0.0096 (0.4741)	0.0108 (0.5337)
	V	-0.0557 (-2.7996)***	0.0081 (0.3986)	0.0103 (0.5110)
Shell Canada+	E	-0.0178 (-0.8165)	0.0139 (0.6317)	0.0005 (0.0188)
	V	-0.0160 (-0.7404)	0.0129 (0.5902)	0.0031 (0.1400)
Stelco	E	0.0075 (0.1833)	0.0131 (0.3247)	0.0146 (0.3619)
	V	0.0010 (0.0204)	0.0046 (0.1076)	0.0146 (0.3484)
Tembec	E	0.0131 (0.5965)	0.0000 (0.0029)	-0.0076 (-0.3458)
	V	0.0116 (0.5230)	-0.0052 (-0.2344)	-0.0063 (-0.2831)
Tembec+	E	-0.0385 (-1.4445)	-0.0087 (-0.3248)	-0.0019 (-0.0690)
	V	-0.0337 (-1.2880)	-0.0062 (-0.2351)	0.0018 (0.0739)
Tembec	E	-0.0066 (-0.3506)	-0.0109 (-0.5787)	-0.0446 (-2.3893)**
	V	-0.0016 (-0.0815)	-0.0015 (-0.0787)	-0.0434 (-2.3753)**
TimberWest	E	-0.0041 (-0.3088)	0.0125 (0.9397)	0.0093 (0.6993)
	V	-0.0019 (-0.1356)	0.0144 (1.0429)	0.01340 (0.9676)
Weyerhaeuser	E	-0.0037 (-0.1251)	0.0005 (0.0222)	0.0153 (0.5427)
	V	-0.0054 (-0.1854)	-0.0051 (-0.1720)	0.0164 (0.5860)

Table 3: (Continued) Individual Abnormal Returns and t-statistics for Individual Tests of Stock Price Response to ISO 14001

Company	Index	t = -1	t = 0	t = +1
Weyerhaeuser	E	0.0547 (1.9463)*	-0.0227 (-0.8144)	0.0195 (0.6919)
	V	0.0591 (2.0932)**	-0.0292 (-0.7467)	0.0205 (0.7247)
Weyerhaeuser	E	0.01890 (0.6714)	-0.0289 (-1.0399)	0.0149 (0.5280)
	V	0.0200 (0.7058)	-0.0284 (-1.0157)	0.01758 (0.6212)

+Companies that experienced confounding events during the event window, t-statistics are in parentheses

* p<0.10
** p<0.05
*** p<0.01

3.6 Discussion

The goal of this research is to determine whether ISO 14001 has an effect on the market value of companies that choose to adopt this standard. No evidence that ISO 14001 influences the abnormal returns in the share prices of the companies is found within the overall sample. Although no positive rewards are established within the overall sample, some individual companies did experience both positive and negative abnormal returns within the event window. Lack of overall sample significance suggests that management, owners, and analysts should be cautious about expecting an abnormal return (Adams *et al.*, 1999) after ISO 14001 registration. Though it is possible for individual companies to experience an abnormal return, the return is not guaranteed to be positive, and may in fact be a negative, as some companies within the sample experienced.

Many of the companies in the sample are from primary industries such the forestry industry (Abitibi-Consolidated, Canfor, Interfor, Tembec, TimberWest, and

Weyerhaeuser). Sometimes, in the forest products industry, environmental certification is seen as an add-on to a company's existing practices to appease customers (Johnson and Walck, 2004). This may have been the case with the ISO 14001 registration of Tembec, in Toronto and Spruce Falls, which has a negative significant abnormal return on Day +1 of the event window. The Toronto and Spruce Falls location took longer to register (ISO 14001 registered in 2002) as opposed to the other Tembec locations (1999 and 2001 registration dates), and possibly this registration was perceived to be carried out for superficial reasons to please the public's demand for sustainability within the forest products sector. However, most of the other companies in the forestry sector such as Abitibi-Consolidated, Canfor Corporation, Domtar, and Weyerhaeuser did experience significant positive abnormal returns during various days within the event window in the individual company analysis. Perhaps these registrations are viewed by stock market investors as a full integration of environmental and sustainability principles that entered into companies' core business strategies (Johnson and Walck, 2004).

Mining, another one of Canada's primary industries, also experienced both negative and positive abnormal returns during the event window. Cameco experienced positive market returns on both Day -1 and Day 0 for the registration of the Port Hope uranium conversion facility. It is possible that the significant abnormal returns that are found on these two days are due to Cameco creating community and investor awareness regarding its emergency responses and environmental management strategies (Cameco, 2004). On the other hand, Cambior, another mining company experienced negative abnormal returns on Day -1. Similarly, Shell experienced negative abnormal returns for two of its company locations. The negative abnormal return experienced by Shell

Canada for the ISO 14001 registration at the Sarnia manufacturing centre may not be a reaction to the ISO registration, but the market reaction to the withdrawal of an Aboriginal coalition pulling out of a tentative pipeline deal with major oil and gas producers in the Northwest Territories on this day (O'Meara, 2001).

It is also possible that the market reacted negatively or did not react at all (in most of the cases) to corporations that presented themselves as being environmentally conscious because many analysts believe that corporations that present themselves as environmentally friendly are actually feigning their commitment to the environment (Haas *et al.*, 1993). The argument that is prevalent is that companies will deceitfully market themselves as being environmentally conscious even though their environmental initiatives are forced by either legal compliance or because of a marketing strategy. Investors may be aware of this or be able to draw inferences for themselves regarding public relations manipulations which may result in little reaction, or possibly a negative stock market price reaction to ISO 14001 registration.

On the other hand, the announcement of an ISO 14001 registration may not be new information. Stock analysts are usually already informed about a company's environmental programs (Adams *et al.*, 1999). Analysts often go on plant tours, visit company headquarters, and management may visit the analysts to inform them of the company's status (Adams *et al.*, 1999). Often company environmental information is collected due to the increasing popularity of ethical funds, which are socially responsible investments (Brown *et al.*, 2002). These investments may be aimed at supporting companies that are associated with environmental protection, pollution control, conservation, and recycling. Therefore, the lack of stock market response to ISO 14001 registration is not surprising if this type of interaction between stock analysts and companies is taking place.

3.7 Conclusion and Future Research

This study has empirically analyzed the effect that the adoption of ISO 14001 has on the market value of various companies. To accomplish this, the abnormal returns prior to and following the ISO 14001 announcement day were examined. The overall results of this analysis suggests that companies that invest in ISO 14001 management systems have not experienced superior stock market price returns in reaction to ISO registration at the time of the ISO 14001 announcement. In the context of this study, the stock market is not immediately rewarding those companies that choose to adopt ISO 14001. The Canadian government should not rely on the stock market at this time to provide an incentive for companies to adopt and implement certified environmental management systems. Therefore, the government should not assume that market-based incentives are enough to ensure facility compliance or motivation towards environmental improvements.

Negligible or negative stock price responses during the ISO 14001 announcement event window do not necessarily mean that environmental programs are disregarded. Stockholders may still benefit from successful ISO 14001 implementation; however the benefits may not be realized during the event window (Adams *et al.*, 1999). The benefits that accrue may be in the form of a substantial reduction in the perceived risk of a firm which may create additional value for stockholders by experiencing a lower cost of capital (Feldman *et al.*, 1996). The insignificant results that are presented cannot differentiate whether stockholders received no rewards from ISO 14001 or their rewards were experienced either long before or long after the registration announcement. Analysts may already be informed regarding a company's environmental program and therefore the ISO 14001 registration may not be new information.

Future research should also encompass a long term analysis, to measure the impact of environmental initiatives on firms' financial performance using various performance indicators such as return on sales (ROS) and return on assets (ROA). Perhaps comparisons of outcomes between companies that have ISO 14001 registered systems and those who do not have any formal system in place could be made. Lastly, an analysis should be carried out to determine if certified environmental management systems have an effect not only on companies' returns but on firms' perceived level of risk to investors.

4.0 ISO 14001 & Environmental Performance

4.1 Nature of the Problem

Currently, environmental management in many firms is being incorporated into every level of business strategy (Roy and Vezina, 2001) and an ISO 14001 registered environmental management system tends to be automatically equated with positive environmental performance. ISO 14001 certification itself does not measure the actual environmental performance of a company, however the standards assume that certified companies have an EMS in place to deal with environmental impacts (Rondinelli and Vastag, 2000). The exact nature of the relationship between environmental management and performance is still not clear. This can cause difficulties for policy makers and regulators when they are making decisions because there is pressure on them to consider EMSs and ISO 14001 even though the evidence up to this point does not suggest a clear connection between environmental management and improved environmental outcomes (Dahlstrom *et al.*, 2003).

4.2 Objective of the Study

The purpose of this section of the study is to determine whether a quantifiable relationship exists between environmental management and performance. Ultimately, the rationale for conducting this analysis is to gain insight into whether ISO 14001 registered facilities experience greater emission reductions than facilities that are not registered using a sample of facilities in Canada. Also, it is hoped that the analysis will show whether there is a difference between those facilities that adopted ISO 14001 at different time periods and those facilities that did not adopt the ISO 14001 standard at all. A commonly used indicator of environmental performance is employed to ensure that comparisons could be made between this study and other current research on this topic. Emissions data obtained from Environment Canada's National Pollutant Release Inventory (NPRI) are used in the analysis as the indicator of environmental performance. Before conducting the analysis, it is useful to review the relevant literature pertaining to the relationship between environmental management and performance to avoid the shortfalls of previous research and to fill in any gaps that are identified.

4.3 Literature Review

4.3.1 Assessing the Impact of ISO 14001 & EMSs on Environmental Performance

Environmental management is an internal effort of a firm that includes policy making, planning, and implementation in order to lessen the negative environmental impacts of a product throughout its life cycle (Coglianese and Nash, 2001; Klassen and McLaughlin, 1996). Environmental management initiatives may include instruments such as an EMS or an ISO 14001 registered system. The quality of a corporation's EMS is relevant. Even if a corporation has developed an advanced EMS, it is important that these efforts lead to an enhancement of environmental performance (Feldman *et al.*, 1996). Environmental performance measures how successful an organization may be at lessening its impact on the environment (Klassen and McLaughlin, 1996). Companies must be able to show that they are proceeding towards a reduction in the amount and release of pollution produced and ultimately limiting their exposure to liability (Feldman *et al.*, 1996).

Environmental management in many firms has shifted from a secondary function to a central element of doing business because it can be incorporated into every level of business strategy (Roy and Vezina, 2001). The registration of an ISO 14001 system or the presence of an EMS tends to be equated with good environmental performance by many people (Ammenberg and Hjelm, 2002). Rondinelli and Vastag (2000) point out that ISO 14001 certification does not measure the actual environmental performance of a company and that the standards assume that certified companies have an EMS in place to deal with environmental impacts. In reality, there is no way to externally verify that improvements are actually occurring. ISO 14001 standards are process rather than performance standards meaning that they do not guarantee or force companies to be at an optimum environmental performance level. Only the management system covering the processes is certified. The language of the standard is very non-specific, and any commitments made regarding environmental performance are set by the company through the environmental policy, objectives, and targets. The only requirement of environmental performance set by the ISO 14001 standard is to meet the legal level of compliance. Although the standards are voluntary, the system aids a firm in reaching environmental goals (Melnyk *et al.*, 2003) Many scientific investigations have been conducted to determine how EMSs (either registered or not) influence environmental performance. Studies have been carried out using different methods and measures of environmental performance, leading to various results which will be discussed in further detail.

Up to this point, various studies have examined the influence that both ISO 14001 registered systems and EMSs have had on environmental performance. For example, one of the goals of the study by Montabon *et al.* (2000) was to determine what effect, if any, ISO 14000 certification standards have had on firms and their performance. The results indicated that a statistically significant positive relationship was found between the stage of ISO certification and the effectiveness of the EMS. Companies were found to experience a greater positive impact if they were at a later stage in the ISO 14001 certification process. In later phases of certification, companies performed better than at earlier points in the process. Therefore, facilities that are in the process of obtaining ISO 14001 certification are expected to have a more efficient and effective EMS, according to the results of this study.

Steger (2000) reviewed empirical evidence found in surveys using a variety of companies to assess the influence of EMSs on the natural environment. Implementing a registered system did not lead to impressive changes in an organization's environmental performance goal setting. Most companies thought that they would have achieved and set their goals in the same manner regardless of the system. It was also determined that positive environmental impacts of an EMS resulted from the discovery of new situations that could produce "win-win" outcomes due to the systematic approach provided by ISO 14001 as opposed to the development of more impressive goal setting.

Other researchers, such as Ammenberg and Hjelm (2003), have looked at small and medium sized enterprises (SMEs) to examine how the environmental performance of firms adopting EMSs has progressed, and to understand the link between them. The majority of enterprises employing an EMS were found to have improved environmental performance. There were a few cases where negative relationships were found between the environmental aspects that the EMS targets were meant to improve, and there also were a few cases where change was not observed. The measure of environmental performance is an inherent weakness in this study since performance was calculated and compared using a somewhat subjective "performance score". The authors admit that the score only gives a very rough estimate of environmental performance.

The measurement of environmental performance also seemed to be a problem in several case studies and surveys reviewed by Morrow and Rodinelli (2002) from German energy and gas industries. In most of the analyzed studies it was found that it was difficult for companies to attribute environmental progression directly to the EMS implementation. Despite this, there were some ISO 14001 registered companies that reported environmental performance developments especially regarding waste reduction, recycling, emissions, and material reuse. Similar results were demonstrated by Ammenberg and Hjelm (2002) in Sweden who found that some firms interviewed felt that using a joint EMS resulted in their company paying more attention to and achieving waste separation, reduction, and recycling.

Annandale *et al.* (2004) attempted to contribute to the existing research on the impacts of voluntary instruments on actual environmental performance outcomes. In their study, examples of environmental performance improvements due to executing an EMS were given by 43 percent of the respondents, some of which are shown in Table 4.

Another major study carried out in this area was by Russo (2004). The study attempted to determine if facilities registered under ISO 14001 experience greater emissions reductions than those that are not registered within the electronics industry. Emissions were the measure of environmental performance used in this study and the values were obtained from the U.S. TRI database. The absence or presence of a "first mover" advantage was also investigated. "First-mover" advantages are rewards obtained by companies that respond rapidly and act before other companies do. In this case, "first movers" are those companies that acted quickly to be the first to adopt the ISO standard (Esty, 1994). The "first-mover" concept has been applied in the past to show that firms that use new environmental technologies or launch a new product in an existing market are the ones who reap the rewards (Russo, 2004). Russo points out that this concept

Table 4: Examples of the Impacts that EMSs have had on Operational Performance

Sector	Impact
Primary Resources	noise and dust abatement
	energy efficiency, and reduced water consumption
	waste management, reduction, recycling
Construction, Engineering, and Services	energy efficiency, and reduced water consumption
	leakage prevention from tanks
	wastewater monitoring
	management of hydrocarbon spills
Storage, Processing, and Distribution	waste management, reduction, recycling
	energy efficiency gains
	dust abatement
Manufacturing	seepage, clean-up, disposal improvements
	energy efficiency gains
	waste management, reduction, recycling
Energy	waste management, reduction, recycling
	greenhouse gas accounting
Waste Management	energy efficiency gains

SOURCE: Annandale, D., A. Morrison-Saunders, and G. Bouma. 2004. The impact of voluntary environmental performance instruments on company environmental performance. *Business Strategy and the Environment*, 13: 8.

could apply to organizational innovations, such as adopting the ISO 14001 standard. It was also investigated whether greater emission reductions were experienced over time or if the initial success experienced by ISO registered firms wears off as time goes on. It was concluded that various facilities did experience "first mover" advantages and there was an "experience effect" that was encountered by facilities which allowed for benefits of the system to accrue over time.

Another source of information that addresses the impact of EMSs on environmental performance is the National Database on Environmental Management Systems (NDEMS). The database was a joint venture in the U.S. of the University of North Carolina and the Environmental Law Institute that is supported by the Environmental Protection Agency (EPA), environmental agencies, and more than 50 businesses and organizations that contribute data. The goal of the database is to understand the effects of ISO 14001 and EMSs on environmental performance, environmental conditions, economic performance, regulatory compliance, relationships with stakeholders, and pollution prevention (Andrews *et al.*, 2001). The database is limited in that there may be a sample bias. All companies registered in this database did so on a voluntary basis. The data often reported management's perceptions which were not verified independently. Also, there are not enough data to produce statistically significant results that can be translated to entire industrial sectors (Andrews *et al.*, 2001). The database fulfilled the aim of the study to record EMS preparations and procedures, but it does not sufficiently address the linkage between environmental management and performance (Russo, 2004).

4.3.2 Regulatory & Policy Implications

From the literature examined, it is still questionable what the exact nature of the relationship between environmental management and performance is. Different measures and indicators of environmental performance are often used, which makes it increasingly difficult to compare the results of various studies. These results can leave both regulators and policy makers in a predicament when making decisions. Pressure exists on them to take EMSs into consideration even though the evidence to this time does not overwhelmingly suggest that there is a clear, unequivocal connection between environmental management and improved environmental outcomes (Dahlstrom *et al.*, 2003).

If a connection were to be made in the future, it would require that academics use common measures of environmental performance (i.e. widespread metrics) that could be applied to different studies to enable a comparison of results. Within an industry, if companies were to adopt similar metrics, it would be easier to show the effects of environmental initiatives to company management. By devising a way to consistently measure the environmental performance of business operations within similar industries, companies would be enabled to design more effective processes, reduce material use, and lessen environmental impacts (GEMI, 1998a).

If the relationship between improved environmental outcomes and ISO 14001 registration or EMSs could be shown, there could be many regulatory implications. If companies with EMSs have better environmental performance, there may be a reduced need for regulatory oversight and slackening where there is overlap with existing requirements to avoid repetition (Dahlstrom *et al.*, 2003). Russo (2004) gives a cautionary warning to increasing flexibility of regulations because if market place conditions were to change, for example if there were a recession, a firm's dedication to environmental protection could get shifted to a lower priority and emissions could rise back to or beyond old levels.

Other regulatory implications could involve the use of voluntary environmental incentives such as tax incentives, a reduction in regulatory costs, or other substantial financial benefits from local, provincial, or federal governments to those companies that achieve environmental improvements through ISO 14001 certification or through an EMS (GEMI, 1999). Certification could be used instead of issuing permits which are both labour and time intensive. A facility could commit to specific levels of environmental performance and then report each year on how well they achieved these results (GEMI, 1999).

An affirmative relationship possibly suggests that a voluntary system that includes the use, promotion, and offering of incentives to employ an EMS or ISO 14001 could replace the "command-and-control" regime that is present in both the U.S. and Canada. This system is showing signs of strain and is often ineffective (Hillary and Thorsen, 1999; Russo, 2004). The "command" component consists of the minimum standards that are identified in regulations and the "control" component consists of inspection and enforcing the law when there is non-compliance (Hillary and Thorsen, 1999). Russo (2004) recommends that a voluntary system should be supported by an enforced method of both gathering and dispersing information, possibly through the TRI database in the U.S. or the National Pollutant Release Inventory (NPRI) in Canada.

The other implication could be that the government may mandate EMSs or ISO 14001 (Russo, 2004). Problems from this idea may arise since firms may decide to proceed ritualistically through the motions of the EMS because they are made to instead of fully committing themselves to making environmental improvements. Mandating may be viewed as just another unreasonable burden imposed on companies (Coglianese, 2002). Whatever form of policy is chosen by the government, it must be realized that either way it is likely that the use of EMSs will increase. The important issue that remains is whether significant modifications will be made to decrease the environmental impacts of firms (Coglianese and Nash, 2002). To help provide information that will form the basis of sound policy and regulations, this analysis will try to further clarify the relationship that exists between environmental management and performance. To accomplish this task, one specific form of environmental management, ISO 14001, will be the focus of this investigation. The effects of ISO 14001 on emissions performance will be examined using emissions data from the NPRI which are described below, along with other background knowledge essential for understanding the data utilized in this study.

4.4 Study Background

4.4.1 General Overview

The NPRI is a database that was created to provide Canadians with access to information regarding the releases and transfers of certain pollutants to the air, land, and water (Environment Canada, 2004a). It aids the Government of Canada in tracking progress in pollution prevention, pin-pointing environmental priorities, executing policy initiatives and assessing releases and transfers of substances that are of concern (Environment Canada, 2004a). The NPRI was officially established in 1992 and it is legislated under the *Canadian Environmental Protection Act*, 1999 (CEPA 1999). This Act encompasses preventing pollution and protecting the environment and human health with the goal of sustainable development in mind (Environment Canada, 2005). CEPA 1999 includes significant improvements over the former Act, CEPA 1988 (Environment Canada, 2005). These improvements include making pollution prevention the cornerstone of efforts to reduce emissions and encouraging citizens to participate in decision making, to name a few (Environment Canada, 2005). Officially, CEPA 1999 came into force in April 2000 which means that the CEPA 1999 legislation was the authority for the NPRI in the 2001 reporting year and beyond (Environment Canada, 2003a). The NPRI data prior to 2001 were under the authority of the old legislation, CEPA 1988. The provisions in CEPA 1999 that refer to the NPRI are the information gathering provisions (sections 46 to 53) that address the creation of inventories of data (section 46) (Environment Canada, 2003a). Also, section 48 refers to the Minister of the Environment establishing a national inventory of pollutant releases (Environment Canada, 2003a). The types of data that must be reported to the NPRI by companies that meet specific reporting thresholds for particular substances are shown in Table 5.

Table 5: Types of Information Reported to the NPRI

1.	Information about the company, its location and number of employees
2.	Information about each substance that meets the reporting requirements, including the substance name and Chemical Abstracts Service registry, the nature of the activities (such as whether the substance is manufactured, processed or otherwise used at the facility)
3.	The quantity of the substance that is released at the facility to water, air or land, underground injection
4.	The quantity of the substance that is transferred off site to another location for final disposal or treatment prior to disposal and the nature of the treatment
5.	The quantity of each reported substance that is transferred off-site for recycling and for energy recovery, and the address of the receiving facility
6.	The reasons for year-to-year changes in releases, transfers and recycling
7.	Information on anticipated changes (mandatory for the three years following the reporting year) in releases, transfers and recycling
8.	Information on the types of pollution prevention activities undertaken at the facility

SOURCE: Environment Canada. 2000. The new CEPA and the National Pollutant Release Inventory (NPRI). <http://www.ec.gc.ca/CEPARegistry/gene_info/fs_1.cfm>.

4.4.2 Reporting to the NPRI

In 1995, the first set of NPRI results was released, which covered data on pollutants that were discharged in 1993 (Jackson, 2000). Under CEPA 1999, the NPRI was legislated to require companies to submit information on pollutant releases and transfers to the Government of Canada every year since 1993 (Environment Canada, 2004a). Environment Canada (2004b) defines a release as an emission or discharge of a NPRI listed substance from a facility site into the air, water, or land. A transfer is defined as a shipment of a NPRI substance found in waste to a location off-site (Olewiler and Dawson, 1998). A substance can be transferred off-site for physical, chemical or biological treatment, incineration, containment (storage or landfill), underground injection, thermal treatment, or treatment at a municipal sewage treatment plant (Environment Canada, 2003a). Substances that are re-used, recycled, or recovered are not included in the transfer component of the information gathered in the NPRI database (Environment Canada, 2003a). Operators of facilities are therefore obligated under CEPA to report releases to the NPRI if they meet certain criteria set out by the Minister of the Environment (Environment Canada, 2004a). These criteria are as follows:

> Anyone in Canada who owns or operates a facility with 10 or more full-time employees in the reporting year, and which manufactures, processes or otherwise uses any of the NPRI-listed substances, in concentration equal to or greater than 1% and in quantities equal to or greater than 10 tonnes (10,000 kg), must file a report with Environment Canada and identify any releases or transfers in waste of those substances to air, water or land, (Environment Canada, 1996).

The requirements state that facilities are required to file a report if they manufacture, process or otherwise use any of the NPRI-listed substances, in concentration equal to or greater than one percent (Environment Canada, 1996). By-products that are produced in concentrations less than the one percent threshold must also be reported. This is meant to ensure that high volume, low concentration releases and disposals of NPRI substances are also included in the database (Environment Canada, 2003b). A facility must also report if an NPRI substance is manufactured, processed or otherwise used by a facility in annual amounts greater than 10 tonnes (10,000 kg) (Environment Canada, 2003b). In 2000, lower thresholds were adopted for certain chemicals such as mercury, dioxin, and furans (Jackson, 2000). The threshold for mercury was reduced to 5 kg. Only one facility in the sample was found to have released mercury in 2001, after the new threshold was put into place. Even after weighting for toxicity, the amount was so minute (0.01) that the threshold alteration was not deemed to make a notable difference in the results. The NPRI reporting is conducted at the facility level, which means that if a company has facilities located in different provinces or territories, each facility has to be reported separately. The facilities must each individually meet the reporting criteria in order to have to file a report. If the reporting criteria are not met, the facility does not have to report (Jackson, 2000). A facility is defined as all "buildings, equipment, structures or other stationary items that are located on a single site or on contiguous or adjacent sites and that are owned by the same company and operated as a single integrated site" (Jackson, 2000).

The reporting criteria apply to 245 substances listed in Appendix B by Environment Canada. The remaining substances such as mercury, polycyclic aromatic hydrocarbons, dioxins, furans, and hexavalent chromium compounds all have alternate reporting thresholds (Environment Canada, 2003c). Substances have been added and deleted from the NPRI list over the years and thresholds have been adjusted after scientific evidence is revealed and public consultation occurs (Jackson, 2000). In 1999, 73 substances were added to the database. From 2000 to 2002, additional substances were also added to the NPRI list. Since these substances had not been tracked over the entire course of the database's existence, data for these substances prior to 1999 to 2002 are not available (Environment Canada, 2004a). In this study, following the methodology of Harrison and Antweiler (2003), the 76 substances that were added to the NPRI list of chemicals in 1999 were not included in the examination to ensure comparability over time. These substances are also listed in Appendix B. Also, acetone was removed from the inventory in 1999, so it was also not considered in the study.

In 2002, some of the reporting criteria changed for certain substances. Cadmium's reporting requirements were altered from a threshold of 10 tonnes to 5 kilograms and from a concentration of 1 percent to 0.1 percent. Likewise, both Arsenic and Lead also experienced changes in thresholds from 10 tonnes to 50 kilograms and from a 1 percent concentration to a 0.1 percent concentration (Environment Canada, 2005b). Without taking these changes into account, total emissions from 2002 would most likely appear to be higher in 2002 than in previous years, since facilities were required to report using a lower threshold in 2002 than in previous years. To counteract this, facilities that reported Cadmium, Lead, or Arsenic in 2002 but not in any other year did not have the emissions data from these chemicals included in their aggregated weighted emission total for 2002. It was assumed that these facilities were only reporting these chemicals in 2002 because of the altered reporting thresholds and otherwise would not have reported them.

In the case where one of the reporting criteria is not met, there is no requirement to file or prepare a report for the NPRI (Jackson, 2000). Various facilities may be exempted from reporting to the NPRI without even having to assess whether they meet the criteria set out by Environment Canada. Exemptions usually result from the unlikelihood of facilities in certain industrial sectors, such as universities, colleges, or research or testing facilities, to meet Environment Canada's criteria for reporting (Jackson, 2000). To determine if facilities are exempt, the chart developed by Environment Canada located in Appendix C is used. On the other hand, Environment Canada recognizes that certain facilities that discharge significant amounts of NPRI substances end up not reporting since they do not meet the employee threshold (Jackson, 2000). To remedy this problem, waste incineration, wood preservation, terminal operation, and waste water system activities report to the NPRI regardless of the 20,000 hour or 10 full-time employee threshold (Environment Canada, 2003b).

4.4.3 Limitations of the NPRI Database

The NPRI database has a number of limitations that must be identified and discussed. The first is that facilities must prepare their own reports regarding releases with minimal supervision from regulators (Harrison and Antweiler, 2003). Facilities are given different options of how they provide their information, such as direct measurement, mass-balance calculations, emission factors, or engineering calculations (Jackson, 2000). Even though facilities can estimate their discharges using calculations and measurements, they must outline how they obtained the figures that they reported. Another issue is that not all pollutants of concern are contained within the database (Environment Canada, 2003c). The NPRI neglects to collect information regarding high volume, low toxicity substances such as Biological Oxygen Demand (BOD) and has only recently, in 2002, added various sizes of particulate matter, which have a diameter less than or equal to 10 or 2.5 microns (PM_{10} and $PM_{2.5}$), to the list (Environment Canada, 2003c; Harrison and Antweiler, 2003). Lastly, even though some of the substances listed on the NPRI come from groups of chemicals with similar properties, it cannot be assumed that the risks to the environment or human health are also similar for each group of substances (Environment Canada, 2003c). Environment Canada (2003c) ascertains that the risks to human health and the environment are very complex and cannot be determined from using the NPRI data alone. To establish the risk of substances, many factors such as physical and chemical properties, the ability of the substance to cause harm, the medium to which the pollutant is released, the amount of exposure to organisms, and when and how the chemical is broken down must be taken into consideration (Environment Canada, 2003c). Following the example of Harrison and Antweiler (2003), the chronic human health indicators (CHHI) developed by the United States Environmental Protection Agency (EPA) were used herein to take into account the different toxicities of the substances listed in the NPRI database. Toxicity weightings were used because, if the emissions released by a facility were simply summed for a given year, this would be an inadequate proxy for the possible impairment to human or environmental health since the toxicity of the chemicals on the NPRI varies over six orders of magnitude (Toffel and Marshall, 2004).

4.4.4 Environmental Performance Measures

As previously mentioned, the indicator of environmental performance used in this analysis was emissions data from Environment Canada's NPRI. As outlined by the

Global Environmental Management Initiative (GEMI) (GEMI, 1998a), it is important to select meaningful and effective tools to measure environmental performance. This type of measure of environmental performance was chosen because it is purely quantitative and is the type of measure that is commonly reported by facilities (GEMI, 1998a). Other types of environmental performance indicators that could have been used for analysis such as performance scores are subjective and are usually only very rough estimates (Ammerberg and Hjelm, 2002). Environmental reputation scores were another possible metric that could have been utilized; however, these scores are often highly correlated with financial returns and are calculated at the firm level, not at the facility level (Brown and Perry, 1995; Russo, 2004). It was determined that a weighted emission would be the best measure of potential harm to environmental and human health since different chemicals produce different levels of impacts (Toffel and Marshall, 2004). Facility level performance metrics, such as weighted emissions, are currently being used to compare facilities' performance relative to other facilities or to analyze a facility's performance over time (Toffel and Marshall, 2004). Studies carried out by Harrison and Antweiler (2003), King and Lennox (2000, 2001, 2002), Russo (2004), and Hamilton (1999) are only a few examples of research that have employed the use of emissions data either from the NPRI in Canada or the TRI in the U.S. as an indicator of environmental performance.

It is recognized that there are issues associated with the use of the NPRI data such as adjusting for the toxicity of the different chemicals tracked by the database. To determine the potential damage that a certain quantity of chemical released into the environment has, a number of different factors must be considered (Toffel and Marshall, 2004). These factors include the specific properties of the chemical and the characteristics of the medium in which the chemical is released (Toffel and Marshall, 2004). As Harrison and Antweiler (2003) indicate, the effects of the pollutant released depend not only on the quantity released, but on the "toxicity of component substances, their persistence, synergies among different substances, dispersion patterns, proximity to other sources, and the presence of greater or lesser numbers of people and other vulnerable species in the vicinity". Therefore, if one were to simply sum the NPRI emissions data, this aggregation would be a weak representation of the potential harm to human health and the environment (Toffel and Marshall, 2004). It can be concluded that "mass is a crude proxy for environmental effect" (Lifset, 2001) and that NPRI emissions data should be weighted before comparing the environmental performance between firms or over time (Horvath *et al.*, 1995).

After it was determined that a weighting scheme was necessary, several different schemes were considered before choosing the most suitable one. Schemes such as the Human Toxicity Potential (HTP) and the Indiana Relative Chemical Hazard Score are only a few examples of the types of weighting schemes that were considered for the analysis. Toffel and Marshall (2004) caution that there is no one best weighting method that exists to evaluate chemicals in release inventories and that choosing any one method over another involves trade-offs. Since the substances on the NPRI database were being released in either the land, water, or air, it was imperative that a multi-media fate and transport model was used to weight the emissions data. The chronic human health indicators (CHHI) that were derived for the Risk-Screening Environmental Indicators (RSEI) model met these criteria and accounted for all of the substances released by the facilities in the sample data. Other schemes were more focused on worker exposure hazard or had imprecise measures of potential damage (Toffel and Marshall, 2004). Therefore, the CHHI from the RSEI model were chosen for toxicity adjustments in this investigation to avoid the pitfalls of using unweighted aggregated emission totals following the EPA (2004a) weighting methodology. Other authors such as Harrison and Antweiler (2003) have also applied the CHHI weighting scheme to the NPRI data.

4.4.5 Chronic Human Health Indicators (CHHI)

The CHHI were developed by the U.S. EPA and are a hazard-based perspective that incorporates releases to air, water, land, and underground injection (Toffel and Marshall, 2004). The CHHI are toxicity weights that were developed using current EPA methods for assessing chemical toxicity. This method employs a proportional system of numerical weights that reflects the toxicity of substances relative to one another (EPA, 2004a). The toxicity weight of a substance increases as the potential of that substance to trigger chronic human health effects rises (EPA, 2004a). The EPA considered many factors to determine the toxicity weight of chemicals, such as the number of effects it causes, the severity of effects, the potential of the chemical to cause one or more effects, and the uncertainty inherent in differentiating effects (EPA, 2004a). The method used to derive the CHHI concentrates on the last two factors, and the EPA relied on both quantitative and qualitative elements to assess the relative toxicity of substances. The process used to transform this information into toxicity weights is described in further detail below.

Weight of evidence (WOE) classification was used for the CHHI toxicity weighting method (EPA, 2004a). This type of classification allows risk assessors to qualitatively judge the strength of the body of evidence consisting of acute and chronic animal studies, epidemiological data, and *in vitro* toxicity tests to determine the probability of the occurrence of certain effects caused by chemicals in humans. This type of information applied in the CHHI weighting scheme is considered to be qualitative data and the categories that evidence can be divided into are shown in Table 6.

Table 6: Weight-of-Evidence Categories for Carcinogenicity

Category	Weight-of-Evidence
A	Sufficient evidence from epidemiological studies to support a causal relationship between exposure to the agent and cancer.
B1	Limited evidence from epidemiological studies and sufficient animal data.
B2	Sufficient evidence from animal studies but inadequate or no evidence or no data from epidemiological studies.
C	Limited evidence of carcinogenicity in animals and an absence of evidence or data in humans.
D	Inadequate human and animal evidence for carcinogenicity or no data.
E	No evidence for carcinogenicity in at least two adequate animal tests in different species or in both adequate epidemiological and animal studies, coupled with no evidence or data in epidemiological studies.

SOURCE: Environmental Protection Agency (EPA). 2004a. *EPA's Risk-screening environmental indicators (RSEI) chronic human health methodology.* Office of Pollution Prevention and Toxics. Washington, D.C., p.34.

Information regarding the relative potency of a chemical is the form of quantitative data employed in the CHHI weighting method. This information was typically obtained from a dose-response assessment which illustrates the relationship between the exposure and the extent of harm of a substance (EPA, 2004a). Studies have shown that as the dose of a toxic substance is increased, the response (with regards to severity and/or incidence of effect) also escalates (EPA, 1988). In this toxicity weighting model, both cancer and non-cancer risk assessments were used. Cancer risk assessments utilized the EPA's standard methods for forecasting the incremental lifetime cancer risk per dose of a specific chemical (EPA, 2004a). Oral Slope Factors were used in the CHHI method. These factors characterize the upper-bound estimate of the slope of the dose-response curve in the low-dose region and are expressed in (mg/kg-day)$^{-1}$ (EPA, 2004a). Inhalation Unit Risk was also employed and it describes the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to a chemical at a concentration of 1 μg/m^3 in air (EPA, 2004a). The algorithms involving the Oral Slope Factors and Inhalation Unit Risk that are used to calculate the CHHI weights are shown in Table 7. For further information and to understand how these algorithms were derived, refer to explanations and calculations in Appendix D. The EPA (2004a) contends that the Oral Slope Factors and Unit Risk Factors "are the best readily available values that allow a comparison of the relative cancer potency of chemicals."

Table 7: Algorithms for Assigning Toxicity Weights

Non-carcinogens	0.5 / RfD (mg/kg-day) or 1.8 / RfC (mg/m^3)
Carcinogens (WOE categories A and B):	Oral Slope Factor (risk per mg/kg-day)/ 0.0005 or Inhalation Unit Risk (risk per mg/m^3)/ 0.00014
Carcinogens (WOE category C):	Oral Slope Factor (risk per mg/kg-day)/ (0.005) or Inhalation Unit Risk (risk per mg/m^3)/ (0.0014)

SOURCE: Environmental Protection Agency (EPA). 2004a. *EPA's Risk-screening environmental indicators (RSEI) chronic human health methodology*. Office of Pollution Prevention and Toxics. Washington, D.C., p.36.

In regards to non-cancer risk assessment, doses were compared to a Reference Dose (RfD) or an Inhalation Reference Concentration (RfC) (EPA, 2004a). RfD and RfC are both defined as "an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious [noncancer] effects during a lifetime" (EPA, 1988; EPA, 1990). RfC is measured in mg/m^3 and whereas RfD is measured in mg/kg-day (EPA, 1988). An RfD or RfC for a chemical is composed of the No Observable Adverse Effect Level (NOAEL) or Lowest Observable Adverse Effect Level (LOAEL) divided by an uncertainty factor which takes into account variability and extrapolation from human or animal data (EPA, 2004; Phillips, 2004). This uncertainty factor can be multiplied by a modifying factor which is based on expert judgement regarding the entire toxicity database for the chemical (EPA, 2004; Phillips, 2004). Doses that are found to be below the RfD or RfC are not likely to be connected with negative health risks (EPA, 1988). Whereas if the exposures are above the RfD or RfC value, this indicates that an individual may be at risk for the effect (EPA, 2004a). As the frequency or the magnitude of the exposures that are greater than the RfD rise, the higher the probability of negative effects in a human population (EPA, 1988). The algorithms used by the EPA to calculate carcinogenic and non-carcinogenic toxicity weights are shown in Table 7. To understand how these algorithms were derived, refer to Appendix D.

The algorithms for assigning toxicity weights are a modified version of the Hazard Ranking System (HRS) employed by the EPA's Office of Emergency Response and Remediation. The HRS weighting system uses toxicity values in mg per kg body weight per day, but toxicity values for inhalation are usually expressed in mg/m^3 of air. Therefore, the CHHI toxicity weighting method was adjusted by using a standard adult human exposure factor for body weight (70 kg) and by employing an inhalation rate of 20 m^3/day to transform the toxicity values so that they would be articulated in units of exposure (EPA, 2004a). By making these adjustments, the result is that different constants are used to determine the toxicity weights when inhalation toxicity values are used instead of oral toxicity values (EPA, 2004a). All of the final toxicity weights have the units $(mg/kg\text{-}day)^{-1}$.

The RfD, RfC, and WOE used in the cancer and non-cancer risk assessments by the EPA were obtained by the EPA from six different sources. Preferably, the data were taken from the EPA's Integrated Risk Information System (IRIS) which is available online (http://www.epa.gov/iris/). This database is peer reviewed and contains information regarding human health effects that may result from exposure to various chemicals in the environment (EPA, 2004b) Tables such as the EPA's Office of Pesticide Programs (OPP) Acute Chronic and Reference Doses Table, were also relied upon for information (EPA, 2004a). In addition, the Agency for Toxic Substances and Disease Registry (ATSDR) of the U.S. Department of Health and Human Services was drawn on since it collects data regarding the effects hazardous substances have on public health (EPA, 2004a). Final toxicity values were also acquired by the EPA from the California Environmental Protection Agency (CalEPA) since they have a system in place for developing and dispensing toxicological information that is necessary to protect human health (EPA, 2004a). In absence of data from the other sources, the EPA's Health Effects Assessment Tables (HEAST) were used. These tables were only used after all the other sources were exhausted since they do not represent Agency-wide expert judgements. Lastly, some toxicity weights were derived by a group of expert EPA health scientists after reviewing all available data on the necessary chemicals (EPA, 2004a). By weighting emissions data obtained from the NPRI, the potential harm to humans and the environment can be accounted for by considering the toxicity of different chemicals. It is worthwhile to investigate if environmental management, in the form of ISO 14001, can reduce emission releases from facilities. The toxicity weights that were derived using the databases and tables mentioned above are an important part of establishing a performance measure to ensure that facilities' performances can be compared to each other, or examined over time to determine if ISO 14001 is having an effect on emissions. The methodology describing the sample of facilities and analysis involved in examining the weighted emission values are described in further detail below.

4.5 Methodology

In an attempt to provide empirical data regarding the influence of ISO 14001 on environmental performance, the registration and impact of ISO 14001 were examined. More specifically, this investigation was conducted to gain insight to whether ISO 14001 registered facilities experience greater emissions reductions than facilities that are not registered within a sample of companies. Only one major industry was used in this analysis to ensure that there would be a general commonality in the sample since various studies in the past have been criticized for being too dispersed (Griffon and Mahon, 1997; Russo, 2004). By focusing on one major industry, the issue of sample dispersion would be corrected. Emissions data were supplied by the NPRI which means that the sample only contained companies that reported to the NPRI. Other emissions data that facilities may track for their own purposes and that are not included in the NPRI database are considered to be confidential information by facilities and are often difficult to obtain. Due to time and financial constraints, emissions data were restricted to information found only in the NPRI database. It was also taken into consideration that the sample of facilities should be from a sector that has similar regulatory requirements and production levels. To ensure that other voluntary standards were not influencing emissions performance, an industry had to be chosen that did not have any other formal environmental standards or self-regulation in place, such as the Responsible Care® Program used by the Canadian Chemical Producers, or the Sustainable Forestry Initiative in the forestry sector.

The Transportation Equipment Industry (Standard Industrial Classification (SIC) 32) was chosen because it contained both small and large sized facilities, ranging in magnitude from 13 to approximately 6500 employees. SIC Codes are used to group companies with similar products or services. The two digit code is a broad grouping of similar industries, whereas the four digit code is a detailed grouping of similar industries (Environment Canada, 2004c). SIC Code 32 consists of different sectors within the Transportation Equipment Industry, such as motor vehicle stamping industries, steering and suspension facilities, motor vehicle accessories and parts industries, aircraft and aircraft parts manufacturers. The more detailed, four-digit Canadian SIC codes of the facilities that were used in this study, contained within the Transportation Equipment Industry classification, are shown in Table 8.

Table 8: 4-Digit SIC Classification for 87 Company Sample

SIC Code	Sector	Number of Facilities
3211	Aircraft and Aircraft Parts	12
3231	Motor Vehicle	12
3241	Truck and Bus Body	4
3242	Commercial Trailer	3
3251	Motor Vehicle Engine and Engine Parts	13
3253	Motor Vehicle Stampings	19
3254	Motor Vehicle Steering and Suspension	6
3255	Motor Vehicle Wheel and Brake	1
3256	Motor Vehicle Plastic Parts	3
3259	Other Motor Vehicle Accessories	9
3261	Plastic Product Manufacturing	1
3299	Other Transportation Equipment	4

SOURCE: Derived using data from the NPRI website. <http://www.ec.gc.ca/pdb/npri/npri_ home_e. cfm>.

The time period of the sample was restricted from 1996 to 2002. Data were only available until 2002 and therefore, the analysis could not include years beyond this. The first year of the NRPI database (1993) was omitted for a few different reasons. Most studies using the TRI data in the U.S. have excluded data from the first reporting year due to errors and incomplete reporting (Harrison and Antweiler, 2003). It is possible that a similar situation may have been present with the NPRI data in its first year of reporting. In addition, there were concerns that facilities were over-reporting their transfers in the first year of the database (Harrison and Antweiler, 2003). As a precaution, to avoid the use of incorrect data or data that were misrepresentative, 1993 emissions were eliminated from the analysis.

The 1994 dataset had certain information that was not reported (such as employee numbers or emissions data) from over half of the companies in the sample. The study would have been compromised if this year of data had been included, since half of the companies that would have been accounted for in other years would have been missing data. Also, some of the reporting requirements for chemicals like ammonium sulphate and ammonium nitrate were different in 1994 than in later years. Consequently, it was decided that the data from 1994 should also be eliminated from the investigation so that over or underestimation of emissions would not occur. The emissions data and employee numbers reported in 1995 were also lacking for the companies contained in the sample and the absence of these values would have compromised the investigation. To be prudent, this year of data was also eliminated. The years 1996 to 2002 were chosen because they contained all of the employee data and emissions data for all the companies in the sample.

A few facilities were also eliminated for various reasons reported in the NPRI database. ThyssenKrupp Fabco in Dresden, Ontario reported that there were changes to production levels in 1997. Previous years had assumed that all welding equipment was automated. This resulted in a higher quantity of emissions. However, in 1997 the calculations separated automated and manual welders from each other instead of assuming all equipment was automated. As a result, their emissions were reduced. In addition, they also a used more accurate number of hours for their calculations (Environment Canada, 2004d). Western Star Trucks Inc. in Kelowna, British Columbia closed down its manufacturing operations and relocated in 2002. Therefore, in 2002, all of their data reflected lower values than other years due to relocation. After all of these filters had been applied to the sample, 87 facilities with sufficient emissions data remained to be analyzed. The facility emissions were then weighted with the CHHI and used as the dependent variable in this investigation.

4.5.1 Dependent Variable

The dependent variable in this study was the aggregated weighted emissions. To actually weight the emissions, the CHHI from the RSEI model were used to adjust for the toxicity. The outcome is a hazard-based result which was calculated using the following equation obtained from the RSEI model technical document (EPA, 2004a):

$$\text{Hazard-based Result} = \text{Tonnes Emitted} \times \text{CHHI Weight} \qquad (11)$$

The number of tonnes emitted by facility is multiplied by the chemical specific toxicity weight. The exposure pathway of the release will also affect the toxicity weight that is applied. For example, an inhalation toxicity weight was employed for releases or transfers to air, stack emissions, and incineration (EPA, 2004a). An oral toxicity value was used for all other releases (Harrison and Antweiler, 2003).

It is important to note that the CHHI weights for each chemical are based on chronic health effects and do not take into consideration acute health effects of chemical exposure (Harrison and Antweiler, 2003). However, Harrison and Antweiler (2003, 367) argue that chronic health indicators are more appropriate "in light of the low-level exposures resulting from most environmental releases." It also must be reiterated that the scores calculated by using the Hazard-based Result may be useful in identifying facilities or chemicals that have a high potential for risk or hazard, yet the numerical score is not independently meaningful. Instead, the score can be viewed as a hazard-based estimate that can be compared to other estimates calculated using the same technique (EPA, 2004a).

The aggregated releases for each facility in a given year (E_{it}) were calculated by summing the Hazard-based Result of the chemicals released:

$$E_{it} = \sum (TonnesEmitted_{cit} \times CHHIweight_c) \qquad (12)$$

where E_{it} is the aggregate weighted emission for facility *i* in year *t*, $CHHIWeight_c$ is the toxicity weight for chemical *c*, and $TonnesEmitted_{cit}$ is the tonnes of emissions of chemical *c* of facility *i* in year *t* following the methodology outlined by the EPA (2004a).

4.5.2 Independent Variables

The independent variables in this investigation were chosen in attempt to replicate the approach carried out by Russo (2004). Even though Russo (2004) focused on the electronics industry in the United States and he weighted the dependent variable in a different manner than in this study, it was deemed appropriate to follow Russo's approach since the study he carried out was very similar in principle to this investigation. Following the approach outlined by Russo, the independent variables of ISO 14001 registration, facility size, and first mover effects were all taken into consideration.

To determine whether a facility was ISO 14001 registered, the World Preferred Registry online (World Preferred, 2004) was consulted to obtain the dates of the facility registrations within the sample. The World Preferred Registry is a non-governmental organization that reports on registration activities and certificates that are issued by registrars that are independently accredited (World Preferred, 2004). Whether a facility is ISO 14001 registered is a variable that is considered to be categorical or qualitative which does not have a numerical scale (Wesolosky, 1976). Categorical or qualitative regression variables are deemed as dummy, binary, or indicator and allow for some flexibility when handling categories in data (Wesolosky, 1976). Facilities that were ISO 14001 registered for at least half of the year were given a value of 1. If a facility was registered for less than half a year, it was given a value of 0. The earliest date that an ISO 14001 registration could take place was in 1996, since the standards were finalized in that year (Russo, 2004). Of the 87 facilities in the sample, 28 facilities (32.2 %) were found to be ISO 14001 registered between the years 1996 and 2002.

Facility size was also measured using information collected by Environment Canada located in the NPRI dataset. A variable was created to reflect the number of employees at each facility in a given year. King and Lennox (2001) state that although there are other acceptable measures of firm size which include assets, sales, and others, employee data are the most publicly available. Russo (2004) asserts that it would be better to obtain actual outputs for each facility. However, facility output information is confidential and therefore could not be obtained for this analysis.

First mover effects were also included in the analysis. First mover advantages are rewards obtained by companies that respond rapidly and act before other companies do. In this case, the first movers were those companies that acted quickly to be among the first to adopt the ISO standard (Esty, 1994). The theory regarding first movers has previously been applied to new environmental technology adoption (Nehrt, 1996) and market entry (Lieberman and Montgomery, 1988). Therefore, Russo (2004) contends that this idea could pertain to ISO 14001, since those facilities that are the first to adopt the standard may have the tendency to be more enthusiastic and proactive, whereas late adopters of the standard could be less passionate about ISO 14001 and may only be acting reactively. For a facility to be considered a first mover, it had to have been ISO 14001 registered within the first two years that the standard was adopted (in 1996 or 1997) (Russo, 2004). According to Corbett and Kirsch (2001), by 1997 the standard was well established and was becoming internationally known. This analysis was carried out separately from the multiple regression analysis using a repeated measure ANOVA to test if there was any difference in aggregated weighted emissions between those facilities that registered in the first two years, those who were the mid-level adopters (1998-2000), late adopters (2001-2002), and those who did not adopt ISO 14001 at all. If a facility was registered in 1996 or 1997, it was categorized into Group 1. If a facility had registered from 1998 to 2000, it was put into Group 2. Late adopters were assigned to Group 3, and those who did not adopt were labelled Group 4.

Some of the independent variables used in Russo's analysis were eliminated from this examination for various reasons. The age of the facility was included in Russo's analysis as a control variable because he reasoned that younger facilities may have been designed more efficiently and would therefore have fewer emissions. It was also expected that older facilities would have greater amounts of emissions. The age variable was omitted from this analysis since the facility's building age was not believed to be representative of the age of the technology of a facility, the types of pollution control equipment in place within the facility, or reflective of the age of the production line. A more appropriate age variable was requested from various facilities in the sample, however, many facilities that were contacted with regards to this study viewed the age of their facility or related information regarding production line improvements to be confidential and would not contribute this type of information for analysis.

Another independent variable that Russo included in his analysis that was not included in this investigation was the total toxic releases per dollar of state Gross Domestic Product (GDP). This would have been a useful variable to include in the multiple regression model; however a comparable measure for the total toxic releases per dollar of provincial GDP could not be found. Also, approximately 83 percent of the facilities from the sample are located in Ontario, and the value of this variable would have been the same for almost all of the facilities.

Lastly, Russo took into account whether an unregistered facility had an uncertified EMS in place. This variable would have allowed the researcher to test whether or not unregistered EMSs were having an effect on emissions performance in addition to testing if ISO 14001 affected emissions. This would have been a useful independent variable to include in this study, but certain companies within the sample did not cooperate in providing this information. Using size, ISO 14001, and whether a facility was a first mover as independent variables allowed for various statistical analyses to take place.

4.5.3 Statistical Analysis – Multiple Regression

In practical statistical problems often a model that is more complex than a straight-line model is necessary to explain the values of a variable y by using other variables such as $x_1, x_2, \ldots\ldots, x_k$. In this example, a realistic model for the aggregated weighted emission of facilities should include more information than just whether a facility is ISO 14001 registered. Factors such as size and whether a facility was an early or late adopter of ISO 14001 are just a few of the many variables that may influence the aggregated weighted emission total of a facility per year. It is apparent then that any phenomenon is affected by multiple factors. The overall goal is to incorporate potentially important independent variables into a model to enable a researcher to make accurate predictions. This more complex model relating the dependent variable (y) to various independent variables is the multiple regression model and the general form of the model in algebraic terms is:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k + \varepsilon \qquad (13)$$

where y is the dependent variable (the variable to be predicted), $x_1, x_2, \ldots\ldots, x_k$ are the independent variables, β_i determines the contribution of the independent variable x_i, and ε is the random error component of the model (Sincich *et al.*, 1999). The least squares method provides the method to fit the model to the sample data. However, to use the results for any inferences that are made, some assumptions about the underlying probability distribution of the errors in the model are necessary (Hubert, 2000). The most common set of assumptions leads to unbiased (the property that the expected value of the statistic equals the parameter) and efficient (the estimator has minimum variance) estimators that have a normal distribution (Hubert, 2000). These are the same assumptions that are required for simple regression and are shown in Table 9.

Table 9: Assumptions of the Multiple Regression Model

Assumptions	
1.	The error term ε_i is independent of each of the X variables
2.	The error term ε_i is normally distributed
3.	The mean of the distribution of the error term is zero
4.	The variance of the distribution for any error term is the same and is denoted σ_ε^2
5.	Any two errors ε_i and ε_j are independent

SOURCE: Hubert, J.J. 2000. *Design and Analysis of Experiments.* Guelph, Ontario: Department of Mathematics and Statistics, University of Guelph.

Assumptions 1 and 3 are necessary for the property of unbiasedness, and assumptions 4 and 5 are needed for the property of efficiency. Assumption 2 guarantees that the estimators are normally distributed and that the F and t test statistics will be valid (Hubert, 2000). Two other conditions are also necessary for the least squares method of approximating the multiple regression model. They are shown in Table 10.

If the aforementioned assumptions and conditions are violated, problems will arise with the least squares estimation method and the associated statistics in the multiple regression analysis. Multicollinearity, heteroscedasticity, and autocorrelation are three of the

Table 10: Conditions Necessary for the Least Squares Approximation of the Multiple Regression Model

Conditions	
1.	The X variables are not linearly dependent
2.	The sample size exceeds the number of X variables by at least 2

SOURCE: Hubert, J.J. 2000. *Design and Analysis of Experiments.* Guelph, Ontario: Department of Mathematics and Statistics, University of Guelph.

common problems with this analysis that were tested for to ensure that model assumptions and conditions were not violated. All the analyses of the data were either carried out using Microsoft (MS) Excel or using the statistical software package called S-Plus, 6.2 for Windows, Student Edition, developed by the Insightful Corporation.

4.5.3.1 Multicollinearity

Multicollinearity is one of the major causes of misinterpretation and misuse of regression results (Wesolowsky, 1976). It occurs when two or more of the independent variables used in the model are contributing redundant information, or, in other words, are significantly correlated with each other. This is a violation of condition 1 in Table 10. In most research studies, it is not uncommon to observe correlations between the independent variables. However, when serious multicollinearity is present, high correlations among the independent variables increase the likelihood of rounding errors in the β estimates, standard errors, etc. Multicollinearity can also have an effect on the signs of the parameter estimates (i.e., b_i may have the opposite sign from what is expected) (Sincich *et al.*, 1999) and may lead to large standard errors (Wesolowsky, 1976). To test for this phenomenon, the simple correlation coefficients among the x variables were examined and are shown in Table 11. Even though there are significant correlations, none of the correlations are very high. Multicollinearity exists if one or more of the r values are near 1 (in absolute value), and if so, the variables in question are highly correlated (Sincich *et al.*, 1999). Since the r values in this analysis were very small, multicollinearity was not deemed to be an issue.

4.5.3.2 Heteroscedasticity

Heteroscedasticity is the violation of the 4^{th} assumption of the multiple regression model (the variance of the distribution for any error term is the same) and can lead to

Table 11: Descriptive Statistics and Correlations

VARIABLE	DESCRIPTION	MEAN	STD DEV.	MIN.	MAX.	1.	2.
1. Aggregated Weighted Emissions	Natural log (aggregated weighted emissions + 1)	6.53	3.28	0.00	12.56		
2. Size	Measured in natural log(number of employees)	6.36	1.12	2.56	8.70	0.30*	
3. Facility Registered to ISO 14001	ISO registered or not ISO registered	0.11	0.31	0.00	1.00	0.12*	0.19*

N = 609 and *p<0.001

inefficient estimators. To test for heteroscedasticity the Goldfeld-Quandt test was used. The observations are first ordered by increasing x values (in this case the observations were ordered from smallest to largest numbers of the size variable). The sample is then divided in to 3 ranges with 3/8 of the observations with the smallest values of the x variable, 3/8 of the observations with the largest values of x, and 1/4 in the middle. In this analysis, the ranges contained 228, 228, and 153 observations respectively. Regression lines were then fitted to the upper and lower observations. The test statistic is

$$F = \frac{MSaboutregression(lastrange)_2}{MSaboutregression(firstrange)_1} \qquad (14)$$

and has an F distribution with degrees of freedom of $v_1 = n_1 - m_1$ and $v_2 = n_2 - m_2$, where $m = q + 1$ in which q is the number of independent variables and n is the number of observations in the range (Dougherty, 2000). The F statistic in this analysis was 1.15. This was less than the critical values of 1.22 and 1.33 at the 5% and 1% levels. Therefore, the null hypothesis of homoscedasticity is accepted (and the data are not heteroscedastic). All calculations in further detail for heteroscedasticity can be found in Appendix E.

4.5.3.3. Autocorrelation

Autocorrelation is the violation of the fifth assumption which is that any two errors ε_i and ε_j are independent. If the error terms are not independent of each other, then the least squared estimators are not efficient (Hubert, 2000). This can cause larger t values to be calculated and for incorrect decisions to be made in hypothesis testing. The most popular method to test for autocorrelation of the data is the Durbin-Watson Test (Hubert, 2000). The null hypothesis is that no autocorrelation exists and the Durbin-Watson statistic, denoted D, is based on the least squared residuals e_i (Wesolowsky, 1976):

$$D = \frac{\sum_{i=2}^{n}(e_i - e_{i-1})^2}{\sum_{i=1}^{n} e_i^2} \qquad (15)$$

The value of D tends towards 2.0 if there is no autocorrelation, it tends towards zero if there is positive autocorrelation, and it tends towards 4 if there is negative autocorrelation. The data used in the autocorrelation examination can be found in Appendix F. The value calculated for this analysis was 1.46. Critical values of D_L and D_U (lower and upper critical values of D) were obtained from a Durbin-Watson Critical Value Bounds Table (Wesolowsky, 1976) and Table 12 illustrates how to determine if there is autocorrelation present. The null hypothesis is that there is no significant autocorrelation present. The D_L and the D_U were 1.44 and 1.65 respectively at the 1% significance level. The calculated test statistic falls between D_L and D_U which means that the null hypothesis regarding autocorrelation can neither be rejected nor accepted. If one were taking the conservative position, the inconclusive region would be deemed to indicate a minor problem of autocorrelation (even though the data may be slightly autocorrelated). To account for the possibility of the data being autocorrelated, which would run the risk of the ordinary least squares method not providing the best estimate of the model's coefficients, the alternate approach of the General Least Squares estimate of the data was also calculated to analyze the results as a precaution (Pinteris, 2004).

Table 12: Regions of Acceptance and Rejection of the Null Hypothesis

Zero to D_L	D_L to D_U	D_U to (4-D_U)	(4-D_U) to (4-D_L)	(4-D_L) to 4
Reject the null hypothesis – positive autocorrelation	Neither accept or reject	Accept the null hypothesis – no autocorrelation	Neither accept or reject	Reject the null hypothesis – negative autocorrelation

SOURCE: Hubert, J.J. 2000. *Design and Analysis of Experiments.* Guelph, Ontario: Department of Mathematics and Statistics, University of Guelph.

4.5.4 Panel Data

After all the preliminary tests for autocorrelation, heteroscedasticity, and multicollinearity had been carried out, it was deemed appropriate to carry out the multiple regression analysis on the data. The type of data used in this analysis is called cross-sectional time-series or panel data where multiple cases are observed over two or more time periods. These two types of panel data allowed for the regression analysis to have both a spatial and temporal dimension (NYU, 2003). The spatial dimension refers to the set of cross-sectional units of observation, which in this case were the facilities in the Transportation Equipment Industry. The temporal dimension pertains to periodic observations of a set of variables characterizing the cross-sectional units over time (NYU, 2003). For this study, the temporal dimension of the study was restricted to a seven year time span. The structure of the panel data includes sequential cross-sections (or blocks) of data. Within each block there was a time series, as shown below using truncated data from this study:

Facility Number	Year	Weighted Emission	Size	ISO registered
Facility 1	1996	15405.34	2204	0
Facility 1	1997	6828.71	1251	0
Facility 1	1998	20384.50	1600	0
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
Facility 45	2000	50698	570	0
Facility 45	2001	258.01	604	1
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
Facility 87	2002	26390.29	170	0

This data set contained a total of $87 \times 7 = 609$ observations. In other words, the 87 facilities were followed for seven years and were sampled annually. The cross-sectional unit of observation, which were the facilities, were denoted *i*. The temporal dimension was denoted *t*. The error term has two dimensions, one for the facility and one for the time period (NYU, 2003).

Longitudinal data methods allowed the researcher to take advantage of these two different kinds of information in this study. Regular multiple regression techniques could have been used for this study; however, multiple regression by itself may not have been the best method for analysis of the data. Using ordinary multiple regression techniques could make the estimates of the derived coefficients subject to variable bias. Variable bias occurs when there is an unknown variable (or variables) that cannot be controlled for that affect the dependent variable, which in this case was the aggregated weighted emissions (Princeton University Library, 2004). When using longitudinal data, it was possible to control for omitted variables even though they were not observed or measured in the analysis (Princeton University Library, 2004). To do this, a fixed-effects multiple regression model (otherwise known as a Least Squares Dummy Variable Model) was used to control for the omitted variables that differed between facilities and over time. When this model was hypothesized, it was hoped that the independent variables that were chosen would adequately explain the values of the independent variable, however there will always be some unmodeled heterogeneity (Kousser, 2004). If this heterogeneity is not modeled, it will be reflected in the error term.

To create a fixed-effects model, dummy variables were created for each of the facilities and for each year of data. These dummy variables were then included in the model to control for the fixed facility and year effects. The facility effects are known as "within-groups effects" (Hausman and Taylor, 1981) and the year effects are known as the "between effects" (NYU, 2003).

A fixed effects model was chosen over a random effects model since a fixed effects model allowed for the results to be generalized and applied to similar values of the independent variables in the population or in other studies (Newsom, 2004). Almost always, researchers used fixed effects regression rather than random effects, and rarely do situations arise where random effects regression models are used (Newsom, 2004). The random effects model assumes that individual effects are randomly distributed across cross-sectional units, which in this case would be the facilities (Seddighi *et al.*, 2000). The random effects model would most likely produce larger standard errors than the fixed effects model and therefore be less powerful (Newsom, 2004

The estimated fixed-effects model that was used in this analysis is shown in equation (15):

$$E_{it} = \delta_1 + \delta_2 Facility_2 + \delta_3 Facility_3 + \ldots + \delta_{87} Facility_{87} + \beta_1 x + \alpha ISO + \lambda_1 + \lambda_2 1997 + \lambda_3 1998 + \ldots + \lambda_7 2002 + \varepsilon_{it} \quad (16)$$

Each term of the equation is explained further in detail subsequently.

4.5.4.1 Facility Dummy Variables (*Facility*)

Dummy variables corresponding to each facility were included in the analysis. Dummy variable usage is a powerful method that can account for various factors that are specific to certain facilities (Hsiao, 2003). If a facility dummy variable was found to be significant in the regression analysis, then this would indicate that there were other factors, specific to that facility, that were causing an effect on the aggregated weighted emissions. These other factors are independent variables that were not accounted for within the hypothesized multiple regression model. The purpose of the facility dummy variables in this model was to permit a different level of aggregated weighted emissions for each facility while taking into account the size of each individual facility, whether it was ISO 14001 registered or not, and the year of the aggregated weighted emission. To accomplish this, facility dummy variables allowed for a different intercept for each of the 87 facilities while retaining a constant slope (Wesolowsky, 1976). In effect, eighty-seven different lines with the same slope were fitted, which is not the same as separating the data points into eighty-seven different categories and running separate regressions because that would produce eighty-seven different slopes (Wesolowsky, 1976). Figure 5 illustrates that there is a different intercept for each facility.

In the multiple regression model, a dummy variable was created corresponding to each facility. For example, the variable for A.G. Simpson Co. Ltd. (facility 2) was created and was interpreted as meaning that the facility assigned a 1 on this variable was A.G. Simpson Co. Ltd, and all other facilities were assigned a 0 (since they were not this facility). When the data were entered into the model, facility 1 (ACSYS Technologies)

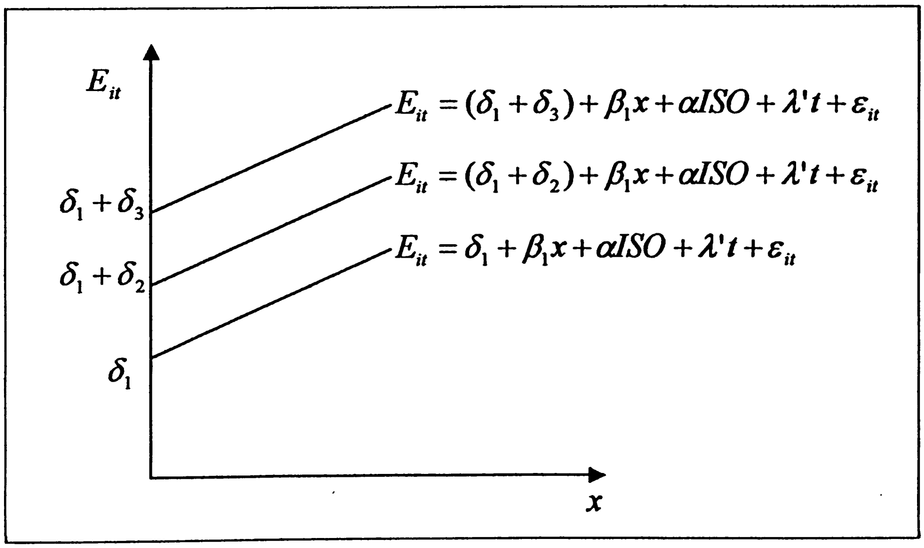

Figure 5. Changing the Intercept with Dummy Variables. Source: Modified from Wesolowski, G.O. 1976. *Multiple regression and analysis of variance*. Toronto, Ontario: John Wiley and Sons.

was omitted because if it was included, no solution would have been able to be found due to multicollinearity. The general rule is that a categorical (dummy) variable with *p* (87) categories will be represented by *p-1* (86) dummy variables (Wesolowsky, 1979). The first facility was coded with all *Facility* variables equal to zero. In other words, when the facilities (numbers 2 to 87) variables are coded 0, this automatically indicates that the variable that is being referring to is ACSYS Technologies (facility 1) as shown in Table 13 along with other facility dummy variables values and their corresponding equations. In this model, it can be seen that the intercepts vary with the facility. For example, the intercept for ACSYS Technologies is δ_1. The intercept for A.G. Simpson Co. Ltd. is $\delta_1 + \delta_2$. The intercept for ArvinMeritor (facility 3) would be $\delta_1 + \delta_3$ and so on for the other facilities.

Table 13: The Role of Dummy Variables in Changing an Equation

Facility	Dummy Variable Values	Equation
1	$Facility_2 = 0, \ldots, Facility_{87} = 0$	$E_{it} = \delta_1 + \beta_1 x + \alpha ISO + \lambda' t + \varepsilon_{it}$
2	$Facility_2 = 1$, $Facility_3 = 0, \ldots, Facility_{87} = 0$	$E_{it} = (\delta_1 + \delta_2) + \beta_1 x + \alpha ISO + \lambda' t + \varepsilon_{it}$
87	$Facility_2 = 0, \ldots, Facility_{86} = 0$ $Facility_{87} = 1$	$E_{it} = (\delta_1 + \delta_{87}) + \beta_1 x + \alpha ISO + \lambda' t + \varepsilon_{it}$

SOURCE: Modified from Wesolowski, G.O. 1976. *Multiple regression and analysis of variance*. Toronto, Ontario: John Wiley and Sons.

If the dummy variable for ACSYS Technologies was attempted to be added into the analysis (with ACSYS Technologies =1 as a dummy variable value), exact multicollinearity would arise. The problem of multicollinearity arises when an independent variable is substantially correlated with another independent variable or with a linear combination of other independent variables (Wesolowsky, 1976). If the dummy variable for ACSYS Technologies was added into the analysis the correlation coefficient (r) between the dummy variables would equal 1. Then the standard error for the regression coefficients would not be able to be determined because the denominator of the following equation:

$$SE_b = \sqrt{\frac{S_y^{\ 2}}{(\sum x^2 - \frac{(\sum x)^2}{n})(1-r^2)}} \qquad (17)$$

would equal zero if $r = 1$ (Vartanian, 2004).

Also, it can be shown using matrix algebra, that the determinant (which needs to be found to solve the ordinary least squares solution of the equation) is equal to zero when one of the dummy variables is not omitted from the analysis. To solve the least squares equation using matrix algebra, the matrix with the dummy variables contained in it must be inverted using the equation $A^{-1} = \frac{1}{\det(A)} adj(A)$, where A is the matrix, det(A) is the determinant of A and adj(A) is the adjoint of A (Anton and Rorres, 1994). If all 87 of the dummy variables were included in the analysis the determinant would be equal to zero and this would result in $A^{-1} = \frac{1}{0} adj(A)$ which would give an error. By omitting a dummy variable from the analysis, the determinant would no longer be equal to zero and the inverse of the matrix would be able to be calculated and therefore the ordinary least squares equation could be solved (Cohen and Cohen, 1983).

Since the ACSYS Technologies facility dummy variable value was excluded from the analysis, this was the facility that all other facilities were compared to (Princeton University Library, 2003). What the regression equation did was examine the differences in aggregated emission between each of the facilities and the excluded facility. The parameters that were calculated are the difference in aggregated weighted emission between the facility that was being examined and the excluded facility (Vartanian, 2004).

4.5.4.2 Size (*x*)

The proxy for size was the natural logarithm of the number of employees at a facility. The natural logarithm was used to transform the data to improve the linearity, the normality (symmetry about the regression equation), and homogeneity of the variance (constant variance about the regression equation) (Dallal, 2002). When the natural logarithmic transformation was applied, the distribution was less skewed.

4.5.4.3 ISO Variable (*ISO*)

Participation in ISO 14001 was coded as a binary variable in each year of its membership as was previously mentioned in the study background section. If a facility was ISO 14001 registered for at least half a year it was coded with a 1, otherwise it was coded with a 0.

4.5.4.4 Year Dummy Variables (*1996-2002*)

The variables 1996 – 2002 are a set of dummy variables that were also used in this analysis. However, 1996 was eliminated from the analysis to prevent the issue of multicollinearity, as was previously stated in the discussion regarding the facility dummy variables. Since 1996 was the year that was omitted, this was the year that all the other years were compared to. These dummy variables were included to test whether there were other variables, aside from the ones already included in the multiple regression model, that contributed to the effects on the aggregated weighted emissions during specific years in the study. Again, like the facility dummy variables, the intercepts for each year vary, however the slopes of the different lines remain the same. The intercept for 1996 is λ_1. The intercept for 1997 is $\lambda_1 + \lambda_2$ and so on for the other years in the analysis.

4.5.4.5 Other Models

Prior to obtaining the multiple regression model described in the previous section, many analyses were carried out before determining which model best suited the data. The first model that was investigated did not contain any transformed data, that is the weighted emissions and employee numbers were in their original state. However, the test for heteroscedasticity failed for this data set. As a result, different combinations of transformations on the data were attempted, such as transforming the weighted emissions only, transforming the size variable only, and then using a combination of both transformations. In addition, an effort was made to use the percentage change in weighted emissions from year to year for the independent variable but a difficulty arose when controlling for facility size since employee numbers were given as yearly totals. Different models using variables for early and late adopters, along with their number of years of experience with ISO 14001 were also attempted but singularities arose due to problems with multicolinearity. It was determined that a repeated measures ANOVA would be a more appropriate way to obtain this information.

4.5.5. Statistical Analysis - Generalized Least Squares Model

A Generalized Least Squares (GLS) analysis was also carried out on the data to be compared with the multiple regression model due to the possibility of minor autocorrelation that may have existed with the data. Unlike the fixed effects model, the GLS model does not contain dummy variables for each facility as shown in the model specification below:

$$E_{it} = \lambda_1 + \lambda_2 1997 + \lambda_3 1998 + \ldots + \lambda_7 2002 + \beta_1 x + \alpha ISO + \varepsilon_{it} \qquad (18)$$

All of the terms in the GLS model are the same as the terms described above for the fixed-effects model, with the exception of the facility dummy variables since the fixed effects model had already been used to control for unobserved heterogeneity between the facilities (King and Lennox, 2000). The GLS model is a regression model with errors that have a "non-standard" covariance structure (Insightful Corp., 2001). Similar to the simple least squares regression, the GLS method uses the maximum likelihood to fit a continuous response as a linear function of a single predictor variable (Insightful Corp., 2001). However, when GLS is used, the errors can be correlated and/or have unequal variances (Insightful Corp., 2001). Unlike in the multiple regression model, autocorrelation can result because of a violation of the assumption that any two errors ε_i and ε_j are independent. The GLS model allows for errors to be correlated and therefore the errors can also be dependent on each other. Since there was a slight possibility of autocorrelation of the data, it seemed necessary to also carry out the GLS analysis because it allows for the possibility of correlation between errors in the model.

4.5.6 Statistical Analysis - Repeated Measures ANOVA

To determine if there was any difference between those facilities that were early, mid, and late ISO 14001 adopters and those that did not adopt ISO 14001 at all, the experimental design applied to the data was the general linear model repeated measures design. All statistical analyses for this section were carried out using SPSS statistical software. The repeated measures research design is one of the most powerful and efficient statistical designs (Weinfurt, 1995). The term repeated measures refers to a situation in which subjects are measured on more than one occasion. For this study, the "subjects" were the facilities (both ISO 14001 registered and not) and the aggregated weighted emissions in each year were the yearly measurements that were "repeated". In this case, the independent variable was time, which was measured in years and was called the within-subjects variable. Seven years was chosen as the time period where facilities were assessed on the dependent variable (aggregated weighted emissions). A between-subjects variable is a grouping variable (Weinfurt, 1995). The values for the between-subjects variable were divided into four groups. The first group was comprised of facilities that adopted ISO 14001 in 1996 or 1997, the second group contained facilities that adopted ISO 14001 in the years 1998 to 2000, the third group adopted in 2001 to 2002, and the last group did not adopt ISO 14001 at all and were labelled Groups 1, 2, 3, and 4 respectively. Lastly, it was expected that pre-existing differences among subjects would also influence the dependent variable (aggregated weighted emissions) in addition to the chosen independent variable of time (Maxwell and Delaney, 1990). These pre-existing differences were not the main focus of this investigation but this information was collected on the facilities in addition to the aggregated weighted emission. This variable is a covariate and was introduced into the analysis. The covariate in this analysis was the facility size which was measured using average employee numbers of a facility as a proxy. An abridged set up of the data is shown below with the weighted emissions of each facility found under each year that they were emitted:

Facility	*Group*	1996	1997	1998	1999	2000	2001	2002	*Employees*
Facility$_1$	4	15405.43	6828.71	20384.50	11706.37	9376.80	18207.99	77146.41	1579
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
Facility$_8$	3	12275.00	16135.86	18586.89	18595.11	7803.75	11394.33	7450.92	969
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
Facility$_{87}$	4	49660.71	67908.26	69649.53	82642.84	40580.56	82213.20	26390.29	457

A repeated measures analysis of variance (ANOVA) was carried out to test the equality of the means of the four different groups. Using a standard ANOVA with this type of data was not sufficient since it failed to adequately model the correlation between the repeated measures (Information Technology Services, 2004). There were three possible effects that were tested for in the investigation which are outlined in Table 14.

Table 14: Hypothesis Testing in Repeated Measures Analysis

Possible Effects of Interest	
1.	Between-subject effects (between Groups 1, 2, 3, and 4)
2.	Within-subject effects (Time – 1996 to 2002)
3.	Interactions between the two types of effects (Groups*Time) (This is also considered a type of within-subject effect)

Source: Derived from Girden, E.R. 1992. *ANOVA Repeated Measures.* London, England: Sage Publications

The effect of the repeated measures analysis that was of most interest for this investigation was the interaction effect and this was the test that was highlighted in this paper for analysis. The interaction effect was examined because it made it possible to test whether there was a significant difference between Groups 1, 2, 3, and 4 over time. The results of the other effects (numbers 1 and 2 in Table 14) were not considered to be as informative in discovering whether there was a difference over time between groups that registered to ISO 14001 at different time periods (or not at all). The results of the between-subjects and within-subjects effects can be found in Appendix G.

In SPSS, the within-subjects effects (which included the interaction effects) were computed by transforming the within-subjects variables into single degree of freedom tests of the null hypothesis. In this study, the time within-subjects effect had seven levels (years 1996 to 2002), so there were six degrees of freedom for the time main effect and the General Linear Model (GLM) repeated measures procedure on SPSS created six new variables: linear, quadratic, cubic, and polynomials of the 4^{th}, 5^{th}, and 6^{th} order which were transformations of the original within-subjects variables. These new variables and their sums of squares (SS), degrees of freedom (df), mean square (MS), F test statistics and significance are shown in Table 15.

To test the year variables with 6 degrees of freedom (J-1 = 7-1 = 6, where J is the number of year categories), the statistical package added together the six single degree-of-freedom effects estimates, which means that the sum of squares for each of the six new variables were added together (0.379 + 4.800 + 10.353 + 1.088+ 0.776 + 0.301 = 17.697). In the ANOVA table listed in the results section of the thesis on page 95, 17.697 is the value used as the sum of squares for the year variables with (1+ 1+ 1+ 1+

Table 15: Tests of Within-Subjects Contrasts

Source	Year	Type III Sum of Squares	df	Mean Square	F	Sig.
Year	Linear	0.379	1	0.379	0.042	0.838
	Quadratic	4.800	1	4.800	1.218	0.273
	Cubic	10.353	1	10.353	4.117	0.046
	Order 4	1.088	1	1.088	0.744	0.391
	Order 5	0.776	1	0.776	0.731	0.395
	Order 6	0.301	1	0.301	0.227	0.635
Year * Group	Linear	9.737	3	3.246	0.360	0.782
	Quadratic	3.978	3	1.326	0.336	0.799
	Cubic	21.971	3	7.324	2.912	0.039
	Order 4	2.602	3	0.867	0.593	0.621
	Order 5	2.441	3	0.814	0.767	0.516
	Order 6	0.382	3	0.127	0.096	0.962
Error(Year)	Linear	738.778	82	9.009		
	Quadratic	323.247	82	3.942		
	Cubic	206.207	82	2.515		
	Order 4	119.842	82	1.461		
	Order 5	87.044	82	1.062		
	Order 6	108.841	82	1.327		

1+ 1 = 6) six degrees of freedom. The same procedure was also carried out for the Year * Group variables and the Error (Year) variables. It was rational to add those variables together only if they met the following two conditions (Becker, 1999):

1. Their variances were equal.
2. They were uncorrelated with each other.

To test both of these assumptions at the same time, the Mauchly Test of Sphericity was utilized. If the test was not significant, then it was appropriate to add the six single degrees of freedom estimates together to get an overall estimate with six degrees of freedom. However, as Table 16 shows, the Mauchly Test was significant and the sphericity assumption was not met. This meant that the F tests would overestimate the strength of the relationships. To account for this, a correction was applied to the F tests. To correct the data, the Year, Year*Groups and the Error(Year) degrees of freedom were multiplied by an epsilon value provided in Table 16. The significance of the F value was then determined by using the corrected degrees of freedom (Becker, 1999). Three types of epsilons are shown in Table 16. The difference between the three is that they vary in robustness (protection against Type I errors which is the probability of rejecting the null hypothesis when it is true) (Girden, 1992). The lower bound epsilon is very conservative and is rarely used (Becker, 1999), but it was included for comparison sake. The F ratios were calculated by SPSS by dividing the mean square of regression by the mean square error ($MS(regression) = \frac{SS}{df}$, $F = \frac{MS(regression)}{MS(error)}$). The ratio would yield approximately 1.00 in the absence of an effect and a value that was significantly greater than 1.00 if there was an effect (Girden, 1992).

Table 16: Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon(a)		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Year	0.059	226.401	20	0.000	0.501	0.548	0.167

4.6 Results

4.6.1 Multiple Regression

The multiple regression results for the data appear in Table 17. The Analysis of Variance (ANOVA) F test for Model A is significant. This means that at least one of the independent variables in Model A is contributing significant information to the prediction of the aggregated weighted emissions variable and that at least one of the ß parameters in the model has a non-zero value (Mendenhall *et al.*, 1999). The F test evidence suggests

Table 17: Regression Results
(Dependent Variable: Aggregated Weighted Emission)

	Model A: Fixed Effects	Model B: Generalized Least Squares
Intercept	6.497*** (2.052)	1.347 (0.806)
Size[a]	0.875** (0.380)	0.818*** (0.116)
Facility Registered to ISO 14001	0.324 (0.339)	1.045** (0.453)
Year 1997	0.310 (0.269)	0.296 (0.475)
Year 1998	0.142 (0.271)	0.131 (0.475)
Year 1999	0.191 (0.274)	0.140 (0.476)
Year 2000	-0.1183 (0.272)	-0.180 (0.476)
Year 2001	-0.604** (0.276)	-0.734 (0.482)
Year 2002	-0.314 (0.291)	-0.554 (0.498)
R^2	0.754	0.104
R_a^2	0.708	0.092
F-Statistic	16.78***	8.680***

[a] Natural logarithmic transformation used

N = 609 observations. Standard errors are in parentheses. Significance levels, based on one-tailed tests:
* p < .10
** p < .05
*** p < .01

that the model is adequate and that it is reasonable to analyze the t tests on the ß parameters for the models (Sincich *et al.*, 1999). In Model A, the t test for β_1 implies that the "size" variable is significant (p<0.05). This indicates that there is sufficient evidence that facility size (which is measured in number of employees) contributes to the prediction of y (aggregated weighted emission) when all the other independent variables are held fixed. In other words, β_1 represents the mean change in y for every unit increase in x (number of employees). The regression coefficient for "size" is -0.125 after the data were back-transformed from its logarithmic value. It is estimated then, that the aggregated weighted emission decreases 0.125 with an increase of one employee when the other independent variables are held fixed.

In Model A, a dummy variable is present to track whether or not a facility is ISO 14001 registered for the greater part of the year. Results indicate that the regression coefficient has a positive sign which was not anticipated; however, the coefficient is not statistically significant. The lack of significance for this parameter implies that there is not sufficient evidence that ISO 14001 contributes to the prediction of aggregated weighted emissions when all other independent variables are held fixed. For the year (1997-2002) dummy variables, the 2001 regression coefficient is significant ($p<0.05$) when compared to the 1996 omitted year. This coefficient suggests that the difference between the mean aggregated weighted emission of 2001 is significantly different than the mean aggregated weighted emission in 1996. The significance of the negative coefficient indicates that there is some other factor, not ISO 14001, which occurred in 2001 that lead to the decrease in the aggregated weighted emissions of all the facilities. None of the other year dummy variables are significant.

With regards to the facility dummy variables, the facility dummy variables that were found to be significant are shown with their t and p values in Appendix H. The facility dummy variables that were significant indicate that the mean aggregated weighted emissions of these facilities are significantly different than the mean aggregated weighted emissions of facility 1. What this reveals is that there are other factors that are specific to certain facilities that are influencing the aggregated weighted emissions in addition to the other significant independent variables specified in the model.

To test how well Model A fits the data, the statistical measure of the strength of the model is provided. This measure, the coefficient of determination (R^2), tells the proportion of the total variation that is explained by the regression of the aggregated weighted emissions (y variable) on the independent variables (i.e. size, ISO registration) (Mendenhall *et al.*, 1999). The R^2 value of Model A is 0.754. An adjusted co-efficient of determination (R^2_a) is also used as an alternative measure of model accuracy. Both of the sample size, n, and the number of ß parameters are adjusted for with R^2_a and R^2_a, unlike R^2, will not simply increase by adding more independent variables to the model. The R^2_a value is 0.708.

Note that the value of R^2_a is slightly smaller than the R^2 value. After adjusting for sample size and the number of parameters contained within the model, approximately 71 percent of the sample variation can be explained by Model A. However, it is suspected that most of this sample variation is being accounted for by the facility dummy variables. Since these dummy variables represent other factors not included in the model that are influencing the aggregated weighted emissions, in reality, the high values of the coefficients of determination are reflecting the need for other explanatory variables in the model, such as presence or absence of an unregistered EMS, age of production lines, differences in pollution control technology, etc.

4.6.2 Generalized Least Squares

The GLS Model B regression results are shown in Table 17. The F test for Model B is significant which reveals that at least one of the independent variables in the model is contributing significant information to the prediction of dependent variable (Mendenhall *et al.*, 1999). This result implies that the model is adequate and that it is reasonable to analyze the t tests on the ß parameters in the model (Sincich *et al.*, 1999). For Model B, the t test for β_1 implies that the "size" variable is significant ($p<0.01$). This indicates that there is sufficient evidence that facility size plays a role in prediction of the dependent variable when all the other independent variables are held fixed. After back-transforming the data, the regression coefficient for "size" is -0.182. It is estimated then, that the aggregated weighted emission decreases 0.182 with an increase of one employee when the other independent variables are held fixed.

For the ISO 14001 registration dummy variable, the results indicate that the regression coefficient is positive and that the coefficient is statistically significant ($p<0.05$). The significance of this parameter implies that there is sufficient evidence, using the GLS approach that ISO 14001 does contribute to the prediction of aggregated weighted emissions when all other independent variables are held fixed. After transforming the data, the regression coefficient for ISO registration is 1.844. It is estimated then, that the aggregated weighted emission increases by 1.844 with ISO 14001 registration when the other independent variables are held fixed.

For the year (1997-2002) dummy variables, none of the regression coefficients are found to be significant when compared to the 1996 omitted year. The results of this analysis indicate that the mean aggregated weighted emissions in 1997 to 2002 are not significantly different than the mean aggregated weighted emission in 1996. According to the analysis, no other factors are significantly influencing the mean aggregated weighted emissions for each of the years from 1997 to 2002.

The facility dummy variables are not included in the GLS model since the multiple regression Model A is the model that is used to control for unaccounted differences regarding the magnitude and significance of individual facility effects.

Model B has an R^2 value of 0.104. The adjusted co-efficient of determination, R^2_a, is 0.092. Again, the value of R^2_a is slightly smaller than the R^2 value. After adjustments, approximately 10 percent of the sample variation can be explained by Model B. The R^2 is believed to be much lower than that of Model A since the facility dummy variables are not included in the GLS model. The dummy variables of Model A represent other factors not included in the model that are influencing the aggregated weighted emissions. Therefore, it inferred that the high R^2 value of Model A can be attributed to other factors, specific to the individual facilities that are not included in the model. Whereas Model B had a low R^2 value since this model did not account for these other factors specific to individual facilities. It is believed that the R^2 value of Model B is better representative of the proportion of the total variation that is explained by the regression of the aggregated weighted emissions on the independent variables.

4.6.3 Repeated Measures ANOVA

The results of the repeated measures ANOVA are located in Table 18. From this table, it is apparent that neither the Year nor the Year*Group interaction is significant. What this tells the researcher is that there is no significant difference between Groups 1, 2, 3, and 4 over time. From this it can be inferred that there is no significant difference in the mean aggregated weighted emissions over time among early, mid, late, or non-adopters of ISO 14001. Within this sample of companies, no advantage is realized from adopting the standard at an early, mid, or late time period or from adopting the ISO 14001 standard at all.

Table 18: Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Year	Sphericity Assumed	17.697	6	2.949	0.916	0.483
	Greenhouse-Geisser	17.697	3.006	5.887	0.916	0.434
	Huynh-Feldt	17.697	3.285	5.387	0.916	0.440
	Lower-bound	17.697	1.000	17.697	0.916	0.341
Year* Group	Sphericity Assumed	41.110	18	2.284	0.709	0.803
	Greenhouse-Geisser	41.110	9.018	4.559	0.709	0.700
	Huynh-Feldt	41.110	9.856	4.171	0.709	0.713
	Lower-bound	41.110	3.000	13.703	0.709	0.549
Error(Year)	Sphericity Assumed	1583.959	492	3.219		
	Greenhouse-Geisser	1583.959	246.497	6.426		
	Huynh-Feldt	1583.959	269.404	5.880		
	Lower-bound	1583.959	82.000	19.317		

4.7 Discussion

The results of this analysis suggest that there is no evidence to support the hypothesis that ISO 14001 registered facilities experience greater emissions reductions than those facilities that are not registered to ISO 14001 in the Transportation Equipment Industry. On the contrary, evidence is presented that facilities that have obtained ISO

14001 encounter an increase in aggregated weighed emissions. However, this finding could be the consequence of facilities with a track record of emitting higher amounts of pollution registering to ISO 14001. It is possible that higher emitting facilities are registering to improve their environmental image to the public and to investors without making substantive enough changes in their environmental performance to reveal an effect on the aggregated weighted emissions. Perhaps the time period that is used in the study did not allow for the benefits of registered facilities to be realized, especially since approximately 45 percent of the ISO 14001 registered companies in the sample obtained their registration in 2002. Also, unregistered facilities may not have been subscribing to ISO 14001; however, it is possible that they may have had an uncertified EMS which could have caused their emissions to be less than ISO 14001 registered facilities. It is possible that ISO 14001 registered facilities may have decreased their less toxic emissions over time, but these decreases could have been offset by minute increases of highly toxic chemicals, which would be reflected as an increase in aggregated weighted emissions in the GLS model. Lastly, facilities that are participating in ISO 14001 may be more vigilant or precise when reporting their emissions to the NPRI than unregistered facilities. This would make these facilities appear "dirtier" than non-registered facilities (King and Lennox, 2000).

The outcome of this study regarding the estimated negative relationship predicted by the regression coefficients in both models for "size" seems to be counter-intuitive, since one would expect that as the size of a facility increases, that so would its production of toxic emissions. However, in this sample of companies, it is possible that the larger companies are emitting substantial amounts of chemicals; nevertheless, these chemicals may not be very toxic and therefore are not weighted significantly. Since more toxic substances are weighted heavily, this implies that the model estimates that medium to smaller sized facilities are releasing more toxic substances into the environment than larger facilities. Another possible explanation of the relationship between the size and aggregated weighted emission is that larger facilities may have economies of scale when it comes to pollution reduction (King and Lennox, 2000). The marginal cost of environmental improvements may be less for larger facilities than for smaller facilities (King and Lennox, 2000).

The results of the repeated measures analysis suggest that there is no advantage to having been a first mover when it came to implementing ISO 14001. In fact, no difference is found between those facilities that registered during various years in the 1996 to 2002 time span and those who did not register at all. First mover advantages are not present with respect to the aggregated weighted emissions of ISO 14001 registered facilities. Those facilities that were the first to adopt the standard did not appear to have the tendency to be more enthusiastic and proactive than late adopters or those who did not adopt ISO 14001 at all. It is possible that no first mover effects were experienced in this sample of companies due to the very small number of facilities that were registered to ISO 14001 in the first two years. As shown in Figure 6, only two facilities were registered in the 1996 to 1997 first mover (early adopter) category. Unfortunately, the small number of facilities in this category could not be improved upon since the analysis was restricted by the emissions data.

It is apparent in the fixed-effects model that there are other factors specific to individual facilities not accounted for by Model A that are leading to changes in the

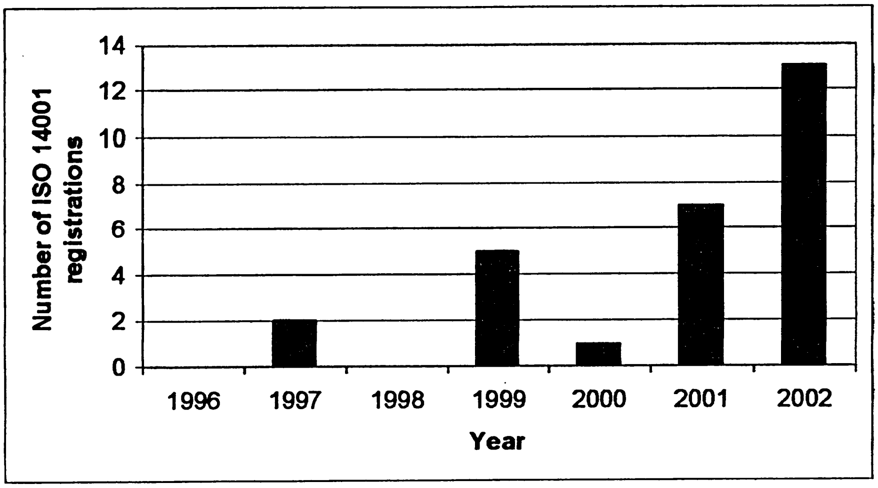

Figure 6: ISO Registrations in Transportation Equipment Industry Sample

aggregated weighted emissions. This is indicated by the coefficients of the dummy variables for each facility having significance as shown in Appendix H. To account for some of these factors that are specific it is recommended that the following limitations are addressed in future studies.

One of the limitations of this study is that a longer time period is necessary to analyze the influence of ISO 14001 on emissions performance. Even though this study encompasses seven years of emissions data, almost half of the registrations took place in 2002 as seen in Figure 6 and therefore any benefits that may have been accrued from this large portion of ISO 14001 registered facilities most likely did not surface in the dataset. This could not have been improved upon in this study since the NPRI emissions data were only available up until 2002 at the time of this research. Future researchers on this topic may not have as much difficulty determining relationships because of the increasing number of facilities and firms that are becoming ISO 14001 registered. For example, in 1997 there were a total of 27 facilities that were registered in all of Canada as compared to the 1064 facilities and firms that were registered in 2002 within all sectors (ISO, 2005).

A limitation of both models in this study is that neither one took into account the age of the production lines in the facilities. Russo (2004) included a variable for facility age to try and pick up any influence of its vintage and found that the older the plant, the greater the emissions of the plant. The actual building age was not deemed the best variable to reflect "age", since production lines can go through varying degrees of upgrades. Therefore, the actual structure could be many years old, whereas the production lines could be fairly new or younger than the physical structure housing the production line. It is recommended that some sort of indicator of production line age is included as a control variable, if this information can be obtained since many companies view this information to be confidential and will not make it readily available to researchers.

Another limitation is that a control variable for the presence or absence of an uncertified EMS was not introduced into the model. This would most likely be another useful control variable to ascertain whether changes in emissions are due to other factors unique to individual facilities. However, there is evidence from Russo (2004) indicating that environmental management systems had no influence on emissions which suggests that even if this variable had been included in the analysis, no significant effect may have been found.

Lastly, some relative measure of emissions to other facilities in the industry is necessary to differentiate between those facilities that are operating in "dirtier" segments of the transportation equipment industry. By including a variable that encompasses this information, one could ascertain if facilities from a traditionally higher polluting segment of the industry are adopting ISO 14001, resulting in an increase in aggregated weighted emissions with ISO registration.

4.8 Conclusion

This study adds to the empirical body of knowledge regarding the effects of environmental management on emissions performance. The notion that ISO 14001 registered facilities have greater emission reductions is not supported by this study nor does there seem to be a difference, using this sample of facilities, between facilities registered early, mid, late, or not at all. ISO 14001 registered facilities are found to cause an increase in aggregated weighted emissions in this sample. This study also implies that other factors, not only the size of the facility and whether a facility is ISO 14001 registered, are necessary when analyzing changes in emissions of facilities over time.

These results should not encourage regulators and policy makers to abandon voluntary initiatives such as ISO 14001. Further research is still necessary, perhaps using a longer time period of analysis to account for the large quantity of late ISO 14001 adopters in Canada, to establish a clear, unequivocal connection between environmental management and environmental outcomes. Industry as a whole would further the research in this area if companies were to adopt similar metrics to make it easier to show the effects of environmental initiatives on performance. By devising a way to consistently measure the environmental performance of business operations, companies would be enabled to design more effective processes, reduce material use, and lessen environmental impacts (GEMI, 1998a).

The regulatory implications of this study are clear. Regulators, at this time, should not decrease regulatory oversight or be less vigilant with respect to existing requirements since according to these results, ISO 14001 registered facilities in this sector do not have greater emission reductions. Regulators and policymakers should be cautious in offering incentives to ISO registered facilities until solid proof of ISO 14001 improving emission performance can be shown. It is recommended that the government does not mandate EMSs or ISO 14001 until it can be proven that facilities are not just ritualistically proceeding through the motions of ISO 14001. Mandating may be viewed as just another unreasonable burden imposed on companies or facilities (Coglianese, 2002). Whatever form of policy is chosen by the government, it must be realized that either way it is likely that the use of ISO 14001 will increase. The important issue that remains is whether significant modifications will be made to decrease the environmental impacts of facilities (Coglianese and Nash, 2002).

Both investors and consumers are beginning to hold companies accountable for their influence on the environment (GEMI, 1998b). This emergence of accountability and growing interest in corporate activities has resulted in the widespread use of ISO registered systems. Adopting an ISO 14001 registered EMS allows companies to strive to achieve continual improvements while attempting to reduce their impacts on the environment. Even though this study has shown that these improvements have not taken place in the Transportation Equipment Industries, the case may not be the same for other industries. Also, benefits may not have been accrued or may not even have been reflected in the seven year time span. This would not be surprising, especially with the skewed number of ISO 14001 registration dates present in the sample.

5.0 Overall Conclusion and Summary

This study allowed for an investigation of the relationship between ISO 14001 and both financial and environmental performance. The abnormal returns of firms during a three day event window served as an indicator of share response to ISO 14001 registration. Although in the overall sample of companies there was no global significant effect on stock market returns during the three day event window, the individual company analysis did reveal that more companies were experiencing significant positive abnormal financial returns than negative abnormal returns. With respect to the linkages examined between ISO 14001 and environmental performance, the GLS model revealed that ISO 14001 registered facilities have increased weighted emissions. There also does not seem to be a difference, using this sample of facilities, between facilities registered early, mid, late, or not at all.

This study has contributed to the current literature by expanding upon empirical evidence regarding ISO 14001 and environmental and financial performance in the Canadian context. As a result, Canadian regulators and policy makers have a certain amount of evidence indicating that stock market is not rewarding, at least in the short-term, those companies that choose to adopt ISO 14001. This suggests that the government should not be hasty in lessening its environmental monitoring of companies in Canada, since the stock market at this point in time does not provide a noteworthy incentive for companies to adopt and/or implement certified environmental management systems. Future research regarding the financial performance of firms and ISO 14001 should encompass a long term analysis, to measure the impact of environmental initiatives on firms' financial performance over an extended period of time.

This study also enhances the empirical body of understanding regarding the effects of environmental management on emissions performance. The results regarding ISO 14001 and environmental performance should not prompt regulators and policy makers to abandon voluntary initiatives such as ISO 14001. Further research is still necessary, perhaps using a longer time period of analysis to account for the large quantity of late ISO 14001 adopters in Canada. Regulators should not diminish regulatory oversight or be less watchful with respect to existing emissions requirements since according to these results, ISO 14001 registered facilities in this sector do not have greater emission reductions. Regulators and policymakers should be wary of offering incentives to ISO registered facilities until solid proof of ISO 14001 improving emission performance can be shown.

However, one should not overlook the notion that industry self-regulation is very dynamic and that its eventual outcome is not certain (King and Lennox, 2000). ISO 14001 standards are enhanced continually and are being revised as user experience increases. For example, in November 2004, ISO published an improved version of its ISO 14001 standards (ISO, 2004). These updated versions now take into account experiences of users that have adopted the standards since they were first put into place in 1996 (ISO, 2004). Perhaps after all of the inefficiencies of the ISO 14001 certification process are worked out, an effective voluntary initiative may result that has an affirmative influence on environmental and financial performance. Still, continual research will be necessary as more firms and facilities adopt this method of environmental management to validate or refute their claims of environmental improvements and sustainability.

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Appendix A

ISO 14001 Registration Descriptions and Year of ISO 14001 Certification used in the Financial Event Study Analysis

Table A1: Company Description, Number of ISO 14001 Certificates, and Year of ISO 14001 Certificates used in Financial Event Study Analysis

Company	Description	Number of Certificates	1999	2000	2001	2002
Abitibi - Consolidated	Newfoundland woodlands	2		2		
	Woodland sectors in Lac-Saint-Jean and on the Quebec North Shore					
Cambior	Mining	1	1			
Cameco	Blind River	1				1
	Port Hope uranium conversion facility					
Canfor	Certified forest	1		1		
Dofasco	All of Dofasco's facilities, both primary and finishing, with the exception of the company's DSG facility	1				1
Domtar	White River Forest	4		1	2	
	Spanish Forest					
	Forest management practices in Matagami, Lebel-sur-Quevillon, Val-d'Or and Grand-Remous, Quebec					
	All forestry operations					
Interfor	Forestry operations	1		1		

Company	Description	Number of Certificates	1999	2000	2001	2002
IPSCO	Canadian operating facilities	1		1		
Nortel Networks	Saint-Laurent facility near Montreal, Quebec	1			1	
Shell Canada	Montreal East refinery, Quebec	3			3	
	Sarnia Manufacturing Centre, Ontario					
	All key operating facilities including 4 natural gas plants, 3 oil refineries, 2 lubricants manufacturing plants, and 1 heavy oil production facility.					
Stelco	Integrated steel facilities, Lake Erie Steel Company, and Hilton Works	1			1	
Tembec	Spruce Falls Inc	3	1		1	1
	Most operations in Canada					
	Toronto and Spruce Falls					
TimberWest		1	1			

Company	Description	Number of Certificates	1999	2000	2001	2002
Weyerhaeuser	Grande Prairie/Grande Cache Forestlands	3		1	2	
	Pulp mill in Kamloops, BC					
	4.9 million hectares (12.1 million acres) of Saskatchewan Forestland operations					

Appendix B

NPRI Substances and Substances that were added from 1999 to 2002

NPRI Substance List

Acetaldehyde
Acetonitrile
Acetophenone
Acrolein
Acrylamide
Acrylic acid
Acrylonitrile
Alkanes, C $_{6-18}$, chloro
Alkanes, C $_{10-13}$, chloro
Allyl alcohol
Allyl chloride
Aluminum
Aluminum oxide
Ammonia (total)
Aniline
Anthracene
Antimony
Asbestos
Benzene
Benzoyl chloride
Benzoyl peroxide
Benzyl chloride
Biphenyl
Bis(2-ethylhexyl) adipate
Bis(2-ethylhexyl) phthalate
Boron trifluoride
Bromine
1-Bromo-2-chloroethane
Bromomethane
1,3-Butadiene
2-Butoxyethanol
Butyl acrylate
i-Butyl alcohol
n-Butyl alcohol
sec-Butyl alcohol
tert-Butyl alcohol
Butyl benzyl phthalate
1,2-Butylene oxide
Butyraldehyde
C.I. Acid Green 3

C.I. Basic Green 4
C.I. Basic Red 1
C.I. Direct Blue 218
C.I. Disperse Yellow 3
C.I. Food Red 15
C.I. Solvent Orange 7
C.I. Solvent Yellow 14
Calcium cyanamide
Calcium fluoride
Carbon disulphide
Carbon tetrachloride
Catechol
CFC-11
CFC-12
CFC-13
CFC-114
CFC-115
Chlorendic acid
Chlorine
Chlorine dioxide
Chloroacetic acid
Chlorobenzene
Chloroethane
Chloroform
Chloromethane
3-Chloro-2-methyl-1-propene
3-Chloropropionitrile
Chromium
Cobalt
Copper
Cresol
Crotonaldehyde
Cumene
Cumene hydroperoxide
Cyanides
Cyclohexane
Cyclohexanol
Decabromodiphenyl oxide
2,4-Diaminotoluene
2,6-Di-*t*-butyl-4-methylphenol
Dibutyl phthalate
o-Dichlorobenzene

p-Dichlorobenzene
3,3'-Dichlorobenzidine dihydrochloride
1,2-Dichloroethane
Dichloromethane
2,4-Dichlorophenol
1,2-Dichloropropane
Dicyclopentadiene
Diethanolamine
Diethyl phthalate
Diethyl sulphate
Dimethylamine
N,N-Dimethylaniline
N,N-dimethylformamide
Dimethyl phenol
Dimethyl phthalate
Dimethyl sulphate
4,6-Dinitro-*o*-cresol
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Dinitrotoluene
Di-*n*-octyl phthalate
1,4-Dioxane
Diphenylamine
Epichlorohydrin
2-Ethoxyethanol
2-Ethoxyethyl acetate
Ethoxynonyl benzene
Ethyl acrylate
Ethylbenzene
Ethyl chloroformate
Ethylene
Ethylene glycol
Ethylene oxide
Ethylene thiourea
Fluorine
Formaldehyde
Formic acid
Halon 1211
Halon 1301
HCFC-22
HCFC-122

HCFC-123
HCFC-124
HCFC-141b
HCFC-142b
Hexachlorocyclopentadiene
Hexachloroethane
Hexachlorophene
n-Hexane
Hydrazine
Hydrochloric acid
Hydrogen cyanide
Hydrogen fluoride
Hydrogen sulfide
Hydroquinone
Iron pentacarbonyl
Isobutyraldehyde
Isophorone diisocyanate
Isoprene
Isopropyl alcohol
p,p'-Isopropylidenediphenol
Isosafrole
Lithium carbonate
Maleic anhydride
Manganese
2-Mercaptobenzothiazole
Methanol
2-Methoxyethanol
2-Methoxyethyl acetate
Methyl acrylate
Methyl tert-butyl ether
p,p'-Methylenebis (2-chloroaniline)
1,1-Methylenebis (4-isocyanatocyclohexane)
Methylenebis(phenylisocyanate)
p,p'-Methylenedianiline
Methyl ethyl ketone
Methyl iodide
Methyl isobutyl ketone
Methyl methacrylate
N-Methylolacrylamide
2-Methylpyridine
N-Methyl-2-pyrrolidone
Michler's ketone

Molybdenum trioxide
Naphthalene
Nickel
Nitrate ion
Nitric acid
Nitrilotriacetic acid
p-Nitroaniline
Nitrobenzene
Nitroglycerin
p-Nitrophenol
2-Nitropropane
N-Nitrosodiphenylamine
Nonylphenol
Nonylphenol hepta(oxyethylene) ethanol
Nonylphenol, industrial
Nonylphenol nona(oxyethylene) ethanol
n-Nonylphenol
Nonylphenol polyethylene glycol ether
p-Nonylphenol polyethylene glycol ether
Nonylphenoxy ethanol
2-(*p*-Nonylphenoxy)ethanol
2-(2-(*p*-Nonylphenoxy)ethoxy) ethanol
2-(2-(2-(2-(*p*-Nonylphenoxy)ethoxy)ethoxy)ethoxy) ethanol
4-*tert*-Octylphenol
Oxirane, methyl-, polymer with oxirane, mono(nonylphenol)ether
Paraldehyde
Pentachloroethane
Peracetic acid
Phenol
p-Phenylenediamine
o-Phenylphenol
Phosgene
Phosphorus
Phthalic anhydride
Polymeric diphenylmethane diisocyanate
Potassium bromate
Propargyl alcohol
Propionaldehyde
Propylene
Propylene oxide
Pyridine
Quinoline

p-Quinone
Safrole
Selenium
Silver
Sodium fluoride
Sodium nitrite
Styrene
Styrene oxide
Sulphur hexafluoride
Sulphuric acid
1,1,1,2-Tetrachloroethane
1,1,2,2-Tetrachloroethane
Tetrachloroethylene
Tetracycline hydrochloride
Thiourea
Thorium dioxide
Titanium tetrachloride
Toluene
Toluene-2,4-diisocyanate
Toluene-2,6-diisocyanate
Toluenediisocyanate
1,2,4-Trichlorobenzene
1,1,2-Trichloroethane
Trichloroethylene
Triethylamine
1,2,4-Trimethylbenzene
2,2,4-Trimethylhexamethylene diisocyanate
2,4,4-Trimethylhexamethylene diisocyanate
Vanadium
Vinyl acetate
Vinyl chloride
Vinylidene chloride
Xylene
Zinc
Cadmium
Hexavalent chromium compounds
Lead
Mercury
Tetraethyl lead

Substances Added to the NPRI List After 1998

Acetophenone
Boron trifluoride
Bromin
1-Bromo-2-chloroethane
2-Butoethanol
C.I. Direct Blue 218
Calcium Fluoride
Chlorendic Acid
3-Chloro-2-methyl-1-propene
3-Chloropropiontrile
Crotonaldehyde
Cyclohexanol
2,6-Di-t-butyl-4-methylphenol
3,3-Dichlorobenzidine dihydrochlorine
Dicyclopentadience
Dimethylamine
Dimethyl phenol
Diphenylamine
Fluorine
Formic Acid
Hexachlorophene
n-Hexane
Hydrogen sulphide
Iron pentacarbonyl
Isoprene
Lithium carbonate
2-Mercaptobenzothiazole
N-Methilolacrylamide
2-Methylpyridine
N-Methyl-2-pyrrolidone
p-Nitroaniline
Paraldehyde
Pentachloroethane
Potassium bromate
Porpargyl alcohol
Sodium fluoride
Sodium nitirite
Sulphur hexafluoride
1,1,1,2-Tetrachloroethane
Tetracycline hydrochloride
Tetaethyl lead
Triethylamine
Alkanes, C6-18, chloro
Alkanes, C10-13, chloro

Isophorone diisocyanate
1,1-Methylenebis(4-isocyanatocyclohexane)
2,2,4-Trimehtylhexamethylene diisocynate
2,4,4-Trimethylhexamethylene diisocyanate
Halons 1211
Halons 1301
CFC-11
CFC-12
CFC-13
CFC-114
CFC-115
HCFC-22
HCFC-122
HCFC-123
HCFC-124
HCFC-141b
HCFC-142b
Ethoynonyl benzene
Nonylphenol
Nonylphenol hepta(oxyethylene) ethanol
Nonylphenol, industrial
Nonylphenol non(oxyethylene) ethanol
n-Nonylphenol (moxed isomers)
Nonylphenol polyethylene glycol ether
p-Nonylphenol polyethylene glycol ether
Nonylphenoxy ethanol
2-(p-Nonylphenoxy) ethanol
2-(2-(p-Nonylphenoxy)ethoxy) ethanol
2-(2-(2-(2-(p-Nonylphenoxy)ethoxy)ethoxy)ethoxy) ethanol
Cresol
N,N-Dimethyl formamide
Vanadium
Benzo(a)anthracene
Benzo(a)phenanthrene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(e)pyrene
Benzo(g,h,i)perylene
Benzo(j)fluoranthene
Benzo(k)fluoranthene
Dibenz(a,j)acridine
Dibenzo(a,h)anthracene
Dibenzo(a,i)pyrene
7H-Dibenzo(c,g)carbazole
Fluoranthene

Indeno(1,2,3-c,d)pyrene
Perylene
Phenanthrene
Pyrene
Hexachlorobenzene
Dioxins and furans
Carbon monoxide
Oxides of nitrogen (expressed as NO2)
Particulate matter with a diameter [less than or equal) 2.5 microns ($PM_{2.5}$)
Particulate matter with a diameter [less than or equal) 10 microns (PM_{10})
Sulphur dioxide
Total particulate matter with diameter ‹ [less than] 100 microns
Volatile organic compounds

Appendix C

Reporting to the NPRI

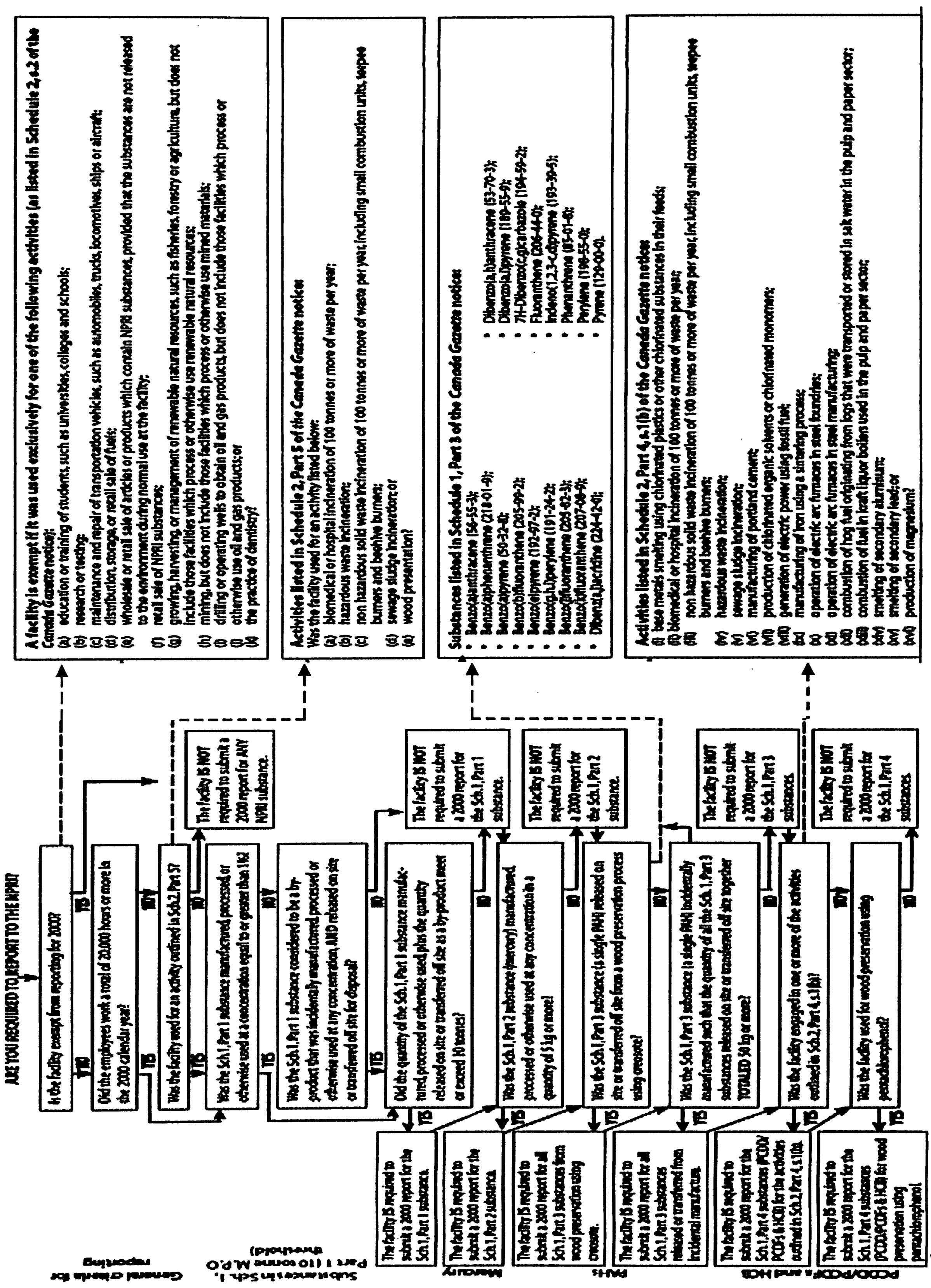

Figure B1. SOURCE: Environment Canada. 2005b. 2002- The NPRI – Are you required to report? <http://www.ec.gc.ca/pdb/npri/documents/html/Brochure2002_e.cfm#substances>. Accessed on February 25, 2005.

Appendix D

CHHI Algorithms Explained

The algorithms for assigning toxicity weights were derived by the EPA using the tables below and were taken from the Hazard Ranking System Training Course (EPA, 2003). For the algorithm calculations, the EPA used the most sensitive endpoints in Tables D1 and D2 to weight a given chemical (Bouwes and Hassur, 1997). All values that were derived by EPA were based on experts' judgements and assessments (Bouwes and Hassur, 1997).

The algorithms were calculated for the non-carcinogens by dividing the RfD by its assigned weight. The most conservative values were used for to derive all the CHHI weights. For example, the most conservative value from Table D1 was an RfD = 0.5 and it was divided by its assigned weight of 1 ($\frac{0.5}{1} = 0.5$). To calculate the overall weight of non-carcinogenic chemicals, 0.5 was then divided by the RfD (Overall Weight $= \frac{0.5}{RfD}$).

This was done because one would want more toxic chemicals to have higher weightings than less toxic chemicals. A large RfD value of a chemical would indicate the chemical was less toxic and by putting the RfD as the denominator in the CHHI weighting equation, the result would give a lower CHHI weight. A lower CHHI weight would indicate that a chemical is less toxic. Conversely, a chemical that has a small RfD is more toxic. When 0.5 is divided by a small RfD, the result will be a large CHHI weight, indicating that the chemical is more toxic. The same argument was applied to the RfC in Table D1. To get the RfC values, a dose of 0.5 was converted to mg/m^3 of air by using a standard adult human exposure factor for body weight of 70 kg and by using an inhalation rate of 20 m^3/day. The conversion was carried out as follows:

$$0.5\frac{mg}{kgday} \times 70kg \times \frac{1}{20\frac{m^3}{day}} = 1.8\frac{mg}{m^3}$$

Table D1: Toxicity Weights for Non-Cancer Effects

RfD Range (mg/kg-day)	RfC Range (mg/ m^3)	Assigned Weight
$0.5 \leq$ RfD	$1.8 \leq$ RfC	1
$0.05 \leq$ RfD < 0.5	$0.18 \leq$ RfC < 1.8	10
$0.005 \leq$ RfD < 0.05	$0.018 \leq$ RfC < 0.18	100
$0.0005 \leq$ RfD < 0.005	$0.0018 \leq$ RfC < 0.018	1000
$0.00005 \leq$ RfD < 0.0005	$0.00018 \leq$ RfC < 0.0018	10000
RfD < 0.00005	RfC < 0.00018	100000

Source: Bouwes, N.W., and Hassur, S.M. 1997. Toxic Release Inventory relative risk-based environmental indicators. U.S. Environmental Protection Agency. Washinton, D.C.: Office of Pollution Prevention and Toxics.

Table D2 was used to determine the CHHI weights for carcinogens in weight-of-evidence (WOE) categories A, B, and C. Again, the most conservative values were used by the EPA for the CHHI weights. The Oral Slope Factor (OSF) of 0.005 was divided by10 from the WOE category to get 0.0005. The CHHI weights for carcinogens in categories A and B were then calculated by: $Weight = \frac{OSF}{0.0005}$. Since OSF was in the units of risk per mg/kg-day, the larger the OSF, the larger the risk per mg/kg-day. Therefore, one would desire that large risks would have larger CHHI values and smaller risks would have smaller CHHI values. That was why the OSF was put in the numerator position to calculate the overall CHHI weight (this relationship was the inverse to that of the RfD and RfC described previously). The Inhalation Unit Risk (IUR) followed the same type of reasoning to obtain its CHHI weights. To get the IUR, a conversion factor using the body weight and inhalation rate mentioned prior were applied:

$$0.005\frac{risk}{\frac{mg}{kgday}}\times\frac{1}{70kg}\times 20\frac{m^3}{day}=0.0014$$

For the WOE category C, shown in Table D2, the same procedure was carried out as in WOE category A and B. However, the OSF of 0.005 was divided by its assigned weight of 1 instead of 10. The weights in the "C" column in Table D2 were determined by dividing the weights in category A/B by 10. This division was carried out because evidence that these chemicals cause cancer in human was less than certain. The division of the A/B by 10 was based on the advice of peer review and was considered to be an arbitrary uncertainty factor (Bouwes and Hassar, 1997).

Table D2: Toxicity Weighting Matrix for Carcinogenic Effects

Range of Oral Slope Factor (risk per mg/kg-day)	Range of Inhalation Unit Risk (risk per mg/ m³)	Weight of Evidence Category	
		A/B (Known/Probable)	C (Possible)
< 0.005	< 0.0014	10	1
0.005 to < 0.05	0.0014 to < 0.014	100	10
0.05 to < 0.5	0.014 to < 0.14	1000	100
0.5 to < 5	0.14 to < 1.4	10000	1000
5 to < 50	1.4 to < 14	100000	1000
≥ 50	≥ 14	1000000	10000

Source: Bouwes, N.W., and Hassur, S.M. 1997. Toxic Release Inventory relative risk-based environmental indicators. U.S. Environmental Protection Agency. Washinton, D.C.: Office of Pollution Prevention and Toxics.

Appendix E

Goldfeld-Quandt Test for Heteroscedasticity

Following the methodology outlined by Wesolowsky (1976), the observations are first ordered by increasing x values (in this case the observations were ordered from smallest to largest numbers of the size variable). The sample is then divided in to 3 ranges with 3/8 of the observations with the smallest values of the x variable as shown in Table E1, 3/8 of the observations with the largest values of x found in Table E2, and 1/4 in the middle. In this analysis the ranges in this analysis contained 228, 228, and 153 observations respectively. Regression lines were then fitted to the upper and lower observations. The test statistic is

$$F = \frac{MSaboutregression(lastrange)_2}{MSaboutregression(firstrange)_1} \qquad (13)$$

and has an F distribution with degrees of freedom of $\nu_1 = n_1 - m_1$ and $\nu_2 = n_2 - m_2$, where $m = q + 1$ in which q is the number of independent variables and n is the number of observations in the range (Dougherty, 2000). MS is the mean square of regression. The test statistic using the MS values obtained from the regressions the two sets of data are shown in Tables E3 and E4.

$$F = \frac{79.35182}{68.80425} = 1.15 \qquad \text{(using equation 13)}$$

Using m = q + 1 = 2 +1 = 3 with both n_1 and n_2 equal to 228.

Table E1: 3/8 of the Smallest X Observations

X	Y	X	Y	X	Y
2.564949	2.923162	4.828314	6.398595	5.192957	11.3223
2.772589	2.923162	4.867534	0.000000	5.225747	2.214584
2.944439	2.923162	4.867534	0.000000	5.225747	2.388102
4.007333	3.197039	4.867534	6.25094	5.247024	9.242711
4.174387	0.000000	4.882802	8.591185	5.247024	9.140053
4.174387	0.000000	4.905275	0.000000	5.247024	11.28854
4.330733	8.190382	4.905275	0.000000	5.298317	4.362793
4.330733	9.409691	4.941642	6.45677	5.298317	0.000000
4.330733	9.409691	4.941642	6.563856	5.298317	0.530628
4.442651	0.011632	4.941642	9.177895	5.32301	0.000000
4.442651	0.013854	4.94876	9.409691	5.32301	5.533389
4.442651	3.197039	4.976734	8.636996	5.32301	5.9215
4.488636	0.014741	5.003946	9.409691	5.32301	5.801449
4.49981	3.856688	5.010635	8.449961	5.32301	6.427493
4.543295	0.009851	5.023881	9.08446	5.327876	9.409273
4.543295	0.011632	5.023881	9.40929	5.327876	5.533389
4.553877	3.086943	5.075174	5.677774	5.347108	1.83737
4.553877	0.000000	5.075174	6.09245	5.347108	9.409273
4.564348	0.011187	5.075174	10.81299	5.347108	9.409273
4.564348	1.637053	5.075174	11.12593	5.347108	9.409273
4.564348	3.610918	5.081404	6.637325	5.347108	7.053586
4.574711	0.015627	5.099866	9.370723	5.347108	4.078266
4.574711	0.239017	5.105945	9.668151	5.351858	2.392389
4.574711	0.239017	5.117994	6.459122	5.351858	5.658398
4.59512	9.409691	5.135798	0.000000	5.351858	5.102037
4.59512	9.409691	5.135798	6.563856	5.393628	1.83737
4.59512	9.409691	5.135798	8.470482	5.393628	0.000000
4.615121	8.190382	5.135798	10.61107	5.393628	5.293305
4.615121	8.560474	5.135798	11.31708	5.393628	2.224624
4.615121	7.583248	5.135798	10.18079	5.393628	0.530628
4.634729	9.409691	5.153292	9.918343	5.4161	8.189087
4.644391	8.334068	5.164786	10.06033	5.4161	8.188967
4.644391	3.803944	5.164786	6.265301	5.438079	0.000000
4.644391	4.49069	5.164786	3.790759	5.438079	4.094261
4.644391	4.696822	5.170484	8.13939	5.442418	8.316627
4.644391	4.577789	5.17615	8.941889	5.442418	4.561574
4.663439	7.571546	5.181784	9.668151	5.459586	6.526047
4.663439	0.239017	5.181784	9.409691	5.459586	4.610864
4.727388	6.997596	5.181784	9.668151	5.480639	1.83737
4.744932	4.343182	5.181784	4.369448	5.480639	1.83737
4.744932	3.69332	5.181784	4.330733	5.480639	3.537475
4.762174	5.476464	5.192957	4.330733	5.480639	3.537475
4.762174	5.533389	5.192957	2.564949	5.480639	6.59987
4.812184	6.155707	5.192957	6.506158	5.480639	7.865854
4.812184	5.652798	5.192957	4.259153	5.480639	4.348418
4.828314	3.335093	5.192957	11.15125	5.497168	8.190382

X	Y	X	Y
5.513429	11.67777	5.669881	2.601949
5.513429	5.658398	5.676754	9.409799
5.521461	7.885215	5.676754	9.40979
5.521461	8.189726	5.676754	8.197849
5.521461	3.605226	5.703782	10.44045
5.521461	3.659451	5.703782	9.681838
5.521461	0.000000	5.703782	3.896706
5.521461	1.783391	5.703782	0.000000
5.521461	4.140433	5.703782	1.852384
5.521461	3.453157	5.703782	7.831497
5.521461	4.098005	5.703782	8.164969
5.521461	7.950475	5.703782	4.084109
5.521461	2.805092	5.703782	7.068172
5.521461	3.306154	5.70711	6.680629
5.533389	0.000000	5.70711	8.188967
5.541264	4.50921	5.713733	1.832581
5.541264	2.079442	5.717028	11.40676
5.541264	0.000000	5.723585	7.801918
5.541264	0.405465	5.723585	8.188967
5.549076	9.409691	5.723585	8.188967
5.549076	7.307503	5.723585	8.188967
5.549076	6.803504	5.7301	0.000000
5.549076	6.704238	5.7301	5.036953
5.560682	9.289853	5.7301	5.07985
5.560682	9.476844	5.736572	9.60915
5.560682	0.530628	5.736572	2.825134
5.560682	0.530628	5.739793	5.552311
5.560682	0.530628	5.739793	3.089223
5.560682	0.530628	5.752573	8.188967
5.56452	9.051936	5.755742	8.671136
5.568345	0.405465	5.758902	7.203673
5.598422	9.078216	5.768321	7.726989
5.602119	4.478373	5.783825	2.919067
5.605802	9.409691	5.78996	0.000000
5.605802	9.409691	5.78996	0.000000
5.605802	9.409691	5.78996	8.188967
5.609472	4.758921	5.78996	5.380407
5.609472	8.188967		
5.616771	4.551387		
5.616771	4.949834		
5.616771	5.380407		
5.616771	7.273095		
5.63479	9.545112		
5.63479	4.343296		
5.63479	9.433418		

Table E2: 3/8 of the Largest X Observations

X	Y	X	Y	X	Y
6.60665	9.409691	6.996681	5.359299	7.34601	2.310206
6.60665	9.409691	7.004882	4.579693	7.34601	3.485781
6.609349	9.116684	7.020191	7.821797	7.34601	9.195488
6.620073	8.997461	7.021084	11.61373	7.349231	5.782729
6.635947	8.76276	7.029088	5.947329	7.352441	3.446872
6.647688	8.320032	7.037028	12.02454	7.365813	5.463974
6.652863	7.907975	7.049255	5.296404	7.377759	9.922579
6.670766	5.8174	7.068172	9.851509	7.377759	9.367974
6.670766	9.126902	7.085901	8.916227	7.377759	9.918524
6.684612	10.66793	7.090077	12.37391	7.378384	4.55711
6.709304	4.705206	7.109879	3.118746	7.382124	3.24142
6.740519	6.80642	7.130899	6.061989	7.38709	6.517044
6.740519	6.207422	7.131699	8.829038	7.405496	3.179719
6.740519	6.393574	7.17012	6.951067	7.438384	7.856133
6.742881	5.188155	7.17012	8.395004	7.438384	9.331234
6.745236	8.480641	7.17012	8.082731	7.455877	8.390317
6.751101	7.159505	7.17012	8.546743	7.467371	7.733907
6.756932	0.496219	7.17012	8.749877	7.467371	7.506708
6.756932	0.5738	7.17012	8.647577	7.467371	7.576188
6.767343	8.420299	7.17012	8.952826	7.477604	5.413653
6.779922	10.15444	7.17012	8.671336	7.489971	3.857567
6.791221	9.744785	7.17012	3.411743	7.495542	7.510921
6.802395	4.721744	7.17012	2.97022	7.495542	7.096514
6.807935	0.000000	7.17012	7.513682	7.495542	8.356314
6.813445	9.830265	7.17012	4.820282	7.495542	10.20915
6.834109	10.17476	7.17012	4.820282	7.536364	3.300345
6.841615	10.28986	7.17012	4.820282	7.549609	6.798316
6.856462	9.059695	7.17012	4.330733	7.549609	6.066693
6.856462	0.000000	7.17012	4.330733	7.549609	9.997698
6.856462	0.000000	7.189168	6.067933	7.549609	9.703294
6.856462	0.000000	7.193686	6.908487	7.549609	9.284627
6.856462	8.923803	7.211557	9.340959	7.563201	3.363634
6.887553	10.66936	7.244228	9.809671	7.600902	6.506527
6.887553	10.52474	7.244228	11.39038	7.600902	6.683752
6.900731	5.444303	7.279319	6.161522	7.600902	6.650549
6.907755	5.497168	7.288244	5.992182	7.600902	6.594762
6.907755	4.820282	7.295056	5.792232	7.600902	8.206892
6.907755	0.000000	7.31322	9.1461	7.600902	8.311924
6.907755	8.465862	7.31322	11.25347	7.622664	8.430674
6.930495	0.000000	7.31322	10.97512	7.622664	9.161046
6.932448	8.432387	7.31322	5.941613	7.630461	6.781293
6.94119	10.22912	7.31322	11.61377	7.635787	8.851512
6.943122	5.642208	7.323171	6.212697	7.649693	8.154415
6.979145	8.962488	7.339538	8.722157	7.649693	8.408558
6.990257	9.830708	7.34601	6.722931	7.649693	7.378341
6.995766	6.207313	7.34601	2.640264	7.696213	8.202066

X	Y
7.696213	5.180727
7.696213	8.370905
7.696213	9.618086
7.698029	9.642535
7.704812	8.254863
7.72312	7.964663
7.736307	9.36182
7.762171	6.978793
8.160518	10.46916
8.160518	1.796200
8.160518	0.003594
8.188689	7.756073
8.200014	8.747819
8.200014	8.540885
8.224432	9.354070
8.224432	9.466150
8.283494	8.546432
8.382747	4.697796
8.382747	2.057138
8.382747	2.114314
8.476371	10.30408
8.517193	6.493718
8.517193	6.947380
8.517193	6.142639
8.517193	10.03900
8.571681	9.083271
8.575462	10.25446
8.584852	10.67667
8.612503	7.126569
8.612503	10.64065
8.631949	10.45907
8.631949	10.72793
8.631949	10.63995
8.648221	6.629971
8.65382	9.039588
8.678972	9.505715
8.682538	10.20636
8.699515	10.65364
8.699515	9.308263
8.699515	7.766982
8.699515	7.360386

Table E3: ANOVA for the Lower 3/8 Observations

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	68.80425	68.80425	5.901781	0.015906
Residual	226	2634.758	11.65822		
Total	227	2703.562			

Table E4: ANOVA for the Higher 3/8 Observations

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	79.35182	79.35182	11.32501	0.000898
Residual	227	1590.538	7.006775		
Total	228	1669.890			

Appendix F

Durbin Watson Test

Durbin Watson test statistic is found by using the following formula recommended by Wesolowsky (1976):

$$D = \frac{\sum_{i=2}^{n}(e_i - e_{i-1})^2}{\sum_{i=1}^{n} e_i^2}$$

The null hypothesis is that no autocorrelation exists and the Durbin-Watson statistic, denoted D, is based on the least squared residuals e_i. Calculations are shown in Table F1.

Table F1: Durbin-Watson Calculations

e_i	e_i^2	$(e_i - e_{i-1})^2$
-0.42749	0.182748	
-1.05593	1.114984	0.394933
-0.00973	0.000095	1.09454
-0.61299	0.375761	0.363932
-0.46909	0.220043	0.020709
0.740981	0.549052	1.464263
1.834244	3.36445	1.195224
0.091507	0.008373	3.037133
-0.17957	0.032246	0.073484
0.327862	0.107494	0.25749
0.530799	0.281748	0.041183
0.081519	0.006645	0.201852
0.07384	0.005452	0.000059
-0.92595	0.857392	0.999589
1.690852	2.858979	6.847674
0.023651	0.000559	2.779559
0.352036	0.12393	0.107837
-2.28274	5.210879	6.942021
-5.61222	31.49706	11.0855
1.86054	3.461608	55.8422
3.96788	15.74407	4.440884
-1.50176	2.255282	29.91696
-0.18398	0.033848	1.736549
-0.27739	0.076943	0.008725
-0.29578	0.087484	0.000338
0.868336	0.754007	1.355159
0.474098	0.224769	0.155423
0.916467	0.839912	0.19569
-0.2285	0.052214	1.310956
-0.49892	0.248926	0.073128
-0.37705	0.14217	0.014852
-0.34358	0.118045	0.001121
0.487587	0.237741	0.690833
0.683329	0.466939	0.038315
0.277142	0.076808	0.164988
-1.66252	2.763959	10.96629
-1.26182	1.592197	2.368415
0.489084	0.239203	4.629383

e_i	e_i^2	$(e_i - e_{i-1})^2$	e_i	e_i^2	$(e_i - e_{i-1})^2$
-0.74933	0.561492	0.262651	0.280735	0.078812	0.043409
-0.45173	0.204061	0.088564	0.648084	0.420013	0.134945
-1.12146	1.257674	0.448538	-0.27155	0.073738	0.845721
1.664292	2.769867	7.760416	-0.62848	0.394984	0.1274
1.422115	2.022412	0.058649	-0.50915	0.259236	0.014238
0.497935	0.247939	0.85411	-0.00873	7.62E-05	0.250426
0.511421	0.261551	0.000182	1.598838	2.556283	2.584264
0.654843	0.42882	0.02057	1.225488	1.501822	0.13939
0.918537	0.84371	0.069534	0.047972	0.002301	1.386545
0.342037	0.116989	0.332352	-1.54197	2.377678	2.527922
0.278636	0.077638	0.00402	-1.63923	2.68708	0.009459
-0.590000	0.348094	0.754521	0.357313	0.127672	3.986188
-2.11548	4.475253	2.327102	-0.04841	0.002343	0.164608
0.332402	0.110491	5.992126	0.579947	0.336339	0.394829
0.504338	0.254357	0.029562	1.000079	1.000158	0.176511
0.310616	0.096482	0.037528	1.269323	1.611182	0.072493
0.10776	0.011612	0.041151	-1.18499	1.404193	6.023637
-0.44141	0.194839	0.301583	0.450585	0.203027	2.675093
-0.10434	0.010886	0.113615	-0.49069	0.24078	0.886004
-0.70937	0.503212	0.36607	-1.62426	2.638205	1.284963
1.166797	1.361415	3.520017	0.252911	0.063964	3.523755
0.27515	0.075708	0.795034	0.185524	0.034419	0.004541
0.555366	0.308431	0.078521	0.611678	0.37415	0.181607
0.420303	0.176655	0.018242	0.371503	0.138015	0.057684
0.621096	0.38576	0.040318	0.380049	0.144437	0.000073
-0.58881	0.346699	1.463876	-0.64185	0.411966	1.044269
-2.4499	6.002009	3.463648	-1.15982	1.345181	0.268296
0.005393	2.91E-05	6.028464	-0.15477	0.023953	1.01013
-0.30262	0.091582	0.094875	-0.58179	0.33848	0.182349
-0.24849	0.061746	0.002931	-0.41393	0.171339	0.028177
-0.29253	0.085572	0.00194	1.237511	1.531435	2.727261
0.033886	0.001148	0.106546	1.546848	2.392739	0.095689
0.521824	0.272301	0.238084	0.408999	0.16728	1.294701
0.282536	0.079827	0.057259	-2.04287	4.173317	6.011659
-0.37491	0.140557	0.432234	2.201761	4.847751	18.01689
-0.74574	0.556126	0.137515	2.123449	4.509035	0.006133
0.050642	0.002565	0.634222	1.842237	3.393839	0.07908
0.243254	0.059172	0.037099	-0.02113	0.000446	3.47214
0.307946	0.094831	0.004185	0.30973	0.095933	0.109469
0.249435	0.062218	0.003424	-2.01108	4.044453	5.386172
0.269372	0.072561	0.000398	-4.44496	19.75771	5.92378
-0.08246	0.0068	0.123787	2.142739	4.591331	43.39783
-0.96476	0.930755	0.778443	1.816158	3.298431	0.106655
-1.49755	2.242669	0.283874	2.28853	5.237367	0.223135
1.113834	1.240627	6.81935	2.331373	5.435299	0.001836
1.444431	2.086381	0.109294	-3.0998	9.608782	29.49768

e_i	e_i^2	$(e_i - e_{i-1})^2$	e_i	e_i^2	$(e_i - e_{i-1})^2$
-2.68116	7.188602	0.175265	-0.41367	0.171123	0.274619
1.649023	2.719278	0.041858	-0.17665	0.031206	0.056178
-2.79784	7.827904	0.013615	0.54378	0.295697	0.519021
-1.55122	2.406294	1.55405	0.195603	0.038261	0.121227
-0.67113	0.450418	0.774561	-0.05389	0.002904	0.062245
1.864485	3.476305	6.429355	-0.6764	0.457516	0.387522
0.288391	0.083169	2.484073	-0.04453	0.001983	0.399262
0.453104	0.205303	0.02713	-0.21435	0.045948	0.028841
0.663097	0.439698	0.044097	-0.00732	0.000054	0.042864
-1.04672	1.095627	2.923482	0.784088	0.614794	0.626324
0.710241	0.504442	3.086919	0.212398	0.045113	0.326829
0.454226	0.206321	0.065544	-2.72322	7.415918	8.617844
0.68897	0.474679	0.055105	-0.25862	0.066883	6.074254
0.651224	0.424093	0.001425	0.08202	0.006727	0.116034
-2.70377	7.31036	11.25597	0.325505	0.105954	0.059285
-2.30097	5.294445	0.162249	0.61441	0.37750	0.083466
2.500073	6.250363	23.04997	1.245237	1.550616	0.397943
0.846812	0.717091	2.733269	0.714664	0.510744	0.281508
0.536563	0.2879	0.096255	0.126637	0.016037	0.345775
0.546585	0.298755	0.0001	-0.5595	0.313044	0.470789
-0.55618	0.309337	1.216092	-0.0009	0.000001	0.312034
-1.96284	3.852755	1.9787	-0.42165	0.177787	0.177026
-2.03354	4.135287	0.004998	-0.18419	0.033927	0.056385
2.622605	6.878055	21.67969	0.753653	0.567993	0.879555
-0.72412	0.524353	11.20058	0.285958	0.081772	0.218738
0.202439	0.040982	0.858516	-0.96881	0.938596	1.574448
0.370299	0.137122	0.028177	-0.68591	0.470467	0.080036
0.321636	0.10345	0.002368	0.146929	0.021588	0.693615
0.596332	0.355611	0.075458	0.134534	0.018099	0.000154
0.250421	0.062711	0.119654	0.559086	0.312577	0.180244
-1.01701	1.0343	1.606369	0.621614	0.386404	0.00391
1.287088	1.656595	5.308845	0.192555	0.037077	0.184092
-3.10582	9.64611	19.29763	0.022861	0.000523	0.028796
-3.26802	10.67993	0.026308	0.17915	0.032095	0.024426
-2.14111	4.584331	1.26993	0.40721	0.16582	0.052011
2.310219	5.337111	19.81428	0.756994	0.57304	0.122349
2.569177	6.600671	0.067059	0.830555	0.689821	0.005411
2.348457	5.51525	0.048717	1.07013	1.145178	0.057396
-1.07212	1.149437	11.70033	-3.2669	10.67263	18.80982
0.839219	0.704289	3.653209	0.277223	0.076853	12.5608
-1.07236	1.149962	3.654145	0.137234	0.018833	0.019597
-0.71556	0.512027	0.127308	-2.30532	5.314499	5.966069
-0.42991	0.184821	0.081597	0.175336	0.030743	6.153655
1.356213	1.839313	3.190228	0.462682	0.214074	0.082567
1.094517	1.197969	0.068484	1.143537	1.307678	0.463564
0.077063	0.005939	1.035213	0.109307	0.011948	1.069632
-0.3365	0.113229	0.171031	0.166875	0.027847	0.003314

e_i	e_i^2	$(e_i - e_{i-1})^2$	e_i	e_i^2	$(e_i - e_{i-1})^2$
0.07787	0.006064	0.166406	-0.93499	0.874214	0.317883
0.079281	0.006285	1.99E-06	-1.13264	1.282875	0.039064
0.588517	0.346353	0.259322	-1.05088	1.104354	0.006684
-0.27984	0.078311	0.754045	-0.52119	0.271636	0.280577
-0.30264	0.091594	0.00052	-0.21062	0.044363	0.096449
-0.82732	0.684464	0.275288	4.221512	17.82116	19.64383
-0.98947	0.979055	0.026292	-1.12532	1.266341	28.58859
-0.48835	0.238491	0.251118	-1.46876	2.157258	0.117953
-0.03333	0.001111	0.207051	-1.35669	1.840602	0.01256
-0.19563	0.03827	0.026342	0.206779	0.042757	2.444428
1.380004	1.90441	2.482615	0.621148	0.385824	0.171702
1.154101	1.33195	0.051032	1.08293	1.172737	0.213243
1.215669	1.477852	0.003791	2.039911	4.161237	0.915813
1.854638	3.439682	0.408281	0.884019	0.781489	1.336087
1.952124	3.81079	0.009504	0.573779	0.329222	0.096249
-1.94093	3.76719	15.15583	0.741639	0.550028	0.028177
0.336221	0.113045	5.185394	0.79449	0.631214	0.002793
-0.62893	0.395557	0.931523	-0.1309	0.017134	0.85634
-2.78879	7.777374	4.665	-1.33926	1.793608	1.460133
-1.21101	1.466534	2.489418	-1.52377	2.321884	0.034046
-0.5394	0.290956	0.451049	-0.83967	0.70505	0.467993
-0.57848	0.334637	0.001527	0.200218	0.040087	1.081373
0.164689	0.027122	0.552297	0.368078	0.135481	0.028177
0.586105	0.343519	0.177592	0.319415	0.102026	0.002368
0.618498	0.382539	0.001049	-1.72694	2.982307	4.187552
0.959595	0.920823	0.116347	1.035878	1.073043	7.63314
-0.94523	0.893452	3.628344	0.643019	0.413474	0.154338
-0.55794	0.311295	0.149992	2.972291	8.834512	5.425506
-0.09312	0.008672	0.216053	2.662051	7.086516	0.096249
0.127067	0.016146	0.048484	2.829911	8.008395	0.028177
0.348429	0.121403	0.049001	2.212773	4.896363	0.38086
0.4985	0.248502	0.022521	-6.53759	42.74003	76.56878
0.622292	0.387247	0.015324	-6.05143	36.61979	0.236349
1.005789	1.011611	0.14707	1.911989	3.655703	63.41602
-0.03607	0.001301	1.085478	-7.32742	53.69107	85.36667
0.448259	0.200937	0.234579	1.772032	3.140098	82.80002
0.031288	0.000979	0.173865	1.939892	3.763181	0.028177
-1.9306	3.727208	3.848995	2.133621	4.552339	0.037531
-1.88596	3.556857	0.001992	3.752752	14.08315	2.621584
2.367299	5.604105	18.09024	-1.41287	1.996212	26.68369
-1.29457	1.675911	13.40928	-0.858	0.736171	0.30788
-1.63608	2.676774	0.116633	4.395552	19.32088	27.59986
-1.53523	2.356931	0.010172	1.96682	3.868381	5.898739
-1.56083	2.436177	0.000655	2.139684	4.578249	0.029882
-1.32791	1.76335	0.054249	1.505087	2.265288	0.402713
3.700622	13.6946	25.28615	-5.18159	26.84887	44.71164
3.654	13.35172	0.002174	-4.52187	20.44732	0.435228

e_i	e_i^2	$(e_i - e_{i-1})^2$	e_i	e_i^2	$(e_i - e_{i-1})^2$
1.139798	1.299139	2.083638	0.666087	0.443672	0.001199
-0.90973	0.827612	4.200572	-0.50668	0.256724	1.375381
0.088311	0.007799	0.996089	-0.40224	0.161799	0.010907
-0.33754	0.113932	0.181347	0.058879	0.003467	0.212633
0.163201	0.026634	0.250739	-0.49269	0.242747	0.304232
0.557784	0.311123	0.155696	-0.31595	0.099826	0.031237
-0.70182	0.492556	1.58661	0.22713	0.051588	0.29494
1.892063	3.579903	6.728247	1.43156	2.049363	1.45065
2.801132	7.846343	0.826407	0.809281	0.654935	0.387231
2.968992	8.814915	0.028177	0.41911	0.175653	0.152233
2.331553	5.436141	0.406328	0.589106	0.347046	0.028899
2.689155	7.231552	0.127879	-0.81951	0.671597	1.984201
-6.19635	38.39473	78.95215	-1.00513	1.010277	0.034453
-6.48655	42.0753	0.084216	-0.38413	0.147557	0.385634
1.325767	1.757659	61.03227	0.391269	0.153091	0.601245
1.015528	1.031296	0.096249	-0.93754	0.878976	1.765725
1.008554	1.017181	4.86E-05	-1.24778	1.556947	0.096249
0.959891	0.921391	0.002368	-1.02756	1.055889	0.048493
-0.26721	0.071401	1.505775	2.18008	4.75275	10.28899
-1.98746	3.950002	2.959266	2.524173	6.371449	0.1184
-2.05507	4.223308	0.004571	-0.60059	0.360705	9.764127
-3.57323	12.76798	2.304815	-0.89079	0.793502	0.084216
-1.52643	2.329984	4.189398	-4.39239	19.29306	12.2612
-2.04584	4.185479	0.269793	-4.86733	23.69091	0.225572
-1.44966	2.101514	0.355436	-4.77847	22.83381	0.007896
2.712147	7.355741	17.32064	7.438965	55.3382	149.2658
2.919872	8.525654	0.04315	2.439295	5.950158	24.9967
2.963144	8.780224	0.001872	2.291413	5.250575	0.021869
-3.89799	15.19429	47.0751	1.868518	3.491359	0.17884
0.562899	0.316855	19.89949	0.974579	0.949803	0.799128
-4.30275	18.51364	23.67451	0.664339	0.441346	0.096249
1.320743	1.744363	31.62365	0.832199	0.692555	0.028177
1.885534	3.55524	0.318989	0.833147	0.694134	8.99E-07
2.768566	7.664957	0.779745	-0.9597	0.921033	3.214318
1.662991	2.765538	1.222296	-0.97755	0.955596	0.000318
4.341667	18.85007	7.175305	-1.36701	1.868722	0.151684
4.810609	23.14195	0.219906	-3.71409	13.79443	5.508754
-1.64854	2.717695	41.72064	-4.02433	16.1952	0.096249
0.276659	0.07654	3.706402	-4.46268	19.91547	0.192151
-2.79497	7.811851	9.434895	-4.51134	20.35218	0.002368
-2.30881	5.330609	0.236349	4.965529	24.65648	89.81102
-2.67661	7.164245	0.135277	5.952582	35.43323	0.974274
0.472599	0.22335	9.917522	5.794314	33.57408	0.025049
-0.0961	0.009235	0.323419	-0.20662	0.04269	36.01117
0.330219	0.109045	0.181749	-0.47396	0.224637	0.071472
0.347882	0.121022	0.000312	-0.56962	0.324462	0.00915
-2.35214	5.532583	7.290144	-0.34451	0.118688	0.050672

e_i	e_i^2	$(e_i - e_{i-1})^2$	e_i	e_i^2	$(e_i - e_{i-1})^2$
-0.53199	0.283016	0.246827	-0.52053	0.270949	0.139988
2.16187	4.673684	7.256897	-0.35867	0.128643	0.026198
0.833665	0.694997	1.76413	4.465407	19.93986	23.2717
1.094889	1.198783	0.068238	0.827767	0.685198	13.23243
1.81744	3.303087	0.522079	-0.15936	0.025395	0.974418
-0.87188	0.760176	7.232444	-0.22096	0.048822	0.003794
-0.50537	0.255397	0.134331	-0.26962	0.072695	0.002368
-0.14297	0.02044	0.131333	0.039717	0.001577	0.095689
-2.22578	4.954076	4.338082	0.036326	0.00132	0.000012
0.97682	0.954177	10.25662	-0.25387	0.064452	0.084216
0.800565	0.640905	0.031066	-2.22153	4.935174	3.871651
1.240526	1.538904	0.193565	2.558357	6.545189	22.84727
0.592865	0.351489	0.419464	2.759654	7.615688	0.04052
1.088353	1.184513	0.245509	-1.33314	1.777251	16.75093
0.244456	0.059759	0.712163	-0.59342	0.35215	0.547176
-4.94358	24.43903	26.91576	-0.25047	0.062736	0.117616
0.313325	0.098172	27.63509	-0.91946	0.8454	0.447541
-0.15706	0.024667	0.22126	-0.36762	0.135148	0.304518
0.128424	0.016493	0.0815	-0.69775	0.486858	0.108984
-0.04217	0.001778	0.029102	-0.46514	0.21636	0.054106
0.49701	0.247019	0.290715	-0.47137	0.222187	0.000039
-0.12971	0.016824	0.392775	0.378795	0.143485	0.722775
-0.60982	0.371884	0.23051	0.942533	0.888369	0.317801
-0.23496	0.055206	0.140523	0.68056	0.463162	0.06863
0.026482	0.000701	0.068352	1.052302	1.10734	0.138192
0.025421	0.000646	0.000001	0.742063	0.550657	0.096249
-0.13212	0.017455	0.024818	0.909923	0.827959	0.028177
0.336919	0.113514	0.219994	0.478911	0.229356	0.185771
-0.01968	0.000387	0.127165	-2.02031	4.08166	6.246115
-0.00206	4.25E-06	0.00031	-1.38269	1.911824	0.406565
0.533952	0.285104	0.287311	0.2198	0.048312	2.567966
0.300119	0.090071	0.054678	0.257315	0.066211	0.001407
0.525734	0.276396	0.050902	-0.43364	0.188046	0.477424
0.564094	0.318203	0.001472	-0.47315	0.223875	0.001561
1.560113	2.433952	0.992053	-3.60876	13.02315	9.832026
-2.11363	4.467425	13.49638	1.031313	1.063607	21.53029
-1.37038	1.87795	0.552414	1.849363	3.420145	0.669206
0.342587	0.117366	2.934267	1.377567	1.897691	0.222592
-0.00741	0.000055	0.1225	1.879584	3.532835	0.252021
0.285599	0.081567	0.085856	1.804088	3.254733	0.0057
0.406054	0.16488	0.014509	-0.17352	0.030107	3.910914
2.012856	4.05159	2.581812	-0.26089	0.068065	0.007635
-1.37687	1.895771	11.49024	0.038672	0.001496	0.089739
-1.66281	2.764951	0.081764	-1.24095	1.539967	1.637444
-0.7463	0.556971	0.839989	-2.04698	4.190135	0.649681
-1.05654	1.116287	0.096249	0.501381	0.251383	6.494152
-0.88868	0.789761	0.028177	0.009185	0.000084	0.242257

e_i	e_i^2	$(e_i - e_{i-1})^2$	e_i	e_i^2	$(e_i - e_{i-1})^2$
0.376484	0.14174	0.003413	-0.21982	0.04832	0.002286
0.191718	0.036756	0.034139	0.357562	0.127851	0.333369
0.570188	0.325115	0.14324	-0.26873	0.072217	0.392245
-1.96702	3.869156	6.43741	0.358732	0.128689	0.393711
0.901462	0.812634	8.228173	-0.48783	0.237978	0.716667
0.586253	0.343693	0.099357	0.139505	0.019462	0.393548
0.318563	0.101482	0.071658	-0.74232	0.551045	0.777622
0.269884	0.072837	0.00237	-0.53812	0.289578	0.041697
0.587438	0.345084	0.100841	-0.83981	0.705283	0.091015
-2.6793	7.178659	10.67159	-0.61942	0.38368	0.048573
0.015701	0.000247	7.263042	0.302856	0.091722	0.850592
0.437604	0.191497	0.178002	2.297318	5.277671	3.977878
0.072294	0.005226	0.133451	-0.27492	0.075578	6.616384
-0.25969	0.067441	0.110217	-0.76435	0.584225	0.239543
-0.37705	0.142167	0.013772	0.09026	0.008147	0.730351
1.801249	3.244496	4.744987	0.247728	0.061369	0.024796
1.544856	2.386581	0.065737	0.438032	0.191872	0.036215
-3.21926	10.36362	22.69678	0.601652	0.361985	0.026771
-1.20187	1.444498	4.069843	-0.33841	0.114522	0.883717
-1.0223	1.04509	0.032248	0.110361	0.01218	0.201396
0.806554	0.65053	3.344694	-0.1067	0.011384	0.047114
0.231888	0.053772	0.330241	-0.1475	0.021757	0.001665
0.245792	0.060414	0.000193	-0.24877	0.061887	0.010256
0.468025	0.219048	0.049388	-0.10429	0.010877	0.020874
0.471909	0.222698	1.51E-05	0.423267	0.179155	0.27832
3.419287	11.69153	8.687042	0.073632	0.005422	0.122245
1.381475	1.908474	4.152679	-0.22432	0.05032	0.088777
-1.33683	1.787113	7.389181	-0.40651	0.16525	0.033192
-1.61476	2.607451	0.077246	0.088548	0.007841	0.245082
-1.33367	1.778679	0.079011	0.146915	0.021584	0.003407
-0.84751	0.718279	0.236349	0.657367	0.432132	0.260561
0.332012	0.110232	1.391282	-0.41642	0.173402	1.153009
-0.41306	0.170618	0.555131	0.154416	0.023844	0.325848
-0.66834	0.446678	0.065168	-0.36799	0.135415	0.272906
0.139831	0.019553	0.653139	-0.1476	0.021786	0.048571
0.278781	0.077719	0.019307	-0.0631	0.003981	0.007141
0.329383	0.108493	0.002561	-0.25786	0.066492	0.037933
0.521136	0.271582	0.036769	0.051476	0.00265	0.095689
-0.18773	0.035243	0.502492	0.537634	0.28905	0.236349
-0.59158	0.349961	0.16309	0.247434	0.061223	0.084216
-0.76249	0.581394	0.029212	-0.12267	0.015049	0.13698
-0.4647	0.215947	0.088679	-0.11998	0.014394	7.28E-06
-0.46384	0.215148	7.4E-07	-0.02981	0.000889	0.00813
-0.33714	0.113663	0.016053	0.092578	0.008571	0.014979
-0.21344	0.045555	0.015303	-0.25932	0.067248	0.123834
2.833184	8.026934	9.281895	0.932849	0.870208	1.421274
0.527713	0.278481	5.315197	-0.49364	0.243685	2.034885

e_i	e_i^2	$(e_i - e_{i-1})^2$	e_i	e_i^2	$(e_i - e_{i-1})^2$
-0.26763	0.071625	0.632567	-0.33006	0.108939	0.246943
0.110371	0.012182	0.19969	-0.30368	0.092223	17.79311
-0.37118	0.137777	16.2021	-0.03518	0.001237	0.095689
0.631457	0.398739	8.90188	0.318061	0.101163	0.095405
-0.89468	0.800447	3.59E-05			

Calculations

$$\sum e_i^2 = 1612.384$$

$$\sum (e_i - e_{i-1})^2 = 2353.252$$

$$D = \frac{\sum_{i=2}^{n} (e_i - e_{i-1})^2}{\sum_{i=1}^{n} e_i^2} = \frac{2353.252}{1612.384} = 1.46$$

Appendix G

Detailed Results of Repeated Measures ANOVA

General Linear Model

Table G1: Within-Subjects Factors

Year	Dependent Variable
1	WE1996
2	WE1997
3	WE1998
4	WE1999
5	WE2000
6	WE2001
7	WE2002

Table G2: Between-Subjects Factors

		N
Group	1	2
	2	6
	3	21
	4	58

Table G3: Multivariate Tests

Effect		Value	F	Hypothesis df	Error df	Sig.
Year	Pillai's Trace	0.103	1.469(a)	6.000	77.000	0.200
	Wilks' Lambda	0.897	1.469(a)	6.000	77.000	0.200
	Hotelling's Trace	0.115	1.469(a)	6.000	77.000	0.200
	Roy's Largest Root	0.115	1.469(a)	6.000	77.000	0.200
Year * Employees	Pillai's Trace	0.041	0.552(a)	6.000	77.000	0.767
	Wilks' Lambda	0.959	0.552(a)	6.000	77.000	0.767
	Hotelling's Trace	0.043	0.552(a)	6.000	77.000	0.767
	Roy's Largest Root	0.043	0.552(a)	6.000	77.000	0.767
Year * Group	Pillai's Trace	0.206	0.973	18.000	237.000	0.492
	Wilks' Lambda	0.805	0.965	18.000	218.274	0.501
	Hotelling's Trace	0.228	0.957	18.000	227.000	0.511
	Roy's Largest Root	0.141	1.859(b)	6.000	79.000	0.098

a Exact statistic
b The statistic is an upper bound on F that yields a lower bound on the significance level.
c Design: Intercept+Average#ofEmployees+Group Within Subjects Design: year

Table G4: Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon(a)		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Year	0.059	226.401	20	0.000	0.501	0.548	0.167

Table G5: Tests of Within-Subjects Effects

MSource		Type III Sum of Squares	df	Mean Square	F	Sig.
Year	Sphericity Assumed	17.697	6	2.949	0.916	0.483
	Greenhouse-Geisser	17.697	3.006	5.887	0.916	0.434
	Huynh-Feldt	17.697	3.285	5.387	0.916	0.440
	Lower-bound	17.697	1.000	17.697	0.916	0.341
Year *Employees	Sphericity Assumed	9.380	6	1.563	0.486	0.819
	Greenhouse-Geisser	9.380	3.006	3.120	0.486	0.693
	Huynh-Feldt	9.380	3.285	2.855	0.486	0.710
	Lower-bound	9.380	1.000	9.380	0.486	0.488
Year * Group	Sphericity Assumed	41.110	18	2.284	0.709	0.803
	Greenhouse-Geisser	41.110	9.018	4.559	0.709	0.700
	Huynh-Feldt	41.110	9.856	4.171	0.709	0.713
	Lower-bound	41.110	3.000	13.703	0.709	0.549
Error(Year)	Sphericity Assumed	1583.959	492	3.219		
	Greenhouse-Geisser	1583.959	246.497	6.426		
	Huynh-Feldt	1583.959	269.404	5.880		
	Lower-bound	1583.959	82.000	19.317		

Table G6: Tests of Within-Subjects Contrasts

Source	Year	Type III Sum of Squares	df	Mean Square	F	Sig.
Year	Linear	0.379	1	0.379	0.042	0.838
	Quadratic	4.800	1	4.800	1.218	0.273
	Cubic	10.353	1	10.353	4.117	0.046
	Order 4	1.088	1	1.088	0.744	0.391
	Order 5	0.776	1	0.776	0.731	0.395
	Order 6	0.301	1	0.301	0.227	0.635
Year * Employees	Linear	1.067	1	1.067	0.118	0.732
	Quadratic	0.697	1	0.697	0.177	0.675
	Cubic	4.493	1	4.493	1.787	0.185
	Order 4	2.235	1	2.235	1.529	0.220
	Order 5	0.217	1	0.217	0.204	0.652
	Order 6	0.671	1	0.671	0.505	0.479
Year * Group	Linear	9.737	3	3.246	0.360	0.782
	Quadratic	3.978	3	1.326	0.336	0.799
	Cubic	21.971	3	7.324	2.912	0.039
	Order 4	2.602	3	0.867	0.593	0.621
	Order 5	2.441	3	0.814	0.767	0.516
	Order 6	0.382	3	0.127	0.096	0.962
Error(Year)	Linear	738.778	82	9.009		
	Quadratic	323.247	82	3.942		
	Cubic	206.207	82	2.515		
	Order 4	119.842	82	1.461		
	Order 5	87.044	82	1.062		
	Order 6	108.841	82	1.327		

Table G7: Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	4489.238	1	4489.238	85.639	0.000
Employees	312.386	1	312.386	5.959	0.017
Group	138.757	3	46.252	0.882	0.454
Error	4298.472	82	52.420		

Appendix H

Complete Fixed-Effects Model Results

Table H1: Parameter and Standard Error Values for the Fixed-Effects Model

Independent Variable	Value	Std. Error	t value	Pr(>|t|)
Intercept	6.497	2.0516	3.1668	0.0016**
Employees	0.8746	0.3801	2.3012	0.0218**
ISO	0.3243	0.3392	0.9562	0.3394
1997	0.3102	0.2691	1.1527	0.2496
1998	0.1424	0.2711	0.5252	0.5997
1999	0.191	0.2741	0.6971	0.4861
2000	-0.1183	0.2721	-0.4348	0.6639
2001	-0.6045	0.2761	-2.1894	0.0290**
2002	-0.3143	0.2914	-1.0786	0.2813
Facility2	1.3927	1.0657	1.3069	0.1918
Facility 3	-2.3462	1.0838	-2.1648	0.0309**
Facility 4	-3.7316	0.9996	-3.733	0.0002***
Facility 5	-6.3998	0.9469	-6.7584	0.0000***
Facility 6	-0.725	0.9615	-0.754	0.4512
Facility 7	-4.8041	1.0316	-4.657	0.0000***
Facility 8	0.0809	0.9728	0.0831	0.9338
Facility 9	0.3575	0.9813	0.3643	0.7158
Facility 10	-7.2167	1.4347	-5.03	0.0000***
Facility 11	0.6548	1.1711	0.5591	0.5763
Facility 12	-2.9109	0.9604	-3.0311	0.0026***
Facility 13	-0.1314	1.0332	-0.1272	0.8988
Facility 14	-1.828	1.0729	-1.7038	0.0890*
Facility 15	-2.1534	0.9492	-2.2686	0.0237**
Facility 16	-1.0092	1.0048	-1.0044	0.3157
Facility 17	-6.0218	1.1958	-5.0356	0.0000***
Facility 18	1.0847	1.1615	0.9339	0.3508
Facility 19	-2.4076	1.2044	-1.999	0.0461**
Facility 20	0.8287	0.9751	0.8499	0.3958
Facility 21	-5.2715	1.1678	-4.5141	0.0000***
Facility 22	0.2607	1.0945	0.2382	0.8118
Facility 23	1.5407	1.4078	1.0944	0.2743
Facility 24	-4.3263	0.9469	-4.569	0.0000***
Facility 25	-7.2538	1.1536	-6.2878	0.0000***
Facility 26	-2.7841	1.034	-2.6925	0.0073***
Facility 27	-1.1594	0.9692	-1.1963	0.2321
Facility 28	-0.7301	1.0343	-0.7058	0.4806
Facility 29	-1.0877	0.9964	-1.0916	0.2755
Facility 30	-1.7516	0.9551	-1.834	0.0672*
Facility 31	-4.248	1.2051	-3.5251	0.0005***
Facility 32	-1.8637	1.0017	-1.8606	0.0634*
Facility 33	-2.0894	0.9657	-2.1636	0.0310**

Independent Variable	Value	Std. Error	t value	Pr(>|t|)
Facility 34	-3.6363	0.9498	-3.8286	0.0001***
Facility 35	0.2091	0.9731	0.2148	0.8300
Facility 36	-1.5321	0.9976	-1.5358	0.1252
Facility 37	-0.477	1.0644	-0.4481	0.6543
Facility 38	-4.1477	0.9469	-4.3802	0.0000***
Facility 39	-7.3088	1.0571	-6.9138	0.0000***
Facility 40	-3.2551	1.0656	-3.0546	0.0024***
Facility 41	-2.176	0.9526	-2.2844	0.0228**
Facility 42	-4.28	0.9972	-4.2921	0.0000***
Facility 43	0.8848	1.2167	0.7273	0.4674
Facility 44	-2.6781	0.9769	-2.7414	0.0063***
Facility 45	-1.6881	1.0182	-1.6579	0.0979*
Facility 46	-2.8666	1.151	-2.4904	0.0131**
Facility 47	-0.2319	0.9973	-0.2325	0.8162
Facility 48	-0.8267	1.3882	-0.5956	0.5517
Facility 49	-0.3945	1.0733	-0.3676	0.7133
Facility 50	-2.8098	1.163	-2.4161	0.0160**
Facility 51	0.3685	0.9479	0.3887	0.6976
Facility 52	-4.1862	1.4084	-2.9722	0.0031***
Facility 53	1.3262	1.273	1.0418	0.2980
Facility 54	-1.5917	1.3386	-1.1891	0.2349
Facility 55	0.0454	1.0611	0.0428	0.9659
Facility 56	-7.4637	1.0839	-6.8857	0.0000***
Facility 57	-4.1725	1.0196	-4.0924	0.0000***
Facility 58	0.1949	1.163	0.1676	0.8670
Facility 59	-3.2742	1.3588	-2.4096	0.0163**
Facility 60	-3.1054	1.1066	-2.8063	0.0052***
Facility 61	-7.9309	1.0067	-7.8778	0.0000***
Facility 62	-3.8091	0.985	-3.8672	0.0001***
Facility 63	0.47	1.033	0.4549	0.6493
Facility 64	-4.2651	0.9728	-4.3843	0.0000***
Facility 65	0.7456	1.1346	0.6571	0.5114
Facility 66	-0.4824	1.1806	-0.4086	0.6830
Facility 67	-8.3633	1.0038	-8.3319	0.0000***
Facility 68	-4.7095	0.9517	-4.9485	0.0000***
Facility 69	-1.7007	1.1228	-1.5147	0.1305
Facility 70	-9.0112	0.970	-9.2903	0.0000***
Facility 71	-1.2066	1.153	-1.0465	0.2958
Facility 72	-3.9025	1.6824	-2.3196	0.0208**
Facility 73	-3.4688	1.2499	-2.7753	0.0057***
Facility 74	-1.663	1.3092	-1.2703	0.2046
Facility 75	-0.0705	1.0033	-0.0702	0.9440
Facility 76	-1.3506	0.9514	-1.4196	0.1563
Facility 77	-2.5176	0.9891	-2.5454	0.0112**

Independent Variable	Value	Std. Error	t value	Pr(>|t|)
Facility 78	-6.8841	1.0264	-6.7072	0.0000***
Facility 79	-0.1536	0.9478	-0.1621	0.8713
Facility 80	0.5922	0.996	0.5946	0.5524
Facility 81	-2.114	1.2077	-1.7505	0.0806*
Facility 82	1.379	1.288	1.0707	0.2848
Facility 83	-3.1413	1.3957	-2.2507	0.0248**
Facility 84	-5.4717	1.1356	-4.8182	0.0000***
Facility 85	-3.8394	1.2049	-3.1864	0.0015***
Facility 86	-7.6033	1.1881	-6.3994	0.0000***
Facility 87	3.1595	1.2671	2.4935	0.0130**

* $p < .10$
** $p < .05$
*** $p < .01$

Appendix I

Sample Calculations for the Aggregated Weighted Emissions

Table I1: Sample Calculations for FLEET Industries Ltd., Fort Erie, Ont.

Chemical Name	**Methyl ethyl ketone**				
CAS Number	78-93-3				
Year	1996				
Medium	***Release***	***Quantity***	**On-Site Releases**	***Disposal Method***	***Quantity***
		(tonnes)			***(tonnes)***
Releases to Air	Stack or point releases:	0	***On-Site disposal***	Landfill:	0
	Storage or handling releases:	0		Land treatment or application farming:	0
	Fugitive releases:	12.119		Underground Injection:	0
	Spills:	0		**Sub-total:**	**0**
	Other non-point releases:	0	***Off-Site disposal***	Containment, landfill:	0
	Sub-total:	**12.119**		Underground injection:	0
Releases to Surface Water	Direct discharges:	0		Land treatment:	0
	Spills:	0		Containment, other storage:	0
	Leaks:	0		**Sub-total:**	**0**
	Sub-total:	**0**	***Off-Site***	Physical treatment:	0
Releases to Land	Spills:	0	***treatment***	Chemical treatment:	0
	Leaks:	0	***prior to***	Biological treatment:	0
	Other:	0	***final disposal***	Incineration or thermal:	2.401
	Sub-total:	**0**		Municipal sewage treatment plant:	0
Total Releases:		**12.119**		**Sub-total:**	**2.401**
				Total Disposals	**2.401**

Toxicity Weight		
Inhalation	1.8	
Oral	0.83	
Inhalation Score	(12.119+2.401)*1.8 = 26.136	
Oral Score	(0)*0.83 = 0	
Total	(26.136+0) = 26.136	Weighted Emission

Chemical Name	Methyl ethyl ketone				
CAS Number	78-93-3				
Year	1997				
Medium	***Release***	***Quantity***	**On-Site Releases**	***Disposal Method***	***Quantity***
		(tonnes)			***(tonnes)***
Releases to Air	Stack or point releases:	0	***On-Site disposal***	Landfill:	0
	Storage or handling releases:	0		Land treatment or application farming:	0
	Fugitive releases:	12.9		Underground Injection:	0
	Spills:	0		**Sub-total:**	**0**
	Other non-point releases:	0	***Off-Site disposal***	Containment, landfill:	0
	Sub-total:	**12.9**		Underground injection:	0
Releases to Surface Water	Direct discharges:	0		Land treatment:	0
	Spills:	0		Containment, other storage:	0
	Leaks:	0		**Sub-total:**	**0**
	Sub-total:	**0**	***Off-Site***	Physical treatment:	0
Releases to Land	Spills:	0	***treatment***	Chemical treatment:	0
	Leaks:	0	***prior to***	Biological treatment:	0
	Other:	0	***final disposal***	Incineration or thermal:	2.401
	Sub-total:	**0**		Municipal sewage treatment plant:	0
Total Releases:		**12.9**		**Sub-total:**	**2.401**
				Total Disposals	**2.401**

Toxicity Weight		
Inhalation	1.8	
Oral	0.83	
Inhalation Score	(12.9+2.401)*1.8 = 27.5418	
Oral Score	(0)*0.83 = 0	
Total	(27.5418+0) = 27.5418	Weighted Emission

Chemical Name	**Methyl ethyl ketone**				
CAS Number	78-93-3				
Year	1998				
Medium	***Release***	***Quantity***	**On-Site Releases**	***Disposal Method***	***Quantity***
		(tonnes)			***(tonnes)***
Releases to Air	Stack or point releases:	0	***On-Site disposal***	Landfill:	0
	Storage or handling releases:	0		Land treatment or application farming:	0
	Fugitive releases:	12.8		Underground Injection:	0
	Spills:	0		**Sub-total:**	**0**
	Other non-point releases:	0	***Off-Site disposal***	Containment, landfill:	0
	Sub-total:	**12.8**		Underground injection:	0
Releases to Surface Water	Direct discharges:	0		Land treatment:	0
	Spills:	0		Containment, other storage:	0
	Leaks:	0		**Sub-total:**	**0**
	Sub-total:	**0**	***Off-Site***	Physical treatment:	0
Releases to Land	Spills:	0	***treatment***	Chemical treatment:	0
	Leaks:	0	***prior to***	Biological treatment:	0
	Other:	0	***final disposal***	Incineration or thermal:	7.035
	Sub-total:	**0**		Municipal sewage treatment plant:	0
Total Releases:		**12.8**		**Sub-total:**	**7.035**
				Total Disposals	**7.035**

Toxicity Weight		
Inhalation	1.8	
Oral	0.83	
Inhalation Score	(12.8+7.035)*1.8 = 35.703	
Oral Score	(0)*0.83 = 0	
Total	(35.703+0) = 35.703	Weighted Emission

Chemical Name	**Methyl ethyl ketone**				
CAS Number	78-93-3				
Year	1999				
Medium	***Release***	***Quantity*** (tonnes)	**On-Site Releases**	***Disposal Method***	***Quantity*** (tonnes)
Releases to Air	Stack or point releases:	0	***On-Site disposal***	Landfill:	0
	Storage or handling releases:	0		Land treatment or application farming:	0
	Fugitive releases:	16		Underground Injection:	0
	Spills:	0		**Sub-total:**	**0**
	Other non-point releases:	0	***Off-Site disposal***	Containment, landfill:	0
	Sub-total:	**16**		Underground injection:	0
Releases to Surface Water	Direct discharges:	0		Land treatment:	0
	Spills:	0		Containment, other storage:	0
	Leaks:	0		**Sub-total:**	**0**
	Sub-total:	**0**	***Off-Site***	Physical treatment:	0
Releases to Land	Spills:	0	***treatment***	Chemical treatment:	0
	Leaks:	0	***prior to***	Biological treatment:	0
	Other:	0	***final disposal***	Incineration or thermal:	4.04
	Sub-total:	**0**		Municipal sewage treatment plant:	0
Total Releases:		16		**Sub-total:**	**4.04**
				Total Disposals	**4.04**

Toxicity Weight		
Inhalation	1.8	
Oral	0.83	
Inhalation Score	(16+4.04)*1.8 = 36.072	
Oral Score	(0)*0.83 = 0	
Total	(36.072+0) = 36.072	Weighted Emission

Chemical Name	**Methyl ethyl ketone**				
CAS Number	78-93-3				
Year	2000				
Medium	***Release***	***Quantity***	**On-Site Releases**	***Disposal Method***	***Quantity***
		(tonnes)			***(tonnes)***
Releases to Air	Stack or point releases:	0	***On-Site disposal***	Landfill:	0
	Storage or handling releases:	0		Land treatment or application farming:	0
	Fugitive releases:	23.88		Underground Injection:	0
	Spills:	0		**Sub-total:**	**0**
	Other non-point releases:	0	***Off-Site disposal***	Containment, landfill:	0
	Sub-total:	**23.88**		Underground injection:	0
Releases to Surface Water	Direct discharges:	0		Land treatment:	0
	Spills:	0		Containment, other storage:	0
	Leaks:	0		**Sub-total:**	**0**
	Sub-total:	**0**	***Off-Site***	Physical treatment:	0
Releases to Land	Spills:	0	***treatment***	Chemical treatment:	0
	Leaks:	0	***prior to***	Biological treatment:	0
	Other:	0	***final disposal***	Incineration or thermal:	4.28
	Sub-total:	**0**		Municipal sewage treatment plant:	0
Total Releases:		**23.88**		**Sub-total:**	**4.28**
				Total Disposals	**4.28**

Toxicity Weight		
Inhalation	1.8	
Oral	0.83	
Inhalation Score	(23.88+4.28)*1.8 = 50.688	
Oral Score	(0)*0.83 = 0	
Total	(50.688+0) = 50.688	Weighted Emission

Chemical Name	**Methyl ethyl ketone**				
CAS Number	78-93-3				
Year	2001				
Medium	***Release***	***Quantity***	**On-Site Releases**	***Disposal Method***	***Quantity***
		(tonnes)			***(tonnes)***
Releases to Air	Stack or point releases:	0	***On-Site disposal***	Landfill:	0
	Storage or handling releases:	0		Land treatment or application farming:	0
	Fugitive releases:	21.159		Underground Injection:	0
	Spills:	0		**Sub-total:**	**0**
	Other non-point releases:	0	***Off-Site disposal***	Containment, landfill:	0
	Sub-total:	**21.159**		Underground injection:	0
Releases to Surface Water	Direct discharges:	0		Land treatment:	0
	Spills:	0		Containment, other storage:	0
	Leaks:	0		**Sub-total:**	**0**
	Sub-total:	**0**	***Off-Site***	Physical treatment:	0
Releases to Land	Spills:	0	***treatment***	Chemical treatment:	0
	Leaks:	0	***prior to***	Biological treatment:	0
	Other:	0	***final disposal***	Incineration or thermal:	8.018
	Sub-total:	**0**		Municipal sewage treatment plant:	0
Total Releases:		**21.159**		**Sub-total:**	**8.018**
				Total Disposals	**8.018**

Toxicity Weight		
Inhalation	1.8	
Oral	0.83	
Inhalation Score	(21.159+8.018)*1.8 = 52.5186	
Oral Score	(0)*0.83 = 0	
Total	(52.5186+0) = 52.5186	Weighted Emission

Chemical Name	Methyl ethyl ketone				
CAS Number	78-93-3				
Year	2002				
Medium	***Release***	***Quantity***	**On-Site Releases**	***Disposal Method***	***Quantity***
		(tonnes)			***(tonnes)***
Releases to Air	Stack or point releases:	0	***On-Site disposal***	Landfill:	0
	Storage or handling releases:	0		Land treatment or application farming:	0
	Fugitive releases:	8.19		Underground Injection:	0
	Spills:	0		**Sub-total:**	**0**
	Other non-point releases:	0	***Off-Site disposal***	Containment, landfill:	0
	Sub-total:	**8.19**		Underground injection:	0
Releases to Surface Water	Direct discharges:	0		Land treatment:	0
	Spills:	0		Containment, other storage:	0
	Leaks:	0		**Sub-total:**	**0**
	Sub-total:	**0**	***Off-Site***	Physical treatment:	0
Releases to Land	Spills:	0	***treatment***	Chemical treatment:	0
	Leaks:	0	***prior to***	Biological treatment:	0
	Other:	0	***final disposal***	Incineration or thermal:	5.845
	Sub-total:	**0**		Municipal sewage treatment plant:	0
Total Releases:		**8.19**		**Sub-total:**	**5.845**
				Total Disposals	**5.845**

Toxicity Weight		
Inhalation	1.8	
Oral	0.83	
Inhalation Score	(8.19+5.845)*1.8 = 25.263	
Oral Score	(0)*0.83 = 0	
Total	(25.263+0) = 25.263	Weighted Emission

Chemical Name	**Sulphuric acid**		Chemical Name	**Sulphuric acid**	
CAS Number	7664-93-9		CAS Number	7664-93-9	
Year	1996		Year	1997	
Medium	***Release***	***Quantity***	***Medium***	***Release***	***Quantity***
		(tonnes)			***(tonnes)***
Releases to Air	Stack or point releases:	0	*Releases to Air*	Stack or point releases:	0
	Storage or handling releases:	0		Storage or handling releases:	0
	Fugitive releases:	0		Fugitive releases:	0
	Spills:	0		Spills:	0
	Other non-point releases:	0		Other non-point releases:	0
	Sub-total:	**0**		**Sub-total:**	**0**
Releases to Surface Water	Direct discharges:	0	*Releases to Surface Water*	Direct discharges:	0
	Spills:	0		Spills:	0
	Leaks:	0		Leaks:	0
	Sub-total:	**0**		**Sub-total:**	**0**
Releases to Land	Spills:	0	*Releases to Land*	Spills:	0
	Leaks:	0		Leaks:	0
	Other:	0		Other:	0
	Sub-total:	**0**		**Sub-total:**	**0**
Total Releases:		**0**		***Total Releases:***	**0**
Disposal		***Off-Site Recycling***		***Disposal***	***Off-Site Recycling***
On-Site	***Off-Site***		***On-Site***	***Off-Site***	
0	5.6	0	0	5.97	0
Toxicity Weight			**Toxicity Weight**		
Inhalation	1400		Inhalation	1400	
Oral	0.01		Oral	0.01	
Inhalation Score	(0*1400) = 0		Inhalation Score	(0*1400) = 0	
Oral Score	(5.6*0.01) = 0.056		Oral Score	(5.97*0.01) = 0.0597	
Total	0.056	Weighted Emission	Total	0.0597	Weighted Emission

Chemical Name	**Sulphuric acid**		Chemical Name	**Sulphuric acid**	
CAS Number	7664-93-9		CAS Number	7664-93-9	
Year	1998		Year	1999	
Medium	***Release***	***Quantity (tonnes)***	***Medium***	***Release***	***Quantity (tonnes)***
Releases to Air	Stack or point releases:	0	*Releases to Air*	Stack or point releases:	0
	Storage or handling releases:	0		Storage or handling releases:	0
	Fugitive releases:	0		Fugitive releases:	0
	Spills:	0		Spills:	0
	Other non-point releases:	0		Other non-point releases:	0
	Sub-total:	**0**		**Sub-total:**	**0**
Releases to Surface Water	Direct discharges:	0	*Releases to Surface Water*	Direct discharges:	0
	Spills:	0		Spills:	0
	Leaks:	0		Leaks:	0
	Sub-total:	**0**		**Sub-total:**	**0**
Releases to Land	Spills:	0	*Releases to Land*	Spills:	0
	Leaks:	0		Leaks:	0
	Other:	0		Other:	0
	Sub-total:	**0**		**Sub-total:**	**0**
Total Releases:		**0**	***Total Releases:***		**0**
Disposal		***Off-Site Recycling***	***Disposal***		***Off-Site Recycling***
On-Site	***Off-Site***		***On-Site***	***Off-Site***	
0	5.6	0	0	5.6	0
Toxicity Weight			**Toxicity Weight**		
Inhalation	1400		Inhalation	1400	
Oral	0.01		Oral	0.01	
Inhalation Score	0		Inhalation Score	0	
Oral Score	0.056		Oral Score	0.056	
Total	0.056	Weighted Emission	Total	0.056	Weighted Emission

Chemical Name	**Trichloroethylene**	
CAS Number	79-01-6	
Year	1996	
Medium	***Release***	***Quantity (tonnes)***
Releases to Air	Stack or point releases:	0
	Storage or handling releases:	0
	Fugitive releases:	30.97
	Spills:	0
	Other non-point releases:	0
	Sub-total:	**30.97**
Releases to Surface Water	Direct discharges:	0
	Spills:	0
	Leaks:	0
	Sub-total:	**0**
Releases to Land	Spills:	0
	Leaks:	0
	Other:	0
	Sub-total:	**0**
Total Releases:		**30.97**
Disposal		***Off-Site Recycling***
On-Site	***Off-Site***	
0	0	0
Toxicity Weight		
Inhalation	14	
Oral	14	
Inhalation Score	(30.97*14) = 433.58	
Oral Score	(0*14) = 0	
Total	433.58	Weighted Emission

Chemical Name	Trichloroethylene		Chemical Name	Trichloroethylene	
CAS Number	79-01-6		CAS Number	79-01-6	
Year	1997		Year	1998	
Medium	***Release***	***Quantity (tonnes)***	***Medium***	***Release***	***Quantity (tonnes)***
Releases to Air	Stack or point releases:	0	*Releases to Air*	Stack or point releases:	0
	Storage or handling releases:	0		Storage or handling releases:	0
	Fugitive releases:	26.25		Fugitive releases:	29.3
	Spills:	0		Spills:	0
	Other non-point releases:	0		Other non-point releases:	0
	Sub-total:	**26.25**		**Sub-total:**	**29.3**
Releases to Surface Water	Direct discharges:	0	*Releases to Surface Water*	Direct discharges:	0
	Spills:	0		Spills:	0
	Leaks:	0		Leaks:	0
	Sub-total:	**0**		**Sub-total:**	**0**
Releases to Land	Spills:	0	*Releases to Land*	Spills:	0
	Leaks:	0		Leaks:	0
	Other:	0		Other:	0
	Sub-total:	**0**		**Sub-total:**	**0**
Total Releases:		**26.25**	***Total Releases:***		**29.3**
Type	***Disposal Method***	***Quantity (tonnes)***	***Type***	***Disposal Method***	***Quantity (tonnes)***
On-Site disposal	Landfill:	0	***On-Site disposal***	Landfill:	0
	Land treatment or application farming:	0		Land treatment or application farming:	0
	Underground Injection:	0		Underground Injection:	0
	Sub-total:	**0**		**Sub-total:**	**0**
Off-Site disposal	Containment, landfill:	0	***Off-Site disposal***	Containment, landfill:	0
	Underground injection:	0		Underground injection:	0
	Land treatment:	0		Land treatment:	0
	Containment, other storage:	0		Containment, other storage:	0
	Sub-total:	**0**		**Sub-total:**	**0**
Off-Site treatment prior to final disposal	Physical treatment:	0	***Off-Site treatment prior to final disposal***	Physical treatment:	0
	Chemical treatment	0		Chemical treatment	0
	Biological treatment:	0		Biological treatment:	0
	Incineration or thermal:	2.3		Incineration or thermal:	1.2
	Municipal sewage treatment plant :	0		Municipal sewage treatment plant:	0
	Sub-total:	**2.3**		**Sub-total:**	**1.2**
Total Disposals		**2.3**	***Total Disposals***		**1.2**

Off-Site Recycling	***Units***		***Off-Site Recycling***	***Units***	
0	tonnes		0	tonnes	
Toxicity Weight			**Toxicity Weight**		
Inhalation	14		Inhalation	14	
Oral	14		Oral	14	
Inhalation Score	(26.25+2.3) = 399.7		Inhalation Score	(29.3+1.2) = 427	
Oral Score	0		Oral Score	0	
Total	399.7	Weighted Emission	Total	427	Weighted Emission

Chemical Name	Trichloroethylene		Chemical Name	Trichloroethylene	
CAS Number	79-01-6		CAS Number	79-01-6	
Year	1999		Year	2000	
Medium	***Release***	***Quantity (tonnes)***	***Medium***	***Release***	***Quantity (tonnes)***
Releases to Air	Stack or point releases:	0	*Releases to Air*	Stack or point releases:	0
	Storage or handling releases:	0		Storage or handling releases:	0
	Fugitive releases:	19.394		Fugitive releases:	19.7
	Spills:	0		Spills:	0
	Other non-point releases:	0		Other non-point releases:	0
	Sub-total:	**19.394**		**Sub-total:**	**19.7**
Releases to Surface Water	Direct discharges:	0	*Releases to Surface Water*	Direct discharges:	0
	Spills:	0		Spills:	0
	Leaks:	0		Leaks:	0
	Sub-total:	**0**		**Sub-total:**	**0**
Releases to Land	Spills:	0	*Releases to Land*	Spills:	0
	Leaks:	0		Leaks:	0
	Other:	0		Other:	0
	Sub-total:	**0**		**Sub-total:**	**0**
Total Releases:		**19.394**	***Total Releases:***		**19.7**
Type	***Disposal Method***	***Quantity (tonnes)***	***Type***	***Disposal Method***	***Quantity (tonnes)***
On-Site disposal	Landfill:	0	***On-Site disposal***	Landfill:	0
	Land treatment or application farming:	0		Land treatment or application farming:	0
	Underground Injection:	0		Underground Injection:	0
	Sub-total:	**0**		**Sub-total:**	**0**
Off-Site disposal	Containment, landfill:	0	***Off-Site disposal***	Containment, landfill:	0
	Underground injection:	0		Underground injection:	0
	Land treatment:	0		Land treatment:	0
	Containment, other storage:	0		Containment, other storage:	0
	Sub-total:	**0**		**Sub-total:**	**0**
Off-Site	Physical treatment:	0	***Off-Site***	Physical treatment:	0
treatment	Chemical treatment:	0	***treatment***	Chemical treatment:	0
prior to	Biological treatment:	0	***prior to***	Biological treatment:	0
final disposal	Incineration or thermal:	6.637	***final disposal***	Incineration or thermal:	1.486
	Municipal sewage treatment plant:	0		Municipal sewage treatment plant:	0
	Sub-total:	**6.637**		**Sub-total:**	**1.486**
Total Disposals		**6.637**	***Total Disposals***		**1.486**
Off-Site	***Units***		***Off-Site***	***Units***	

Recycling			***Recycling***		
0	tonnes		0	tonnes	
Toxicity Weight			**Toxicity Weight**		
Inhalation	14		Inhalation	14	
Oral	14		Oral	14	
Inhalation Score	(19.394+6.637)*14= 364.434		Inhalation Score	(19.7+1.486)*14 = 296.604	
Oral Score	0		Oral Score	0	
Total	364.434	Weighted Emission	Total	296.604	Weighted Emission

Chemical Name	Trichloroethylene		Chemical Name	Trichloroethylene	
CAS Number	79-01-6		CAS Number	79-01-6	
Year	2001		Year	2002	
Medium	***Release***	***Quantity (tonnes)***	***Medium***	***Release***	***Quantity (tonnes)***
Releases to Air	Stack or point releases:	0	*Releases to Air*	Stack or point releases:	0
	Storage or handling releases:	0		Storage or handling releases:	0
	Fugitive releases:	21.379		Fugitive releases:	17.613
	Spills:	0		Spills:	0
	Other non-point releases:	0		Other non-point releases:	0
	Sub-total:	**21.379**		**Sub-total:**	**17.613**
Releases to Surface Water	Direct discharges:	0	*Releases to Surface Water*	Direct discharges:	0
	Spills:	0		Spills:	0
	Leaks:	0		Leaks:	0
	Sub-total:	**0**		**Sub-total:**	**0**
Releases to Land	Spills:	0	*Releases to Land*	Spills:	0
	Leaks:	0		Leaks:	0
	Other:	0		Other:	0
	Sub-total:	**0**		**Sub-total:**	**0**
Total Releases:		**21.379**	***Total Releases:***		**17.613**
Type	***Disposal Method***	***Quantity (tonnes)***	***Type***	***Disposal Method***	***Quantity (tonnes)***
On-Site disposal	Landfill:	0	***On-Site disposal***	Landfill:	0
	Land treatment or application farming:	0		Land treatment or application farming:	0
	Underground Injection:	0		Underground Injection:	0
	Sub-total:	**0**		**Sub-total:**	**0**
Off-Site disposal	Containment, landfill:	0	***Off-Site disposal***	Containment, landfill:	0
	Underground injection:	0		Underground injection:	0
	Land treatment:	0		Land treatment:	0
	Containment, other storage:	0		Containment, other storage:	0
	Sub-total:	**0**		**Sub-total:**	**0**
Off-Site	Physical treatment:	0	***Off-Site***	Physical treatment:	0
treatment	Chemical treatment:	0	***treatment***	Chemical treatment:	0
prior to	Biological treatment:	0	***prior to***	Biological treatment:	0
final disposal	Incineration or thermal:	1.609	***final disposal***	Incineration or thermal:	1.326
	Municipal sewage treatment plant:	0		Municipal sewage treatment plant:	0
	Sub-total:	**1.609**		**Sub-total:**	**1.326**
Total Disposals		**1.609**	***Total Disposals***		**1.326**
Off-Site Recycling	***Units***		***Off-Site Recycling***	***Units***	

0	tonnes		0	tonnes	
Toxicity Weight			**Toxicity Weight**		
Inhalation	14		Inhalation	14	
Oral	14		Oral	14	
Inhalation Score	(21.379+1.609) = 321.832		Inhalation Score	(17.613+1.326) = 265.146	
Oral Score	0		Oral Score	0	
Total	321.832	Weighted Emission	Total	265.146	Weighted Emission

Table I2: Yearly Aggregated Weighted Emission Totals For Facility 26

Year Totals	Weighted Emissions
1996	26.136 + 0.056 + 433.58 = 459.772
1997	27.5418 + 0.0597+ 399.70 = 427.3015
1998	35.703 + 0.056 + 427 = 462.759
1999	36.072 + 0.056 + 364.434 = 400.562
2000	50.688 + 296.604 = 347.292
2001	52.5186 + 321.832 = 374.3506
2002	25.263 + 265.146 = 290.409