台灣企業建立ISO14001環境管理系統之決定要素與財務績效

Firms Decisions to Certify ISO14001 EMS and their Financial Performance – An Empirical Study of Taiwan

研 究 生：劉子衙　　Student：Tzu-Yar Liu

指導教授：朱博湧　　Advisor：Po-Young Chu

國 立 交 通 大 學

管理科學系

博 士 論 文

A Dissertation

Submitted to Department of Management Science

College of Management

National Chiao Tung University

in Partial Fulfillment of the Requirements

for the Degree of

Doctor of Philosophy

in

Management

July, 2007

Hsin-Chu, Taiwan, Republic of China

中 華 民 國 九 十 六 年 七 月

台灣企業建立 ISO14001 環境管理系統之決定要素與財務績效

研究生：劉子衡　　指導教授：朱博湧

國立交通大學管理科學系博士班

摘　　要

從國際標準組織(ISO)訂頒 ISO14001 環境管理系統標準以來，全世界的許多公司紛紛建立 ISO14001 環境管理系統。截至 2005 年 4 月份為止，全球已有 88,800 家不同類型和規模的組織通過 ISO14001 驗證。雖然已有許多實證研究檢視在先進國家推行自願性環境管理計畫之決定要素，但是在台灣推行這些自願性計畫的動機卻很少被提及。本研究目的在分析引導台灣上市上櫃公司建立 ISO14001 環境管理系統並尋求驗證之驅動要素。利用 1996-2004 年期間，332 家取得 ISO14001 驗證和 650 家未獲得驗證的公司之長期追蹤調查資料為樣本，迴歸結果證明公司的外銷比率、公司規模、研發強度及科學園區廠商等四要素會影響公司採行 ISO14001 驗證之決策。整體而言，迴歸結果顯示，為了降低公害並改善環境品質，政府雖可透過政策性的工具，如提供補貼增加企業驗證的誘因；或是政府長期累積對環境保護的承諾，增加公司違反環境法規的潛在成本來鼓勵廠商推動 ISO14001 環境管理系統，但政策性工具對廠商是否通過 ISO14001 驗證並無強烈證據支持。同時，隨著全球化趨勢及相關綠色環保規範之要求，外銷導向型的台灣企業不斷面臨來自利害相關團體之持續壓力，比如說來自跨國企業公司所加諸的綠色供應鏈壓力，導致其較內需型產業更可能採行 ISO14001 標準，故企業為了企業形象及潛在市場，往往也會透過取得環保驗證，自發地降低整個生產過程中對環境的潛在破壞。整體而言，從實證結果顯示之主要管理意涵為：外銷導向的台灣企業由於承受來自全球綠色供應鏈(greening supply chain)之壓力，急於把 ISO14001 標準視為一可接受的合法性工具(legitimacy tool)，因為它可用來協助台灣廠商交換合法性，故企業的環境活動與其財務績效之間並無顯著的差異關係存在。

關鍵詞:　驗證、環境績效、ISO14001 環境管理系統、自我治理、綠色供應鏈

Firms Decisions to Certify ISO14001 EMS and their Financial Performance － An Empirical Study of Taiwan

Student：Tzu-Yar Liu　　Advisor：Dr. Po-Young Chu

Department of Management Science
National Chiao Tung University

ABSTRACT

Rare empirical studies have analyzed the responses of Taiwanese manufacturing firms to ISO 14001 despite firm responses to environmental issues being an important aspect of environmental management. This study empirically examines the determinants of firms' environmental self-governance. Export-oriented Taiwanese firms, which face supply chain pressure from multinational firms and environmental concerns from foreign consumers, are found to be more likely than domestic-focused firms to adopt ISO 14001. This study also finds that several firm attributes are decisive for firm adoption of ISO 14001. However, this study does not find a significant impact of local governors' political party affiliation on firms' decisions on ISO 14001 certifications. Since the institutional forces such as greening supply chain pressures have become the major driver of the moves of Taiwanese firms towards more environmentally responsible operations, the estimation results demonstrate that Taiwanese firms regard the ISO14001 standard as an acceptable means of seeking legitimacy, establishing trust and long-term relationships with a wide range of stakeholders, and deflecting the scrutiny and interest of watchdog agencies and other interested parties worldwide; thus, no significant correlation exists between environmental and financial performance.

Key words: Environmental Performance, Environmental self-governance, ISO 14001 EMS

ACKNOWLEDGMENTS

論文付梓之際，心中滿是感謝。本論文得以順利完成，首先要感謝指導老師朱博湧與吳世英兩位教授，於論文撰寫期間之督促與悉心指導，在遭遇瓶頸時總是協助渡過難關，解決心中的疑問，並且撥冗校閱；師恩浩瀚，永銘於心，謹誌於卷首以聊表由衷之敬意與謝意。

口試委員于樹偉老師在環境與安全衛生管理學界享負盛名，學養豐富而治學嚴謹；而黃仁宏老師的管理素養深厚紮實，在行銷領域所發表的文章鞭闢入裡；鄧美貞老師以其在計量經濟和統計技巧之功力，對我論文的完成功不可沒。承蒙三位老師在論文口試上的指正與建議，讓學生多所學習，使得本論文更加完善，在此也深表感激。

感謝朱門團隊的弘書、裕淩及杏華總是提供我許多資訊，對我的研究具有莫大影響力，很慶幸自己能夠認識你們。感謝工研院能環所的好同事們，在我博士班修業期間，總是給我許多的鼓勵與支持，特別因為你們的陪伴使我在工作繁忙之際，適時提供必要協助。

最後要感謝我的母親、愛妻及岳父母，當我在工作和學業蠟燭兩頭燒之際，容忍我的焦躁與不安。也再次謝謝我的太太__世宜對我的支持與包容，陪著我走過這一段歷程，做我精神的後盾。還有因為對三個寶貝__怡萱、冠廷及晏圻的愛，使得我在最苦的時候，還是可以堅強、忍耐，發揮個人最大的潛力。

謹以此論文獻給天人永隔的父親，謝謝他無怨無悔對我的栽培與付出，直到生命終點，在病榻彌留之時仍不忘對我叮嚀與牽掛，希望今日拿到博士學位的我，更能讓父親開心，也想告訴他，我會更加努力善盡對家人、社會及國家之職責！

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 Research Background

In an era defined by accelerated population growth and dwindling non-renewable resources, balancing the pursuit of economic growth with environmental conservation is becoming increasingly important in firm policy making. Since 1987, the U.N. World Commission on Environment and Development has promoted its Agenda 21, inducing nations to devise specific policies addressing sustainable development. During the past decade, sustainable development has become a common value worldwide, a way of thinking, and a watchword; national sustainable development policies have made environmental management a key issue in the twenty-first century. Additionally, growing environmental pollution and ecological destruction have also become major international concerns. In response to a resolution of the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992 on the subject of designing an instrument for encouraging sustainable development, the ISO 14001 International Standard was issued and amended by the International Organization for Standardization (ISO) in September 1996 and November 2004, respectively. ISO 14001 requires firms to establish an Environment Management System (EMS) for supporting environmental protection, pollution prevention and continual improvement in managing the potential environmental hazards related to firm activities, products or services. However, ISO 14001 is not a performance-oriented standard; and focuses on

management processes rather than specific environmental outcomes (Bansal and Bogner, 2002). ISO 14001 is designed to be applicable to all types and sizes of organizations, and to accommodate diverse geographical, cultural and social conditions, and thus offers a more flexible standard than alternatives such as the Eco-Management and Audit Scheme (EMAS). The purpose of the ISO in designing the ISO 14001 system is to establish a basic international standard (currently, nations frequently follow their own environmental management systems, for example, the BS 7750 in the U.K., the EMAS in the E.U., Z-750 in Canada, and so on), and establishment of an international standard can avoid the formation technical barriers to trade (TBT), which could hurt both trade and business. Additionally, the ISO aims to promote a responsible attitude among individuals in the "global village."

Although EMS implementation simply provides a framework for managing environmental impacts and provides a starting-point for developing firm-level environmental strategies (Christmann and Taylor, 2001), an EMS can help enhance firm performance by reducing waste and creating other efficiencies (Porter and van der Linde, 1995a; 1995b). The implementation of ISO14000 may provide a means of establishing a national policy of self-governance, especially in countries that lack environmental regulation or enforcement capabilities (Wilson, 1998).

Winsemius and Guntram (1992) pointed out the emerging awareness of consumers and companies regarding environmental issues; this new wave of thinking regarding sustainable development represents a grass-roots force that

governments and enterprises cannot afford to neglect. Governments and enterprises thus have increased their commitment to responsible environmental management, implementing policies to address adverse environmental impacts (Mulder, 1998; Walton et al., 1998; Gifford, 1997). Klassen and McLaughlin (1996) believed that enterprises promote environmental management to reduce the negative environmental impacts of their operations. Numerous scholars note that by promoting environmental management, companies are not only operationally successful, but also enhance their environmental performance (Eckel et al., 1992; Greeno and Robinson, 1992; Dean and Brown, 1995; Porter and van der Linde, 1995; Nehrt, 1996; Tibor and Feldman, 1996; Magretta, 1997; Weizsacker and Lovins, 1998; Stigson, 1998; Miles et al., 1999). Miles (1997) further stated that companies will have the difficulty of gaining international recognition if they are unable to obtain ISO 14001 certification.

During the recent decade, the emphasis on global environmental management has evolved from the conventional approach of command and control to the voluntary participation and avoidance approach. ISO 14001 is a voluntary scheme in the sense that firms can demonstrate their EMS consistency and management level by passing a third party certification and/or to themselves by self-declaration. Compared to the command and control approach, the voluntary scheme approach is a partnership concept based on corporate environmental management, which allows companies and government agencies to work together to identify their impact on the environment and improve their environmental performance. The empirical analyses for the U.S. Acid Rain Program reveal that voluntary participation

behavior for electric utilities can be explained via economic variables, showing cost-effective compliance strategies and low transaction costs (Montero, 1999). Moreover, empirical evidence shows that American firms have enhanced their financial performance by developing rent generating resources and capabilities, reducing resource use and process waste, improving product quality, and increasing international transactions (Delmas, 2001).

Taiwan is the 13th largest trading nation in the world, and international trade has been crucial to Taiwan's economic development. The United States, Hong Kong, Japan, China, and Europe (notably France, Germany, the Netherlands, and the United Kingdom) remained the top buyers of Taiwanese exports in 2001, accounting for 60.5 % of total exports. The main export markets for Taiwanese firms are in Europe, Japan and North America. Taiwanese suppliers to multinational enterprises in these developed countries, including IBM, Ford, GM, Xerox, Honda, Toyota, HP, and Squibb, face pressure to pursue environmental certifications if ISO 14001 becomes a de facto requirement for selling in any value chain ending in these markets (Bansal and Bogner, 2002). Christmann and Taylor (2001) propose that globalization may have positive environmental effects since multinational ownership, multinational customers, and exports to developed countries increase self-governance of environmental performance. In reacting to this green trend and recognizing the integration of environmental management into business operations (Jiang and Bansal, 2003), Taiwanese firms have responded positively and proactively to ISO 14001 since its introduction. The Taiwanese government and numerous enterprises consider ISO 14001 to be a

"green passport" granting entry to international markets, and the ISO 14001 standard can also improve a firm's image via increased environmental legitimacy (Jiang and Bansal, 2003).

With the growing importance of voluntary instruments for improving environmental quality, the determinants of firm decisions to voluntarily comply with environmental standards need to be well understood. Numerous empirical studies have examined the determinants of firm participation in voluntary environmental schemes in developed countries (DeCanio and Watkins, 1998; Arora and Cason, 1995; Henriques and Sardorsky, 1996; Nakamura et al., 2001). For example, DeCanio and Watkins indicate (1998) that firm-specific variables such as firm size, earnings and insider shareholders are significant determinants of voluntary participation of U.S. firms in the Green Lights program. Moreover, empirical studies have investigated the factors driving firms to seek ISO 14001 certification in developing economies such as China and Hong Kong (Cushing et al., 2005; Christmann and Taylor, 2001; Chan and Li, 2001). They generally find that exports to the developed countries are a key factor of firms' adopting ISO 14001 certification.

Taiwan currently ranks among the top three nations worldwide in 30 products and manufacturing services (IDB, 2002) and globalization has increased the institutional and customer pressures on firms to exceed local regulatory requirements (Christmann and Taylor, 2001) though opponents of the World Trade Organization (WTO) claim that globalization has caused environmental deterioration in developing countries. From a political

perspective, Taiwan has experienced democratization over the past few decades and the central government continues to delegate responsibility for some environmental regulations to local governments. Determining the appropriate role of the various governments in the setting of environmental standards has been a key issue on the political agenda for Taiwan. However, no empirical studies have yet examined the firms' adoption of voluntary ISO certification schemes in Taiwan. Therefore, it is imperative to investigate what factors drive firms to improve environmental protection through their adoption of ISO 14001 certification.

Recently, numerous Taiwanese enterprises have promoted ISO 14001 implementation and certification as an effective means of achieving sustainable development. Companies consider ISO 14001 to be a viable approach for helping them cultivate an ideal image and remain competitive attract sales, rather than as a regulation or limitation that brings unwanted stress. This trend also has positive societal effects. Thus, this study attempts to identify qualitative differences between companies with and without ISO 14001 certification. Additionally, this work also attempts to determine the differences in overall operational effectiveness between ISO 14001-certified and non-certified companies in terms of their efforts to balance environmental conservation and sustainable development.

1.2 Research Objectives

The general objectives of this research are to examine the factors driving Taiwanese firms to seek ISO 14001 certification. Specifically, the

objectives are as follows,

1. Investigation of determinants of firm self-governance in Taiwan from economic, social, environmental and political aspects.

2. Development of a model to assess the determinants of Taiwanese manufacturing companies to eatablish the certified ISO14001 Environmental Management System (EMS).

3. Identification of qualitative differences between companies with and without ISO 14001 certification and determination the differences in overall operational effectiveness between ISO 14001-certified and non-certified companies in terms of their efforts to balance environmental conservation and sustainable development.

To achieve the above objectives, it is based on random effects estimations of panel data over 1996-2004 in the study of determinants of firm self-governance in Taiwan. In order to investigate the factors leading a firm to become certified, firms which have adopted ISO 14001 certification at some previous point in the panel period must be omitted from the regressions. Hence, each firm in the sample has at most one observation of ISO 14001 certification. Following this procedure, this research has a final sample of 6,692 observations from 982 firms over 1996-2004.

In the study of assessing the role of ISO14001 EMS in financial performance, it is based on cross-section data during 1996-2004. This

work performs a business performance analysis of 982 listed companies, 332 of which are certified while 650 are not.

1.3 Research Framework

This research first examines the determinants driving Taiwanese firms to seek ISO 14001 certification. Particularly, it analyzes whether export ratio and local governors' party affiliation influence a firm's likelihood of adopting ISO 14001. Next, This study also seeks to understand the current situation of ISO 14001 certification for Taiwanese businesses and to shore up parameters used by academia to assess performance. Additionally, this study uses number of employees, total capital, and operating quota as indicators to measure enterprise size and to assign the firm to a certain industry category and attempts to use static measurements (ROE, ROA, P/E ratio, rate of gross profit) and dynamic measurements (revenue growth rates) to perform statistics analysis. This work performs a business performance analysis of 982 listed companies, 332 of which are certified while 650 are not.

The contents of this dissertation are organized as follows. The principle scheme of research process is shown in Figure 1.

- Chapter 1 introduces the research background, objectives and framework involved in this research.

- Chapter 2 first discusses pertinent literature such as ISO14001 Environmental Management System, international trade, local political competition, certification subsidy, firm attributes, financial performance and then presents different hypotheses.

- Chapter 3 describes determinants of a firm's ISO 14001 certification. The econometric specification, data sources, explanatory variables and the estimation results are provided and discussed in this chapter.

- Chapter 4 assesses the role of ISO14001 EMS in financial performance. Measurement indicators and methods, research objective, research hypothesis, empirical findings and evidence-based discussione are provided in Chapter 4.

- Conclusions and recommended research directions are finally drawn in Chapter 5.

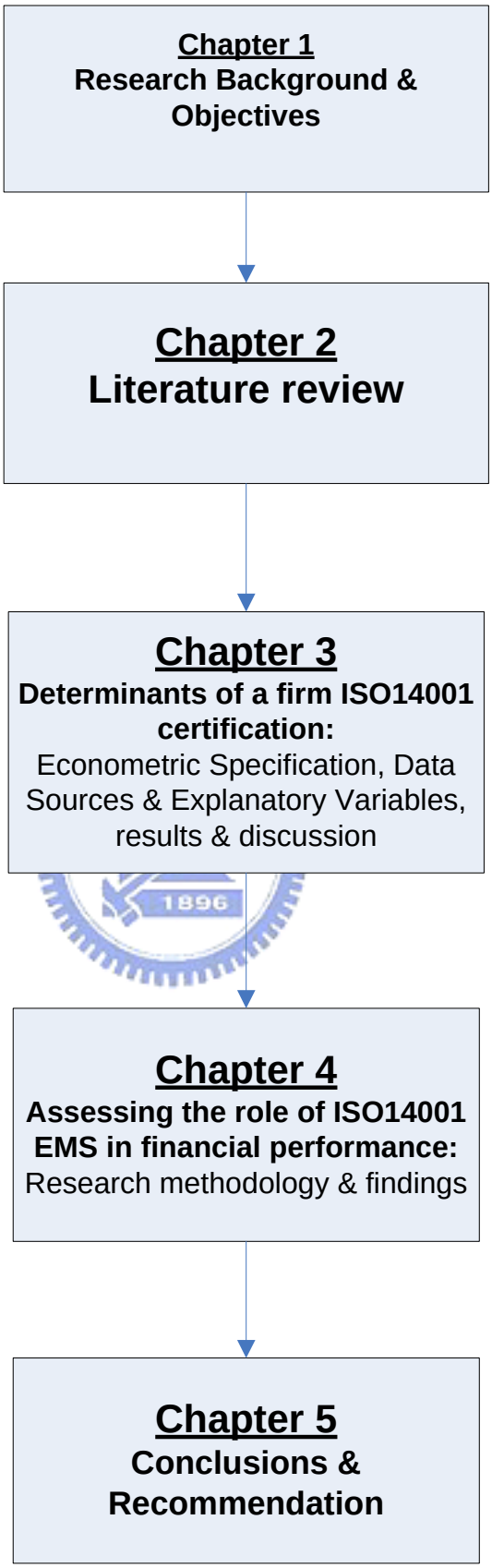

Figure 1: Overview of research process

2. LITERATURE REVIEW

2.1 ISO 14001 Environmental Management System

During 1996, the ISO promulgated the ISO 14001 environmental management system (designed specifically for evaluating organizations) and other related standards (ISO 14004, 14010, 14011, and 14012), with the aim of providing industries with internationally recognized environmental management regulations and a certification standard. In response to the two key U.N. objectives of improving the environment and achieving sustainable development, ISO subsequently also posted environmental assessments of the products of numerous enterprises. Besides methodology and certification provided to firms by the ISO 14001 system, Technical Committee 207 (Environmental Management) focuses on producing environmental evaluations of firms and their products, and standardizing the rules and definitions of Environmental Auditing (EA), Environmental Performance Evaluation (EPE), Life Cycle Assessment (LCA), Environmental Labeling (EL), and Environmental Aspects in Product Standards (EAPS).

The Environmental Management System (EMS) comprises the core of the ISO 14000 family and has the serial number ISO 14001. The system mainly aims to enable environmental conservation via a systemized management program — that is, the system stresses all conservation related matters, enabling management, measurement, improvement, and communication via systematic methodology, and does not address pollution prevention, clean-up technology, or emission standards. However, the system requires enterprises to prevent pollution or operate within the

parameters of sustainable development. ISO 14001 operates based on a voluntary scheme, and provides a new approach to conservation that replaces the command and control system, in which enterprises are led and legally forced by governments to adhere to certain standards. The voluntary scheme enables enterprises to assume responsibility themselves with the expectation that they will inevitably become conscious of the trends and needs of the Twenty-first Century and implement economically sound environmental management plans. Thus, the decision to implement ISO 14001 is voluntary and not binding, unlike the contractual obligations of environmental treaties.

Among the certifications of the ISO 14000 family, ISO 14001 system certification was the earliest to provide official requirements and guidelines for an international standard. ISO 14001 stresses management system, rather than technical pollution emission standard control and pollution testing technology. That is, the essence of the system lies in helping enterprises continually improve their pollution prevention abilities and enhance their environmental performance (Zhang et al., 2000). Accordingly, since promoting certification of the ISO 14000 family, ISO 14001 has increasingly caught the attention of the manufacturing industry along with the ISO 9000 quality management system certification. Certified enterprises have grown rapidly (Montabon et al., 2000; Rezaee, 2000; Chin and Pun, 1999), environmental consciousness is a critical factor in enterprise success, and certification is the only means of sustaining effective business performance (Miles et al., 1999; Magretta, 1997; Hehrt, 1996). Greeno and Robinson (1992) felt that the environmental management activities of enterprises will reduce the environmental impact of enterprise business activities, while

simultaneously enhancing their environmental performance and competitiveness.

Since Taiwan is a major exporting nation, domestic industries fear that once ISO environmental management standards become industry requirement, they will become new trade barriers. However, industrial, political, and academic circles have been actively encouraging industries to promote the establishment and certification of the ISO 14001 system. Based on a survey of ISO 14001-certified enterprises performed by the Federal Environmental Agency in June 1996, the total number of certified Taiwanese enterprises was originally second just behind Japan (Steger 2000). However, since then the numbers of certified Chinese and South Korean enterprises have overtaken the number of such enterprises in Taiwan. In April 2005, certified Taiwanese businesses summed 1,463 out of total 88,800 (see Figure 2), ranking 14th globally in terms of countries with certified enterprises (ISO world, 2005).

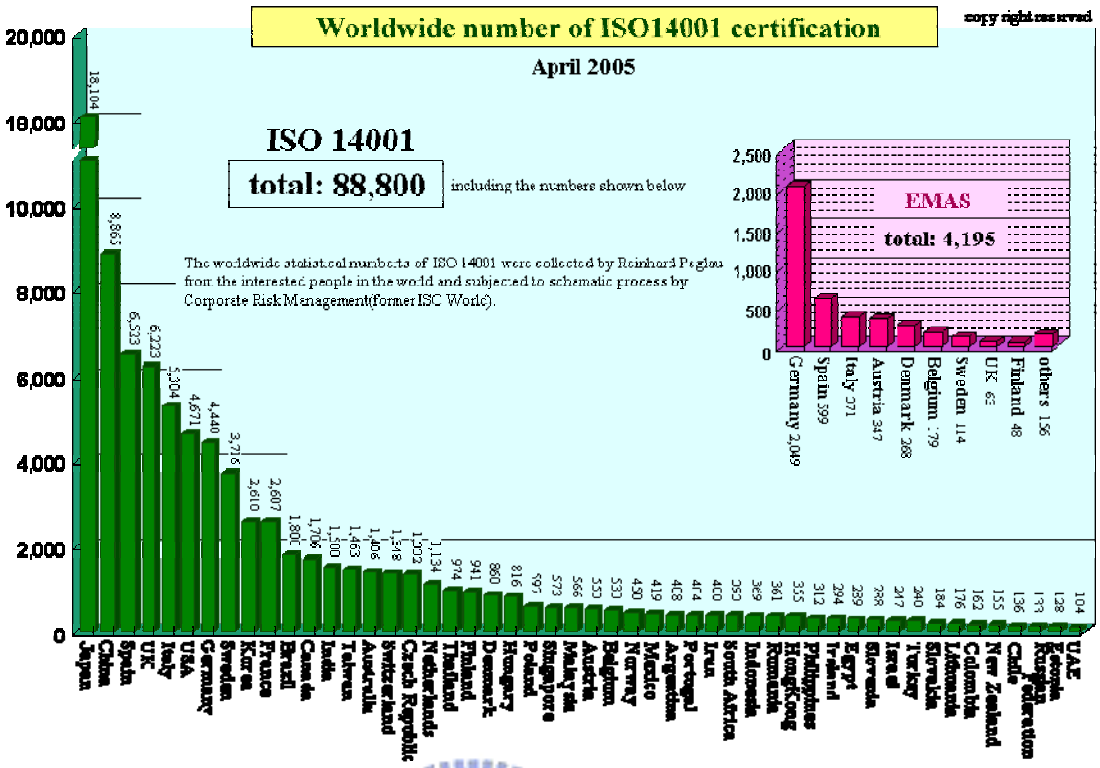

Figure 2: Total no. of ISO 14001-certified enterprises globally

Because ISO 14000 was designed to be compatible with ISO 9000, ISO 9000-certified enterprises can easily adopt ISO 14000. Furthermore, small enterprises can integrate the ISO 9000 and 14000 systems, saving manpower and money, and becoming more efficient. Currently, 10,000 Taiwanese businesses have ISO 9001 certification, while 1,445 have ISO 14001 certification (see Table 1). Table 2 lists the statistics for listed manufacturing enterprises with ISO 14001 certification. Domestic organizations that have received ISO14001 certification are still at the primary stage in the manufacturing industry likewise, other organizations (such as, government organizations, service industries, hospitals, schools, and so on) are still observing developments from the sidelines, or they do have the difficulties to establish the ISO 14001 system in their organizations.

Table 1: No. of Taiwanese ISO 14001-certified enterprises during 1996-2004

Year	Annul No.	Cumulative No.
1996	30	30
1997	80	110
1998	238	348
1999	220	568
2000	181	749
2001	212	961
2002	159	1120
2003	225	1345
2004	100	1445

Source: Taiwan Environmental Management Association/Organized by Industrial Development Bureau, MOEA, May 2005.

Table 2: Annual no. of enterprises that have gained ISO 14001 certification

Year	Annual No.	Cumulative No.
1996	15	15
1997	22	37
1998	35	72
1999	27	99
2000	25	124
2001	35	159
2002	32	191
2003	149	340
2004	29	369

Source: Organized by this investigation

2.2 International Trade

Reduced barriers to trade and foreign direct investment have increased globalization. Consequently, some are concerned that countries with lax environmental regulations might become pollution havens for pollution-intensive industries in a global economy with cross-country differences in environmental regulations. For example, opponents of the World Trade Organization contend that multinational firms relocate to low-income countries, whose people are so eager for jobs that their environmental regulations are weak (Dasgupta et al., 2002). Moreover, developing countries may sacrifice their environmental quality to reduce the production costs of their pollution-intensive products and to raise competitiveness of their products in foreign markets.

Taiwanese firms play an important role in the global supply chains of manufacturing, with an extensive customer base in Europe, Japan, and North America. Since these customers place a high priority on environmental protection, Taiwanese firms face direct pressures from their dominant and definitive stakeholders (Jiang and Bansal, 2003), in the form of supply chain pressure from multinational enterprises such as HP, IBM and Ford. For example, firms such as Ford, General Motors, Volvo, Toyota, and Siemens require that all or some of their suppliers be ISO 14001 certificated. Therefore, seeking ISO 14001 certification has become a key priority for Taiwanese firms because such a certification represents a green passport to the Europe and North American markets, and the lack of such certification can lead to the loss of important business opportunities (Bansal and Bogner, 2002).

Moreover, multinational customers may require their suppliers to obtain ISO 14001 certification because it is more practical than monitoring the environmental performance of their suppliers directly (Christmann and Taylor, 2001). Consequently, firms in many export-oriented Asian countries are rushing to implement ISO 14000 certification (Roht-Arriaza, 1997). A study of China-based businesses reveals broad-based empirical support for export-oriented incentives (Christmann and Taylor, 2001). Jiang and Bansal (2003) also indicate that ISO 14001 is conceived and used as a communication tool and thus increases exchange legitimacy (Suchman, 1995). Although environmental requirements vary among countries, the developed countries including the EU, Japan and the US generally demand a higher environmental standard for imported products. Therefore, this research proposes that firms with higher ratios of products exported to the EU, Japan and the US are more likely to seek ISO 14001 certification than those with lower export ratios.

2.3 Local Political Competition

The literature on environmental federalism argues that local governments may compete to attract business investment and create new jobs by setting lower local environmental standards (Jaffe et a., 1995). Local governments may race to the bottom if the central government does not impose stricter regulations on environmental standards. In contrast, economists also suggest that local policymakers would tailor policies to the

preferences of their constituents. Evidence also exists of a real and substantial response at the state and local levels comprising various programs for improving environmental quality in response to public concern (Oates, 2001).

In 1996, the then ruling Kuomintang (KMT) county magistrate approved the plan of the German chemical and pharmaceutical giant Bayer to establish a giant TDI (Toluylendiisocyanat) plant in Taichung, located in central Taiwan. This factory was to produce 100,000 metric tons of TDI annually, making it the second biggest TDI producer in the world. This investment plan was controversial, with resistance primarily being led by the opposition Democratic Progressive Party (DPP), which organized demonstrations involving up to 4,000 residents of the area around the proposed plant site. The main concern was the threat of phosgene, a poisonous by-product of TDI production, which was used as a chemical weapon during World War I.

The new Taichung county magistrate from the DPP was elected in late 1997, and announced a delay in issuing establishment permits pending a local referendum scheduled for June 1998. Consequentially, Bayer officially cancelled its investment plan in Taiwan in March 1998, and eventually relocated the facility to Texas, although it had obtained approval from the central government and had been negotiating with the local government for four years to proceed with the project in Taiwan (The New York Times, March 19, 1998).

The Bayer incident demonstrated that local governments may advocate more environmentally friendly policies to compete for votes. Since ISO

14001 is perceived to be a valuable environmental protection tool, it provides firms a systematic approach to environmental issues and demonstrates the commitment and performance of firm management to interested parties. ISO 14001 certification can further enhance firm identity and image as environmentally responsible and help minimize potential hazards associated with local government environmental policies. In Taiwan, the DPP mayors or local government magistrates are generally believed to enforce more stringent environmental protection than their KMT counterparts. ISO 14001 certification can protect firms from challenges to their environmental reputation by special interest groups, and thus firms located in the jurisdictions of DPP local governors are expected to be more likely to adopt ISO 14001 certification.

Although the investigation on the relationship between local governors' party affiliation and ISO certification does not provide a test of a race to the bottom, it provides evidence on whether firms adjust their environmental strategies in response to the demand from various local policymakers. As noted above, local policymakers may choose different environmental standards to promote the well-being of their residents or to seek re-election. Therefore, if firm decisions on ISO 14001 certification are affected by local governors' party affiliation, it implies that local standards for environmental quality or local policymakers' attitude toward environmental hazards can influence the firms' environmental protection.

2.4 Certification Subsidy

The Taiwanese government began to promote various programs for improving the environmental performance of industry during the mid 1980s. Notably, the Environmental Protection Administration (EPA) was established to develop and enforce environmental regulations, and the Industrial Development Bureau (IDB) of the Ministry of Economic Affairs (MOEA) was assigned the task of designing appropriate technologies, and providing technical assistance and financial incentives to industries practicing appropriate environmental management. IDB promoted ISO 14001 EMS using a financial subsidy approach. Firms paired with registered technical assistance providers can apply for subsidies to cover 40% to 60% of the cost of preparing ISO certification, up to a maximum of US$16,000 per case over 1996-2000 and up to a maximum of US$6,000 per case since 2001. The government budgets appropriated for subsidizing ISO certification were US$277K, US$267K, US$243K, US$173K, US$207K, US$257K, US$143K, US$170K and US$147K for the years ranging from 1996-2004, respectively (Source: Taiwan Environment Management Association). The exchange rate over this period was around NT$30 per US dollar.

Preparation and implementation costs range between US$10,000 and US$128,000 (Freeman, 1997) and can represent a barrier to ISO certification for firms with little cash flow. With financial incentives provided by the government, firms can not only save on implementation costs, but can also reduce uncertainty regarding the future value of the standard. A subsidy has been proposed to promote firm activities with risks or firm activities

producing public goods. For example, many countries adopt tax-based subsidies to stimulate R&D expenditures (Hall and Van Reenen, 2000). This government sharing of the risk of implementing environmental standards has increased firm motivation to obtain their ISO 14001 EMS. As of the end of 2004, 305 firms receiving subsidies from IDB had already received ISO 14001 certification (IDB, 2004). Firms receiving government subsidies for implementing ISO 14001 EMS are thus believed to have more incentive to seek ISO 14001 certification than those receiving no subsidies.

2.5 Firm Attributes

We also account for firm-level determinants in analyzing firm decision to adopt ISO 14001 certification. These variables include firm size, profitability, debt ratio, R&D expenditure, and location, which are discussed below.

Previous studies indicate that firm size positively influences environmental performance (Hartman, Huq and Wheeler, 1997) owing to economies of scale in pollution control equipment. Nakamura et al. (2001) indicate that certification involves significant fixed costs, which are less significant for larger organizations as compared to smaller ones. Hence, the larger a facility, the greater the potential for spreading these fixed costs across the operation (King and Lenox, 2001).

The costs of ISO 14001 implementation depend on facility size and the sophistication of the environmental management system, and range between US$10,000 and US$128,000 (Freeman, 1997). Additionally, the certified firm needs to bear annual maintenance costs of US$5,000 to US$10,000. Developing, certifying and maintaining ISO 14001 EMS can represent a significant expense for non-profitable firms with high debt ratios and consequently profitable firms are more likely to see it as a useful investment (Aragon-Correa, 1998; Clark, 1999). However, the ISO scheme also represents a way for less competitive firms to seek an advantage over more competitive rivals by playing upon the public image it generates (Chapple et al., 2001). Notably, Chapple et al. (2001) find that less profitable firms were more likely to seek ISO 14001 than profitable firms and contended that they are looking to gaining a competitive advantage through non-price competition focused on environmental quality.

Debt ratio influences capital costs and financial flexibility (Nakamura et al., 2001). Although firms with low debt ratios are expected to have more flexibility to finance new environmental programs, this proposition is less certain since debt ratio may reflect firm financial strategies adopted to reduce tax burden (Nakamura et al., 2001).

Firms are gradually acknowledging eco-efficiency as one of the major challenges in R&D practice in product innovation (Noci and Verganti, 1999). Previous studies on environmental compliance costs have traditionally focused on static cost impacts and ignored the importance of offsetting productivity benefits from innovation. In contrast, innovative solutions and

significant R&D investment can create win-win solutions for environmental problems and productivity improvement (Porter and van der Linde, 1995a). Empirical evidence also indicates that environmental innovation is more likely to occur in internationally competitive industries (Brunnermeier and Cohen, 2003). Konar and Cohen (2001) find that improved environmental performance boosts firm asset value. Firms may voluntarily seek environmental compliance as well as R&D activities to pursue higher profitability. This is particularly appropriate for firms with high R&D investment which are more likely to obtain technological solutions for their environmental problems and thus find it easier to implement the ISO standard (Nakamura et al., 2001). Established in 1980, the Hsinchu Science-based Industrial Park (HSIP) was the first science park of its kind in Taiwan. With the mission of establishing a high quality R&D base for the high-tech industry, HSIP firms enjoy investment privileges and benefits courtesy of government agencies, including preferential tax treatment, lower utility and land costs, and R&D subsidies. However, the environmental activities of HSIP firms, including pollution control plan implementation, air pollutant emissions management, and wastewater inspection are monitored more intensively by interested parties including neighboring communities, government agencies, environmental groups, and the mass media. Bansal and Bogner (2002) state that the ISO 14001 standard provides an acceptable signal, which conforms to the expectations of various stakeholders because it is externally endorsed, and requires extensive documentation. Firms with the ISO 14001 standard can thus help to establish trust and long-term relationships with stakeholders and deflect the scrutiny and interest of watchdog agencies and interest groups.

2.6 Financial Performance

The usage scope of the ISO 14001 system is such that the system standard requirements are applicable only to those environmental aspects that can be effectively controlled by the organization; the system does not assert any specific principles regarding effective environmental management. ISO 14001 and 14004 standards are simply used to assist organizations in establishing their own management systems, not to force on them regulations to achieve certain objectives. Increasing numbers of enterprises are attempting to become ISO 14001-certified of their own accord and are even requesting that suppliers become certified within certain time periods. ISO 14001 has become a key tool for assessing supplier environmental performance (Miles et al., 1997, Miles et al., 1999, Mohamed, 2001). Tibor and Feldman (1996) felt that companies, following having pushed for ISO 14001 certification, have increased their awareness of environmental issues; became more actively involved in environmental management activities, improved their environmental performance, and are more knowledgeable about conducting life cycle analyses and procuring environmentally friendly products. The research of Nakamura et al. (2001) demonstrated that enterprise ISO 14001 certification influences their consumption and procurement of products made from natural resources, such as petroleum products, water, and paper products.

Numerous scholars, both in Taiwan and abroad, hold markedly different views regarding the relationship between the environmental and financial

performance of enterprises. Some of them feel that good environmental performance positively influences financial performance. However, others are suspicious of this belief or even posit contradictory theories. Owing to different research themes and the difficulty of balancing environmental and financial performance, the results of different studies differ markedly.

Allen (1992) and Schmidheiny (1992) believed that the environmental performance resulting from promoting environmental activities can actually reduce product costs and waste, and enhance enterprise financial performance. Moreover, enterprise environmental performance can improve profitability (Bragdon and Marlin, 1972; Spicer, 1978) and reduce environmental risk (Spicer, 1978); environmental activities improve enterprise environmental performance (Moskowitz, 1972; Parket and Eilbirt, 1975; Sturdiva nt and Ginter, 1977; Arolow and Gannon, 1982; Capon et al., 1990). Furthermore, a positive relationship exists between environmental and financial performance (Bragdon and Marlin, 1972). Enterprises that are active in environmental management can significantly improve their environmental performance and upgrade their financial performance (Callan and Thomas, 1996; Ilinitch et al., 1998; Wen and Chen, 1998; An Baoyi, Xu Mulan, Liu Zhongju, 1999; Chin and Pun, 1999; Shi Lixing, Huang Fenghui, Gun Meixiu, 2000; Steger, 2000). The study of Cohen et al. (1995) demonstrated that among large enterprises in the U.S., those with superior environmental performance generally also have good financial performance. However, Nehrt (1996, 1998) observed that large enterprises that lead in terms of environmental innovation are typically the fastest way to achieve financial performance.

On the other hand, some scholars maintain that enterprise social responsibilities and financial performance are antithetical (Carter et al., 2000). Vance (1975) and Ullman (1985) both felt that environmental investments increased enterprise production costs and negatively impacted financial performance. Most of the researchers believed that introducing environmental activities into enterprise business operations negatively influences their financial performance (Freeman, 1994; Judge and Hema, 1994). Moreover, Walley and Whitehead (1994) demonstrated that enterprises generally believe that pushing for environmental-related measures and abiding by related laws and regulations will increase operating costs and negatively impact profitability. Cost increases result from the internalization of costs that were previously external, for example assuming the costs of air pollution (Bragdon and Marlin, 1972; Klassen and McLaughlin, 1996). The research of Jaggi and Freedman (1992) demonstrated that enterprises investing in pollution prevention equipment do not improve their financial performance—that is, no positive relationship exists between environmental and financial performance.

Additionally, some scholars feel that no relationship exists between enterprise social responsibilities and financial performance (Alexander and Buchholz, 1978; Abbot and Monsen, 1979). Additionally, no noticeable differential relationship necessarily exists between enterprise environmental disclosure activities and financial performance (Freedman and Jaggi, 1982; Wiseman, 1982), and nor is their any noticeable difference between enterprise environmental performance and profitability (Fogler and Nutt, 1975; Rockness et al., 1986). Mahaptra (1984) demonstrated that

companies which invest heavily in pollution clean-up are not guaranteed a good environmental performance. Jaggi (1993) felt for businesses that invest in pollution prevention and clean-up equipment, such a move is merely a temporary measure to avoid violating government regulations. Additionally, in the present case, the relationship between environmental and financial performance becomes negative. Conversely, if enterprises make a long-term investment in pollution prevention and clean-up equipment, this equipment will boost their market performance, representing a positive relationship between environmental and financial performance.

In synthesizing the above sources, owing to disparities in research subjects and methods, there is obviously still no overarching theory regarding the relationship between environmental and financial performance. This study analyzes the basic characteristics and financial performances of ISO 14001-certified and uncertified Taiwanese listed enterprises based on the research of scholars regarding ISO 14001 environmental management. Regarding an evaluation standard for measuring performance, the Taiwanese stock market breaks down enterprise finances into five categories: profitability, cash flow, ability to pay debt, capital debt management and growth capabilities. These indicators comprise the evaluation system applied to the finances of listed companies. In assessing enterprise financial performance, the business performance, cash flow, and financial circumstances reflect the profitability of that enterprise, and the enterprise goals and demands must be kept in mind when performing financial ratio analysis. Enterprise performance is defined as the degree to which the enterprise has satisfied its objective(s), and the resource use situation facing

the enterprise, which respectively indicate enterprise effectiveness and efficiency. Katzell (1975) proposed that the scope of efficiency is rather large, and includes performance, productivity, and profitability. Numerous scholars believe that financial performance is influenced by manufacturing performance, product effectiveness, and market conditions (Myers & Marquis,1969; Cooper,1979; Cooper & Kleinschmidt,1987; Zirger & Maidique, 1990).

Although Chakravarthy (1986) found evidence that methodology using profitability as a measure of performance does not accurately determine whether the operations of an enterprise are superior or not, numerous scholars still use financial indicators such as the 14 commonly used measurement parameters identified by Cooper et al. (1986): investment return rates, sales quota return rates, sales income growth rates, cash flow, and investment/market share rates, comparative product quality of competitors, comparative promotions of new products by competitors, comparative direct production costs of competitors, product R&D, manufacturing R&D, differences in return on investment (ROI), changes in ratio of ROI, and cash flow/investment ratio changes. Cooper et al. felt that although measures of profitability are limited, they are still important indicators of performance. Bettis and Mahajan (1985) use the ratio of profitability (namely, the average of capital return rate for the past five years) to risk (namely, shortages in capital return rate for the past five years) to measure organization performance. Ranftl (1979) defined productivity as the ratio of investment to output, that is, using organization resources to effectively produce. Research indicates that financial ratio information is

clearly related to assessments of financial performance; however, past measurement indicators are based on financial indicators such as the definitions of Cohen, Fenn, and Naimon (1995) regarding accounting return rates, the view of Jaggi and Freedman (1992) and Cohen, Fenn, and Naimon (1995) regarding stock market performance, the suggestions of Jaggi and Freedman (1992) to use P/E ratio to measure stock market performance, and the four indicators used by Fullerton and McWitters (2001) in their research on the influences of enterprise financial performance (namely, EBIT, ROA, ROS, and cash flow). Bragdon and Marlin (1972) used EPS, ROE, and ROI as financial indicators to research the relationship between firm environmental and financial performance.

3. DETERMINANTS OF A FIRM'S ISO 14001 CERTIFICATION

3.1 Specification

This study follows previous empirical studies on transition decisions, such as the transition from being employed to self-employment (Bruce, 2000), in developing an empirical strategy to estimate the determinants of firm decision to adopt ISO 14001 certification. Specifically, the econometric specification is defined as follows:

$$P(y_{it} = 1 \mid \mathbf{X}_{it}) = \Phi(\eta_i + \mathbf{X}_{it}\tilde{\beta}),$$

where the dependent variable, y_{it}, equals 1 if firm i obtains ISO 14001 certification at time t, and 0 if firm i remains uncertified. The $\mathbf{X}_{it}$ denotes a vector of variables including export ratio, political party affiliation of local governors, government subsides to certification, firm size, profitability, debt ratio, R&D expenditure, location and other control variables. Meanwhile, Φ represents the cumulative probability of a normal distribution and an empirical specification for the above equation is a random-effects probit. The maximum likelihood estimates for the firm-specific effects η_i and $\tilde{\beta}$ are inconsistent.

As noted above, we can analyze a firm's transition from being non-certified to certified by utilizing panel data. Moreover, estimations based

on panel data can ameliorate the endogeneity problem because firm-specific effects can be controlled for and observations from different years can increase variable variations.

3.2 Data Sources

The estimations used in this study are based on the Taiwan Stock Exchange and Over-the-Counter sample drawn from the Taiwan Economic Journal (TEJ) Data Bank. The data bank includes firms from the cement, food, plastics, textiles, machinery, electrical appliances, chemical, glass and ceramics, paper and pulp, metals, rubber, automobile and electronics industries. The final sample is comprised of a total of 332 ISO 14001-certified firms and 650 non-certified firms from 13 industries over the period of 1996-2004, after some firms were excluded due to missing or outlier values. When the panel period is short (Chamberlain, 1980), on the other hand, the conditional fixed-effects estimations will exclude the firms without transition during the panel period and limit the regressions to the 332 certified firms. Therefore, we do not estimate the fixed-effects model in this study. The observations with sales less than NT$100,000 are omitted from regressions. Nevertheless, we also utilize the whole sample to estimate the coefficients and find no significant changes in estimates.

This study is based on random effects estimations of panel data over 1996-2004. In order to investigate the factors leading a firm to become certified, firms which have adopted ISO 14001 certification at some

previous point in the panel period must be omitted from the regressions. For example, if a firm adopted ISO 14001 certification in 2000, this firm's observations over 2001-2004 would be omitted from the regressions, leaving only the firm's observations over the 1996-2000 period for regressions. Hence, each firm in the sample has at most one observation of ISO 14001 certification. Following this procedure, we have a final sample of 6,692 observations from 982 firms over 1996-2004.

In particular, we obtain the list of ISO 14001-certified firms from the Taiwan Environmental Management Association. Since this study empirically examines various factors leading Taiwanese manufacturers to obtain ISO 14001 certification, several sources of published data have been used to measure these economic and political variables. Firm-specific financial and economic information was primarily gathered from the TEJ Data Bank and also from the Taiwan Stock Outlook published by Wealth Magazine. Information on subsidies for ISO 14001 EMS has been obtained from the websites of the Chinese National Accreditation Board (The Chinese National Accreditation Board has been transformed into the Taiwan Accreditation Foundation since 2004.), Taiwan Environmental Management Association, Bureau of Standards, Metrology and Inspection of Ministry of Economic Affairs (MOEA) and the Foundation of Taiwanese Industry Service. Meanwhile, the information of firms located in HSIP is obtained from the Administration of the Hsinchu Scientific Industrial Park. Moreover, the Central Election Committee provided the names and political affiliations of elected magistrates/mayors; while the Ministry of Interior web

site was the source for information on the regional administrative jurisdictions of elected magistrates/mayors.

3.3 Variable Measurement

The dependent variable in this study is the binary variable, ISO certification, which represents whether a firm becomes ISO certified or not. ISO certification is based on the unit of plants or sites instead of a firm. Given that only firm-level instead of plant-level information is available, ISO certification is coded 1 for firms adopting ISO 14001 certification for at least one plant or site, and 0 otherwise. Among the 332 certified firms in the sample, only 20 firms have adopted ISO 14001 certification for more than one plant or site. Therefore, we do not distinguish the firms with more than one plant or site from those with only one plant or site in the regressions.

For each of the sample firms, firm-specific variables are defined below. Export ratio represents the percentage contribution of exports to total sales revenue. However, the pressure from multinational customers may vary with destination markets. To account for this variation, this study classifies the destination markets into two groups, one with a higher environmental standard for imports while the other has a lower standard. Although no unique criterion was used for the categorization, developed countries are generally believed to require a higher environmental standard for production activities. The EU, Japan and the U.S thus comprise the higher standard group. This study then weights each firm's export ratio by using the ratio of exports in the

firm's industry accounted for by the higher standard group. This study calculates these ratios for each industry utilizing the trade statistics from the governments.

The dummy variable DPP governor indicates the party affiliation of local governors, and is coded as 1 if the county magistrate or city mayor for the jurisdiction where the firm's certified sites or main sites are located is a member of the DPP, and 0 if they are a member of some other political party. Furthermore, Subsidy, a binary dummy variable, is coded 1 for certified firms that received government subsidies to offset the costs of implementing ISO 14001, and 0 otherwise. The government reduced the maximum amount of subsidy to ISO 14001 certification from a previous amount of US$16,000 to $6,000 since 2001. This exogenous policy change provides a natural experiment for investigating whether the government's smaller subsidy would reduce a firm's decision to become ISO certified. Therefore, we include in the regressions the variable of Subsidy since 2001, which equals 1 if a firm received any subsidies over 2001-2004.

Asset denotes the logarithm of a firm's assets and is used as a proxy for firm size. Firm profitability, Profitability, is calculated as the ratio of firm before-tax profits to total sales revenue for the current year. Previous studies have used an averaged measure to account for the volatility in profitability from year to year (Chu et al., 2005). Hence, this study also presents the estimation results based on a 4-year average profitability. To assess whether the estimates are affected by different measures of profitability, this study also utilizes return on asset and return on equity to estimate the effect of profit on

ISO 14001 adoption. Returns on assets are based only on current year data. Meanwhile, firm financial structure, Debt ratio, represents the ratio of current debts to total assets. Additionally, R&D, a proxy for relative size of firm knowledge capital, is calculated as firm R&D expenditure divided by total sales revenue. HSIP is a dummy variable used to indicate whether a firm is located in the Hsinchu Science-based Industrial Park (HSIP). HSIP is coded 1 if the firm is located in the HSIP, and 0 otherwise.

The regressions also include various control variables. This study investigates whether firms with different durations may have different likelihoods of implementing ISO 14001 EMS. Firm age is defined as the number of years between its establishment and 2004. Urban-rural disparity and income inequality exist among geographical regions and thus residents' demand for environmental standards may vary. Therefore, it is necessary to control for possible effects owing to firms' location in urban or county areas. Urban represents a binary dummy and is coded 1 if the firm's main sites are located in any one of the seven urban areas in Taiwan (Taipei-Keelung, Kaohsiung, Taichung-Changhua, Jhongli-Taoyuan, Tainan, Hsinchu and Chiayi), and 0 otherwise.

Industrial pollution characteristics influence the propensity of companies to seek ISO 14001 certification. Firms in highly polluting industries or those with older technologies frequently are involved in a constant battle to reduce emissions incrementally to match increasingly stringent environmental regulations (Bansal, 2002). ISO 14001 certification should provide firms increased latitude to deal with regulators. Because the plastics industry is

generally believed to be one of the most polluted industries, it serves as the baseline industry in this study and dummies for the other 12 industries are included to control for the industry effects in the estimations. Additionally, we also include year dummies in the regressions to control for the year effects.

Table 3 lists the summary statistics for the final sample of 6,692 observations (see Apendix 1) from 982 firms and the subsample of certified firms. As noted above, among the sample of 982 firms, 332 firms have obtained ISO 14001 certification, comprising 5% of the total observations.

Table 3 indicates that the average export ratio is 0.427. This high export ratio supports the observation that the output of Taiwan is heavily export-oriented. To explain varying pressure from customers in different destination countries, this study categorizes export destinations into two groups, among which the EU, Japan and the US represent the countries requiring higher environmental standards for imports. The average weighted ratio of exports to the EU, Japan and the US equals 0.170. The firms located in the jurisdiction of DPP local governors and receiving subsidies for ISO 14001 certification comprise 61.9% and 1% of the total observations.

The average ratio of before-tax profit to sales equals 0.026 while the average ratio of return on asset and the average ratio of return on equity equal 0.1 and 0.096. The four-year average ratio of profit to sales equals 0.014, which is below the profitability for the current year and indicates that firms made smaller profits or incurred losses in the earlier years of the panel period.

The average values of debt ratio and R&D ratio equal 0.407 and 0.046, respectively. The mean value of R&D ratio equals 0.046 and suggests that most Taiwanese firms allocated limited budgets to R&D. The average length of firm establishment is 23 years. Most of the sampled firms' factories are located in urban areas while most of the sampled firms are in the electronics industry.

The certified firms generally have higher mean values of weighted export, asset, and age than other observations. Compared to The whole sample, they also have higher percentages of firms receiving subsidy, and located in HSIP. A high ratio of certified firms became certified in 2003. In contrast, the percentages of certified firms located in jurisdictions of DPP governors and urban areas are lower than the other observations. It is also noteworthy that the four-year average ratio of profit to sale is negative for the certified firms and its variation is quite large.

Table 3: Descriptive statistics

	The whole sample				The certified firms			
Variables	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.
Binary dependent								
ISO certification	0.050	0.217	0	1	1	0	1	1
Explanatory variables								
Export ratio	0.427	0.334	0	1	0.526	0.316	0	1
Weighted export ratio	0.170	0.147	0	0.68	0.198	0.136	0	0.51
DPP governor	0.619	0.486	0	1	0.572	0.495	0	1
Subsidy	0.010	0.100	0	1	0.184	0.338	0	1
Subsidy since 2001	0.006	0.078	0	1	0.111	0.315	0	1
Asset (in logarithm)	14.412	1.306	9.14	19.99	15.441	1.343	12.55	19.61
Profitability								
Current year ratio of profit to sales	0.026	0.463	-9.66	4.12	0.044	0.366	-5.87	0.48
4-year averaged ratio of profit to sales	0.014	0.376	-4.97	2.55	0.048	0.191	-1.68	0.48
Current year return on asset	0.100	0.120	-1.16	1.15	0.098	0.103	-0.53	0.45
Current year return on equity	0.096	0.302	-8.88	1.64	0.090	0.181	-1.12	0.61
Debt ratio	0.407	0.170	0	1.08	0.407	0.141	0.04	0.88
R&D	0.046	0.232	0	9.90	0.047	0.328	0	5.97
HSIP (Science Park)	0.091	0.287	0	1	0.123	0.330	0	1
Control variables								
Age (years)	22.854	12.177	1	65	28.849	13.903	2	65
Urban	0.816	0.387	0	1	0.792	0.406	0	1
Industry dummies								
Cement	0.008	0.091	0	1	0.006	0.077	0	1
Food	0.024	0.154	0	1	0.009	0.095	0	1
Plastics	0.033	0.179	0	1	0.039	0.194	0	1
Textiles	0.071	0.259	0	1	0.060	0.238	0	1
Machinery	0.063	0.243	0	1	0.081	0.274	0	1
Electrical appliance	0.015	0.121	0	1	0.024	0.153	0	1
Chemical	0.079	0.269	0	1	0.045	0.208	0	1
Glass & Ceramics	0.007	0.084	0	1	0.009	0.095	0	1
Paper & Pulp	0.006	0.077	0	1	0.012	0.109	0	1
Metals	0.037	0.188	0	1	0.051	0.221	0	1

Rubber	0.010	0.101	0	1	0.024	0.154	0	1
Automobile	0.003	0.052	0	1	0.015	0.485	0	1
Electronics	0.644	0.479	0	1	0.623	0.485	0	1
Year effect								
1996	0.085	0.279	0	1	0.042	0.201	0	1
1997	0.098	0.298	0	1	0.054	0.227	0	1
1998	0.112	0.315	0	1	0.102	0.304	0	1
1999	0.118	0.322	0	1	0.087	0.283	0	1
2000	0.122	0.327	0	1	0.060	0.238	0	1
2001	0.124	0.329	0	1	0.105	0.308	0	1
2002	0.123	0.328	0	1	0.102	0.304	0	1
2003	0.119	0.324	0	1	0.398	0.490	0	1
2004	0.099	0.299	0	1	0.048	0.214	0	1
Observations	6,692				332			

Notes:

1. A firm's weighted export ratio is obtained by weighting the firm's export ratio by the share of its industry products exported to the EU, Japan and the US.

2. The statistics for a 4-year averaged ratio of profit to sales are based on a subsample of 6,627 observations after observations with larger losses are excluded.

We also provide the summary statistics for each of the six industries with observations more than 200 in Table 4. Table 4 shows that the percentages of certified firms are similar among the six reported industries. The machinery industry and the electronics industry have higher ratios of export while the chemical industry exports a smaller proportion of its products. A higher percentage of firms in the machinery industry receive government subsidy. The firms in the chemical industry and the metals industry adopted ISO 14001 certification in the earlier years of the panel period while the firms in the plastics industry adopted it in the later years of the panel period. Since the HSIP was established to encourage high-tech firms' investment, only firms in the chemical industry and the electronics industry are located in the HSIP. Moreover, the firms in the industry have a shorter period of establishment than those in other industries.

Table 4: Descriptive statistics by industry

	The plastics industry				The textile industry			
Variables	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.
Binary dependent								
ISO certification	0.058	0.235	0	1	0.042	0.201	0	1
Explanatory variables								
Export ratio	0.324	0.242	0	0.94	0.412	0.287	0	1
Weighted export ratio	0.091	0.067	0	0.28	0.105	0.074	0	0.27
DPP governor	0.700	0.459	0	1	0.557	0.497	0	1
Subsidy	0.009	0.094	0	1	0.008	0.092	0	1
Subsidy since 2001	0.009	0.094	0	1	0.004	0.065	0	1
Asset (in logarithm)	14.91	1.504	12.58	19.61	14.92	1.060	12.44	18.16
Profitability								
Current year ratio of	0.037	0.215	-2.47	0.47	-0.012	0.194	-1.68	-/41
4-year averaged ratio	0.043	0.148	-0.99	0.46	0.004	0.136	-0.93	0.35
Current year return	0.077	0.064	-0.17	0.26	0.056	0.075	-0.24	0.31
Current year return	0.053	0.144	-1.48	0.32	0.014	0.146	-0.67	0.42
Debt ratio	0.367	0.149	0.09	0.90	0.411	0.169	0.08	0.88
R&D	0.007	0.011	0	0.06	0.004	0.006	0	0.03
HSIP (Science Park)	0	0	0	0	0	0	0	0
Control variables								
Age (years)	30.38	9.896	12	61	31.25	9.842	13	61
Urban	0.663	0.474	0	1	0.667	0.472	0	1
Observations	223				474			
	The machinery industry				The chemical industry			
Binary dependent								
ISO certification	0.064	0.245	0	1	0.029	0.167	0	1
Explanatory variables								
Export ratio	0.510	0.345	0	1	0.274	0.303	0	1
Weighted export ratio	0.280	0.192	0	0.68	0.048	0.053	0	0.20
DPP governor	0.569	0.496	0	1	0.612	0.488	0	1
Subsidy	0.026	0.159	0	1	0.006	0.075	0	1
Subsidy since 2001	0.024	0.152	0	1	0	0	0	0
Asset (in logarithm)	14.36	0.842	12.29	17.26	14.12	0.012	0.11	0.18
Profitability								
Current year ratio of	0.073	0.130	-1.10	0.47	0.010	0.661	-8.73	2.15
4-year averaged ratio	0.074	0.096	-0.38	0.37	0.012	0.443	-4.20	1.15

Current year return	0.106	0.087	-0.30	0.58	0.097	0.101	-0.58	0.61
Current year return	0.106	0.124	-0.53	0.68	0.052	0.702	-8.88	1.18
Debt ratio	0.451	0.143	0.09	0.84	0.379	0.178	0.02	1.08
R&D	0.022	0.017	0	0.12	0.064	0.393	0	7.80
HSIP (Science Park)	0	0	0	0	0.036	0.187	0	1
Control variables								
Age (years)	27.31	10.17	7	60	29.94	14.00	4	61
Urban	0.718	0.451	0	1	0.643	0.480	0	1
Observations	422				526			
	The metals industry				The electronics industry			
Binary dependent								
ISO certification	0.069	0.254	0	1	0.048	0.214	0	1
Explanatory variables								
Export ratio	0.293	0.295	0	0.99	0.483	0.334	0	1
Weighted export ratio	0.131	0.134	0	0.49	0.199	0.143	0	0.50
DPP governor	0.772	0.420	0	1	0.626	0.484	0	1
Subsidy	0.008	0.090	0	1	0.008	0.091	0	1
Subsidy since 2001	0	0	0	0	0.006	0.077	0	1
Asset (in logarithm)	15.22	1.117	12.4	19.12	14.19	1.301	9.14	19.99
Profitability								
Current year ratio of	0.008	0.137	-1.20	0.36	0.031	0.501	-9.66	4.12
4-year averaged ratio	0.003	0.085	-0.57	0.20	0.008	0.431	-4.97	2.55
Current year return	0.064	0.068	-0.27	0.32	0.114	0.134	-1.16	1.15
Current year return	0.039	0.127	-0.49	0.48	0.124	0.264	-8.88	1.64
Debt ratio	0.513	0.134	0.12	0.79	0.402	0.174	0.02	1.04
R&D	0.002	0.005	0	0.03	0.060	0.253	0	9.90
HSIP (Science Park)	0	0	0	0	0.135	0.342	0	1
Control variables								
Age (years)	29.00	9.422	8	45	17.99	9.337	1	65
Urban	0.622	0.486	0	1	0.910	0.286	0	1
Observations	246				4,308			

Notes:

1. To save space, we report the summary statistics for only the industries with more than 200 observations.

2. A firm's weighted export ratios is obtained by weighting the firm's export ratio by the share of its industry products exported to the EU, Japan and the US.

3.4 Results and Discussion

Table 5 lists the estimates from the random effects probit model. The estimates in columns (1)-(4) are from regressions utilizing different measures of profitability, namely ratio of profit to sales, four-year averaged ratio of profit to sales, return on asset and return on equity. The estimates in column (5) are from a regression based on the observations for the electronics industry. Table 5 indicates that ISO 14001 certification is significantly correlated to export ratio, subsidy, firm size, R&D, and location in HSIP. Moreover, age and location in urban areas are found to influence a firm's decision to adopt ISO 14001 certification. In contrast, profitability, debt and most of the industry dummies exhibit no statistically significant correlation in the probit equation.

The coefficient estimate of export ratio supports the hypothesis that firms with higher export ratios are more likely to seek ISO 14001 certification than those with lower ones. Firms do not spend less in environmental protection to reduce production costs when facing competition in foreign markets. This result implies that ISO 14001 is consistent with corporate internationalization strategies, supporting the objective of facilitating international trade (Bansal and Hunter, 2003). Furthermore, this finding also coincides with the evidence suggesting that export-oriented firms bear a heavy load in relation to supply chain greening from multinational customers (Christmann and Taylor, 2001). Previous studies also reveal that trade facilitation is a key factor for firms' adoption of ISO 14001 in China and Hong Kong (Cushing et al., 2005; Chan and Li, 2001). Firms need to fulfill

environmental concern from foreign consumers if they want to raise their shares of sales in foreign markets. Consequently, exporting to countries with higher environmental standards can improve domestic environmental quality through firms' environmental self-governance.

Firms' environmental management decisions could be influenced by institutional pressures on firm environmental responsiveness. The coefficient estimates of local governors' party affiliation are insignificant and thus do not support the statement that local DPP governors exert larger pressure on firms regarding the adoption of ISO 14001 certification. Previous studies on environmental federalism suggest that local governments may improve environmental quality in response to public concerns and local governments may thus set different environmental standards for business investment. However, the evidence from Taiwan reveals that local political competition does not affect firm decision on ISO 14001 certification. ISO 14001 is not a performance-oriented standard and focuses on management processes rather than specific environmental outcomes. Therefore, it is possible that local governments use environmental policies of standards and regulations instead of firm self-governance to fulfill different environmental requirements.

The coefficient estimates of government subsidy are positive, thus indicating that a firm's ISO 14001 certification and government subsidies are highly correlated. A firm receives government subsidy to its preparation for ISO certification usually because the firm has decided to acquire ISO 14001 certification. Therefore, the estimates are biased upward by the endogeneity of government subsidy and may exaggerate the actual impact of government

subsidies. The maximum amount of subsidy was reduced from US$16,000 to US$6,000 since 2001. We utilize this exogenous policy change to investigate whether a decline in subsidy will reduce a firm's incentive to obtain ISO 14001 certification. We include the interactive term of subsidy and the period over 2001-2004 to estimate this incentive effect on firm decision to adopt ISO 14001 certification. Although the estimates are negative, they are not statistically significant. Overall, our study does not provide strong evidence to support the argument that government subsidies can increase the firms' incentive to become ISO 14001 certified owing to the endogeneity problem.

As noted above, firms can apply for subsidies to cover the cost of preparing ISO certification, up to a maximum of US$16,000 per case over 1996-2000 and up to a maximum of US$6,000 per case since 2001. Therefore, government subsidies can provide a significant positive incentive for Taiwanese firms to seek ISO 14001 certification, possibly by reducing the costs for the certification and the uncertainty of benefits from with the certification. If firms registering with ISO 14001 reduce environmental hazards from their production or products, it could be beneficial to society for governments to subsidize firm ISO 14001 preparation although it costs tax revenues.

The results also indicate that firms with larger facilities are more likely to seek ISO 14001 certification than those with smaller facilities. Christmann and Taylor (2001) and Chan and Li (2001) also find that a firm's likelihood of adopting ISO 14001 certification increases with its size in China and Hong Kong. This finding is likely owing to economies of scale in environmental

protection. Although firms with high profitability and low debt ratios are expected to be more likely to seek ISO 14001 certification than those with low profitability and high debt ratios, the effect of profitability on ISO 14001 certification appears insignificant. Owing to factors such as business cycle, firm decision to adopt ISO 14001 certification primarily depends on its long-term profitability rather than its profitability over a single year. Therefore, the profit rate during a single year may be volatile and may not represent a good proxy for long-term firm profits. This study thus also provides the estimates based on the four-year average ratio of profit to sales. The estimate based on the four-year average profitability suggests that the ratios of profits to sales during the current and previous three years do not significantly affect firm decision in adopting ISO 14001 certification.

Japan's experience shows that a more profitable firm is more likely to adopt ISO 14001 certification (Nakamura et al., 2001). However, Chapple et al. (2001) find that less profitable firms are more likely to seek ISO 14001 than profitable firms in the UK, motivated by the desire to gain a competitive advantage via environmental quality non-price competition. In contrast, this study does not find any significant effect of profits on firm decisions on ISO 14001 certification. The coefficient estimates of debt ratio do not show any statistically negative impact of debt ratios on firms' ISO 14001 certification and are consistent with the evidence from Japanese firms (Nakamura et al., 2001).

Table 5 shows a somewhat positive effect of R&D on ISO 14001 certification. Firms with higher levels of intangible assets such as R&D are

thus found to be more likely to seek ISO 14001 certification than those with lower levels of intangible assets. The finding presented here indicates that Taiwanese firms may seek solutions to broader environmental problems if they value the benefits of product innovation.

The results also show that firms located in the Hsinchu scientific industrial parks (HSIP) are more likely to seek ISO 14001 certification than those located elsewhere. In response to an increasing number of HSIP environmental management issues exposed in the past years, Environmental Management Supervision Committee, including members of academic researchers, government agents, business managers, local community leaders and environmental activists, was established to improve HSIP environmental management. Since institutional pressures that drive regulations, environmental activists, and market demand, subsequently influence firm behavior (Christmann and Taylor, 2001; Fineman and Clark, 1996), high-tech firms in the HSIP consider ISO 14001 standards to be an acceptable legitimacy tool for helping build trust and long-term relationships with a wide range of stakeholders and for deflecting the scrutiny of watchdog agencies and other interested parties. It is also possible that firms located within a short distance such as in the HSIP are more likely to adopt ISO 14001 certification because the spillover and learning effects make these firms understand the benefits and costs of ISO 4001 certification. Chan and Li (2001) indicate that the government can collaborate with the certified firms to promote the ISO 14001 standard by disseminating the information about the areas of concern and the advantages of the ISO 14001 standard.

Regarding other control variables, newly established firms are less likely to adopt ISO 14001 than older counterparts, probably owing to the greater risk of failure associated with newly established firms. Firms located in urban areas are less likely to adopt ISO 14001 certification than firms in the rural areas. Regarding attitudes towards ISO 14001 among firms in different industries, firms in the cement sector and the food sector are less likely to adopt ISO 14001 certification than firms in the plastics industry. Additionally, firms in the electronics industry are more likely to adopt ISO 14001 certification. Cushing et al. (2005) indicate that the industry of electronics and communications accounts for the majority of certifications in China. Finally, we also find that a firm's likelihood to adopt ISO 14001 certification varies substantially over years. Especially, many more firms adopted ISO 14001 certification in 2003 than in other years. A possible reason is that two regulations, Waste Electrical and Electronic Equipment and Restriction of Hazardous Substances, took effect in the European Union since 2003.

Table 5: Results of the random effects probit regressions

	Current-year ratio of profit to sale (1)		4-year averaged ratio of profit to sale (2)		Current-year return on asset (ROA) (3)		Current-year return on equity (ROE) (4)		Current-year ratio of profit to sale -- the electronics industry (5)	
Variables	Estimate	t-values	Estimate	t-values	Estimate	t-values	Estimate	t-value	Estimate	t-values
Main variables										
Weighted export	0.007**	2.12	0.008**	2.30	0.007**	2.05	0.008**	2.12	0.012	2.77
DPP governor	-0.012	-0.13	-0.019	-0.22	-0.011	-0.13	-0.014	-0.15	-0.157	-1.33
Subsidy	3.752***	6.49	3.693***	6.69	3.718***	6.44	3.833***	6.28	2.717	4.35
Subsidy since 2001	-0.509	-0.89	-0.508	-0.90	-0.495	-0.87	-0.532	-0.91	0.719	0.98
Asset (in logarithm)	0.315***	4.47	0.305***	4.64	0.311***	4.44	0.328***	4.28	0.292	3.76
Profitability	0.000	0.25	-0.001	-1.27	0.002	0.60	-0.001	-0.45	-0.000	-0.13
Debt ratio	-0.004	-1.21	-0.004	-1.41	-0.003	-1.12	-0.004	-1.38	-0.001	-0.40
R&D	0.261	1.44	0.155	1.14	0.240**	1.97	0.222*	1.77	0.232	1.25
HSIP (Science Park)	0.286*	1.91	0.237*	1.66	0.291**	1.97	0.286*	1.83	0.340	2.16
Control variables										
Age (years)	0.040***	4.57	0.039***	4.80	0.040***	4.60	0.041***	4.39	0.048	4.00
Urban	-0.181	-1.52	-0.152	-1.34	-0.176	-1.49	-0.188	-1.52	-0.430**	-2.37
Industry dummies										
Cement	-0.933*	-1.72	-0.872*	-1.67	-0.922*	-1.72	-0.964*	-1.71		
Food	-0.945**	-2.14	-0.910**	-2.15	-0.932**	-2.13	-0.971**	-2.11		
Textiles	-0.216	-0.77	-0.216	-0.80	-0.210	-0.76	-0.232	-0.80		
Machinery	0.183	0.64	0.177	0.64	0.176	0.62	0.196	0.66		

Electrical appliance	0.103	0.28	0.091	0.26	0.103	0.29	0.111	0.29		
Chemical	-0.292	-1.01	-0.280	-1.01	-0.294	-1.04	-0.288	-0.97		
Glass & Ceramics	-0.683	-1.06	-0.684	-1.10	-0.672	-1.06	-0.726	-1.09		
Paper & Pulp	-0.878	-1.48	-0.854	-1.49	-0.862	-1.46	-0.908	-1.47		
Metals	0.297	0.99	0.286	0.99	0.290	0.97	0.312	1.00		
Rubber	-0.065	-0.16	-0.058	-0.15	-0.059	-0.15	-0.064	-0.16		
Automobile	0.384	0.73	0.389	0.76	0.384	0.73	0.428	0.77		
Electronics	0.434*	1.70	0.414*	1.70	0.422*	1.68	0.454*	1.71		
Year effect										
1997	0.239	0.98	0.218	0.92	0.236	0.98	0.250	1.00	0.005	0.02
1998	0.852***	3.13	0.816***	3.14	0.849***	3.15	0.874***	3.07	0.863***	2.60
1999	0.799***	2.67	0.739***	2.62	0.792***	2.68	0.828***	2.63	0.669*	1.89
2000	0.517*	1.68	0.480*	1.66	0.507*	1.67	0.550*	1.70	0.612*	1.67
2001	1.009***	2.99	0.961***	3.03	1.001***	3.00	1.043***	2.92	1.018**	2.53
2002	0.999***	2.81	0.948***	2.86	0.988***	2.81	1.041***	2.75	1.067***	2.59
2003	2.025***	4.70	1.963***	4.91	2.005***	4.70	2.089***	4.50	2.036***	4.12
2004	0.932**	2.21	0.874**	2.24	0.912**	2.19	0.989**	2.19	1.089**	2.22
Constant	-8.807***	-5.39	-8.545***	-5.65	-8.737***	-5.41	-9.064***	-5.12	-9.089***	-4.74
σ_u	0.611(0.264)		0.561(0.253)		0.592(0.268)		0.661(0.279)		0.581(0.302)	
ρ	0.272(0.171)		0.239(0.164)		0.260(0.174)		0.304(0.178)		0.252(0.196)	
Log-likelihood	-920.50		-916.11		-920.04		-920.11		-584.41	
Observations	6692		6627		6654		6654		4308	

Notes

1. The measures of profitability utilized for the estimates in columns (1), (2), (3) and (4) are current year ratio of profit to sale, 4-year averaged ratio of profit to sale, current year returns on asset and current year returns on equity, respectively. The estimates in column (5) are based on

only the firms in the electronics industry.

2. The symbols ***, **, and * represent statistical significance at the level of 1%, 5% and 10%, respectively.

4. ASSESSMENT OF ISO14001 EMS IN FINANCIAL PERFORMANCE

4.1 Research Methodology

4.1.1 Measurement Indicators and Methods

This study seeks to first understand the current situation of ISO 14001 certification for Taiwanese businesses and to shore up parameters used by academia to assess performance. Regarding indicators for measuring financial performance, the formulas and implications listed in Table 6 differ from traditional analyses of financial statements and public manuals that classify financial ratios as financial structure, the ability to pay off debt, operational ability, profitability, and growth, in that traditional analyses and public manuals are not entirely appropriate for this study. Additionally, this study uses number of employees, total capital, and operating quota as indicators to measure enterprise size and to assign the firm to a certain industry category.

In the research methodology section, this study attempts to use static measurements (ROE, ROA, P/E ratio, rate of gross profit) and dynamic measurements (revenue growth rates) to perform t Test (when parameters are normally distributed), or to use the Wilcoxon nonparametric test in order to perform the analyses.

Table 6: Measurement index of financial performance

Index	Formula	Description
Net Income Rate	Net Income Rate＝ Annual Net Income／Annual Net Sales	To avoid any confusion created by the size of an enterprise in determining its profitability, the annual net income divided by the net sales formula is used
Return on Assets, ROA	ROA_1 ＝〔Normal operating profit ＋Interest expenses〕／Average total assets	Reflects the average total ROA
	ROA_2 ＝〔Normal operating profit ＋Interest expenses〕／Average total assets	
Return on Equity, ROE	ROE ＝ Income before extraordinary items ／Average shareholder equity	Reflects the average ROE for general shareholder
P/E ratio	P/E ratio ＝ Market prices per share ／ Earnings per share, EPS	Used to express investors' response to the profitability of the enterprise, also indicates the effects that pollution produced by the enterprsie on stock value

Source: Organized by this investigation

4.1.2 Research Object

From 1996 to 2004, Taiwan had 1,445 ISO 14001-certified enterprises (see Appendix 2), including a wide range of enterprise types and sizes. For example, Chinese Petroleum Corp. and Formosa Plastics Corp. have 30 and 9 certified facility levels, respectively. Because this study is focused on the “firm level” rather than the “facility level,” all enterprises with at least one ISO 14001-certified facility level have been included in the analysis. This work performs a business

performance analysis of 982 listed companies, 332 of which are certified while 650 are not. These companies cover 13 industries: cement, food, plastics, textiles, electric machinery, electric appliances and cables, chemical, glass and ceramics, paper, metals, rubber, automobile, and electronics.

This investigation uses relevant open source data to determine financial and economic parameters. The data were obtained from TEJ Data Bank, the Market Observation Post System, informational websites, the Safety, Health and Environment Today (SHE) website of the Industrial Development Bureau of the Ministry of Economic Affairs (seeTable 7), and so on.

Table 7: Sources for important parameters in this investigation

Parameter	Data Source
ISO14001 Certificaetd	Industrial EP Information Website, Industrial Development Bureau, MOEA(http://she.moeaidb.gov.tw/trend.asp)
Net Profit	1.Public Information (http://newmops.tse.com.tw/) 2.TEJ Data Bank
ROA	
ROE	
P/E Ratio	
Year of Establishment	
Scope	
Productivity	

4.1.3 Research Hypothesis

Jiang and Bansal (2003) believed that ISO 14001 certification is simply a procedural, legal distinction that has no real bearing on enterprise performance. Consequently, this investigation devises the following hypotheses for determining whether ISO 14001 certification has any bearing on business profitability, productivity, R&D capabilities, and overall nature.

H1: Certified and uncertified enterprises do not differ significantly in terms of their overall nature (namely, age)

H2: Certified and uncertified enterprises do not differ significantly in terms of size (namely, number of employees, total capital and gross revenue)

H3: Certified and uncertified enterprises do not differ significantly in terms of their profitability (namely, business growth, profit margin, ROA, ROE and P/E ratio)

H4: Certified and uncertified enterprises do not differ significantly in terms of their productivity (namely, operating revenue per employee)

4.2 Findings

4.2.1 Empirical Findings

This investigation analyzed the efficiency of ISO 14001 certified and

uncertified enterprises using a sample of 982 listed enterprises in 2004. Of those, 332 enterprises were certified, representing 33.8% of the total, while 650 enterprises were uncertified. Of the 332 certified enterprises, 62.3% (or 207 enterprises) belonged to the electronics industry, with 12.3% (or 41 enterprises) located in the Hsinchu Science Park. Table 8 below lists basic statistics.

Table 8: Basic analysis of ISO 14001-certified and uncertified enterprises

Item		W/O ISO14001 Certification	W/ ISO14001 Certification	Pearson Square
Year of Establishment	before 1970	90	105	165.445***
	1971-1990	327	190	
	after 1990	233	37	
Industry Type	Eletronics Indutries	441	207	56.3***
	Others	209	125	
Scope of Enterprise--no. of Employees	less than 300 employees	415	93	771.005***
	300-1000 employees	180	127	
	1001-3000 employees	43	72	
	more than 3000	12	40	
Scope of Enterprise--gross revenue	less than 1 billion	259	64	92.679***
	1-5 billion	287	138	
	5-10billion	61	39	
	more than 10 billion	43	91	

Source: Organized by this investigation

In the test (t Test) of the differences in averages and analysis of variances, the observed values of different groups should not accord with the normality (normal distribution) hypothesis, and the sample variance should exhibit homogenous

variance. In undergoing the Kolmogorov-Smirnov normal distribution test, none of the parameters studied in investigation accorded with the normality hypothesis. Thus, a nonparametric test has been performed to test relevant differences.

From Table 9, certified and uncertified enterprises differ significantly in terms of how old they are. Moreover, certified and uncertified enterprises also differ markedly in terms of total amount of capital, gross revenue, and number of employees. However certified and uncertified enterprises do not differ significantly in terms of profitability and productivity.

Table 9: Analysis of Nonparametric Test of ISO 14001-certified and uncertified enterprises

Facet	Item	Mann-Whitney U Statistic	Wilcoxon W Statistic	Significance
Company Features	Company Age	80675	148940	0.000***
Company Scope	Total Assets	80649	330220	0.000***
	Net Income	90732	340303	0.000***
	No. of Employees	63550	306803	0.000***
Profitability	Net Income Rate	128305.5	377876.5	0.686
	ROA	121891.5	367241.5	0.130
	ROE	126684.5	194949.5	0.483
	P/E Ratio	123261.5	372832.5	0.145
	Growth Rate	122861	191126	0.135
Productivity	Revenue per Person	126163.5	194428.5	0.462

Source: Organized by this investigation

4.2.2 Evidence-based Discussion

Estimates of enterprise ages do not support the projections of Hypothesis 1; the evidence presented here indicates that older companies are more likely to seek ISO 14001 certification than younger companies. Hypothesis 2 indicates that firm size (in terms of number of employees, total capital, and gross revenue) does not influence whether that company will implement the ISO 14001 environmental management system and seek to become certified; this hypothesis has been overturned by estimate values listed in Table 9. The implications of what has been discovered from applying Hypotheses 1 and 2 in terms of how enterprise age and size influence environmental policymaking are as follows: Because older or larger enterprises always have considerable liabilities, they are more willing to actively adopt certain measures to ensure their power and health. Additionally, such enterprises have more resources (manpower and material and financial resources), technical capability, wherewithal, and motivation than small to medium-sized enterprises and thus are better positioned to achieve sustainable development. Finally, enterprises must devote considerable resources to establishing and maintaining the ISO 14001 environmental management system to upgrade their environmental performance and achieve sustainable development. Additionally, Hartman, Huq, and Wheeler (1997) have observed that enterprise size influences its environmental performance; owing to the benefits of pollution prevention equipment depending on enterprise scope and size, with large enterprises being more likely to seek to become ISO 14001-certified.

Hypothesis 3 predicts that certification will not influence enterprise profitability (in terms of sales growth rates, profit margins, ROA, ROE, and P/E ratio). Moreover, hypothesis 4 illustrates that certification does not influence productivity (in terms of operating revenue per employee). These two hypotheses are supported by the statistics in Table 9. The implications of the results of applying Hypotheses 3 and 4 in terms of how profitability and productivity are influenced when enterprises engage in environmental managing are as follows: First, Taiwanese industry is an important link in the global supply chain. Additionally, the main customers of Taiwanese enterprises are from Japan, Europe, and North America, and are especially focused on environmental issues. Because Taiwanese industry is facing direct pressure from competitive organizations in developed countries (such as, supply chain pressure generated from Dell, SONY, HP, IBM and Ford), seeking ISO14001 certification has become a priority for Taiwanese industries. ISO 14001 certification represents a "green passport" ensuring that Taiwanese firms can continue to export to European and North American markets, and failure to possess such certification can translate into a loss of business opportunities for domestic businesses (Basnal and Bognor, 2002). Once the influence of organizational pressure on legal structures, environmental conservation groups, and market demand grows, export-oriented industries like those of Taiwan will increasingly bear the pressure of the global greening supply chain, and will view the ISO 14001 standard as an acceptable legitimacy tool. ISO 14001 can assist Taiwanese businesses in communicating with various competitive global organizations, and gaining international trust and fostering long-term partnerships (Jiang and Bansal, 2003), thus increasing the legitimacy of exchanges (Suchman, 1995). Finally, ISO 14001 certification of Taiwanese businesses contributes to achieving a long term profit and is unlikely to produce

gains in less than a year. Accordingly, annual profit margins are unlikely to be good indicators of firm long-term profits. Because of the instability of annual profit margins, this is unlikely to discernibly affect policy decisions to achieve ISO 14001 certification.

5. CONCLUSIONS

5.1 Conclusion and Contribution

5.1.1 Determinants of A Firm's ISO 14001 Certification

International voluntary environmental initiatives such as the ISO 14001 standards have emerged as an important strategy for firm environmental self-governance. Globalization has increased the institutional and customer pressures that force firms to exceed local requirements. Taiwanese firms, which play a vital role in the global supply chain, face constantly increasing pressure from both domestic and global stakeholders to be more environmentally responsible. Moreover, Taiwan has experienced gradual democratization over the past decade and determining the appropriate role of various governments in the setting of environmental standards has been a key issue on the political agenda for Taiwan.

Despite firm responses to environmental issues being an important aspect of environmental management, rare empirical studies have analyzed the responses of Taiwanese manufacturing firms to ISO 14001. This research investigates the determinants of Taiwanese firms' decisions to voluntarily adopt environmental standards, and thus can provide implications regarding future environmental protection. Export-oriented Taiwanese firms, which face supply chain pressure from multinational firms, are found to be more likely than domestic-focused firms to adopt ISO 14001. However, the party affiliation of local governors is not found to affect the firms' decision on the adoption of ISO 14001 certification in Taiwan

though competition among local governments can force local policymakers to respond to the concerns of constituents.

Although this study finds positive coefficient estimates of government subsidies, the estimates may be exaggerated owing to the endogeneity problem. The estimates also indicate that R&D expenditure positively impacts the decisions of Taiwanese firms to obtain ISO 14001 certification. The analysis presented here also shows that firms' profits and debt ratios, despite influencing environmental management for U.S. firms, are not important for Taiwanese firms in environmental management. Finally, firms located in scientific industrial parks are more likely to obtain ISO 14001 certification than firms located elsewhere.

5.1.2 Assessment of ISO14001 EMS in Financial Performance

Enterprises must simultaneously consider their economic growth and environmental conservation in improving their financial and environmental performance. In implementing the ISO 14001 environmental management system, enterprises not only work towards fulfilling their environmental duties, but can also reduce production costs and resource consumption as well as eliminating international trade barriers and doing business in a more "green" fashion. Taking the initiative to become certified is necessary in improving international competitiveness in a world dominated by organizational pressures and market demands. Certification is positively recognized in relation to environmental performance; whether or not certification also significantly influences financial

performance remains uncertain.

The results of this study indicate that among listed Taiwanese companies during 2004, ISO 14001 certification did not influence profitability and productivity. However, regarding overall enterprise nature—for instance, its age—a noticeable difference exists. Simultaneously, a noticeable difference also exists between certified and uncertified enterprises in terms of their size, either in terms of their total amount of capital or gross revenue or their number of employees.

5.2 Study Limitations and Future Research

This study examines the factors which influence a firm to implement the ISO 14001 standard and thus provides further insights into the determinants of the managerial responses of Taiwanese firms regarding environmental self-governance. Nevertheless, this is an exploratory study based on a sample of publicly traded manufacturing firms and thus further investigation is needed to understand more about other firms' decisions on the implementation of ISO 14001 certification.

Since this study used a sample from the Taiwanese manufacturing industry, its findings are limited. Differences in the conclusions of scholars obtained in similar studies can be attributed to the industry investigated, the time of the investigation, and the use of source materials. This study analyzed a sample of Taiwanese certified and uncertified enterprises during 2004, and the results herein could be made more complete by blending time sequences, grouping of industry or

peer pressure among members,…etc.. Additionally, since certification increases competitiveness over an extended period, post-certification performance can be assessed by tracking. Simultaneously, the samples were not equal in number (namely, the certified and uncertified samples). A comparative assessment of the performance of comparable samples may yield more abundant results. Future related studies should improve upon these areas.

Reference

1. 施勵行、黃峰蕙、郭美秀，「Environmental Performance and Corporate Environmental Strategy in Taiwan」，2000 年環境資源經濟、管理暨系統分析學術研討會論文集，台北: 中央研究院經濟研究所主辦，民國八十九年。
2. Abott, W.F., and Monsen, R.J., "On the Measurement of Corporate Social Responsibility: Self-Reported Disclosures As a Method of Measuring Corporate Social Involvement", Academy of Management Journal, 22(3), pp. 501-515, 1979.
3. Alexander, J.G., and Buchholz, R.A., "Research Notes Corporate Social Responsibility and Stock Market Performance", Academy of Management Journal, 21(3), pp. 479-486, 1978.
4. Allen, F.E., "Reducing Toxic Waste Produces Quick Results", The Wall Street Journal, New York, August, 11, B1, 1992.
5. An, B.Y., Hsu, M.L. and Liu, C.C., "The Environmental Management of the Food Industry in Taiwan - An Implementation Perspective", Journal of Technology Management, 4(1), pp. 147-174 (in Chinese), 1999.
6. Aragon-Correa, Juan A., "Strategic Proactivity and Firm Approach to the Natural Environment", Academy of Management Journal, 41, no. 5: 556-567, 1998.
7. Arlow, P. and Gannon, M.J., "Social Responsiveness, Corporate Structure and Economic Performance", Academy of Management Review, 7(1), pp. 235-241, 1982.
8. Arora, Seema and Timothy N. Cason, "An Experiment in Voluntary environmental regulation: Participation in EPA's 33/50 Program", Journal of Environmental Economics and Management , 28: 271-286, 1995.
9. Bansal, P. and W.C. Bogner, "Deciding on ISO14001: Economics, Institutions, and Context", Long Range Planning, 35, pp. 269-290, 2002.
10. Bansal, Pratima and Trevor Hunter, "Strategic Explanations for the Early Adoption of ISO 14001", Journal of Business Ethics ,46: 289-299, 2003.
11. Bansal, Pratima and William C. Bogner, "Deciding on ISO 14001: Economics, Institutions, and Context", Long Range Planning , 35: 269-290, 2002.
12. Bansal, Pratima, "The Corporate Challenges of Sustainable Development", Academy of Management Executive ,16, no. 2: 122-131, 2002.
13. Bettis, R. A. and V. Mahajan, "Risk/Return Performance of Diversified Firms", Management Science, 31, pp. 785-799, 1985.
14. Bragdon, J.H., and Marlin, J., "Is Pollution Profitable? ", Risk Management,

19(4), pp. 9-18, 1972.
15. Bruce, Donald, "Effects of the United States Tax System on Transition into Self-Employment", Labour Economics ,7: 545-574, 2000.
16. Brunnermeier, Smita B. and Mark A Cohen, "Determinants of Environmental Innovation in US Manufacturing Industries", Journal of Environmental Economics and Management 45: 278-293, 2003.
17. Callan, S.J., and Thomas, J.M., Environmental Economics and Management: Theory, Policy, and Applications, Irwin, Chicago, 1996.
18. Capon, N., Farley, J.U., and Hoeing, S., "Determinants of Financial Performance: A Meta-Analysis", Management Science, 36, pp. 1143-1159, 1990.
19. Carter, C.R., Kale, R., and Grimm, C.M., "Environmental Purchasing and Firm Performance: An Empirical Investigation", Transportation Research Part E, 36, pp. 219-228, 2000.
20. Chakravarthy, B.S., "Measuring Strategic Performance", Strategic Management Journal, 7(5), pp. 437-458, 1986.
21. Chamberlain, G., "Analysis of Covariance with Qualitative Data", Review of Economic Studies ,47: 225-238, 1980.
22. Chan, Ka-Yee and Xiang-Dong Li., "A Study of the Implementation of ISO 14001 Environmental Management Systems in Hong Kong", Journal of Environmental Planning and Management ,44, no. 5: 589-601, 2001.
23. Chapple, Wendy; Andrew Cooke; Vaughan Galt and David Paton, "The Characteristics and Attributes of UK Firms Obtaining Accreditation to ISO 14001", Business Strategy and the Environment ,10, no. 4: 238-244, 2001.
24. Chin, K.S., and Pun, K.F., "Factors Influencing ISO14000 Implementation in Printed Circuit Board Manufacturing Industry in Hong Kong" , Journal of Environmental Planning and Management, 14(1), pp. 123-124, 1999.
25. Christmann, P. and G. Taylor, "Globalization and the Environment: Determinants of Firms Self-Regulation in China", Journal of International Business Studies, 32 (3), pp.439-458, 2001.
26. Chu, Po-Young; Mei-Jane Teng; Chi-Hung Huang and Hung-Shu Lin, "Virtual Integration and Profitability: Some Evidence from Taiwan's IC Industry", International Journal of Technology Management, 29, nos. 1/2: 152-172, 2005.
27. Clark, David, "What Drives Companies to Seek ISO14000 Certification?", Pollution Engineering, Summer: 14-18, 1999.
28. Cohen, M. A., Fenn, S. A. and Naimon, J., Environmental and Financial Performance: Are They Related? Investor Responsibility Research Center,

Washington, DC, 1995.
29. Cooper, A.C., Willard, G. E. and Woo, C. Y., "Strategies of High Performing New and Small Firms: A Reexamination of the Niche Concept", Journal of Business Venturing, 1(3), pp. 247-260, 1986.
30. Cooper, R. G. and Kleinschmidt, E. J., "New Products: What Separates Winners From Losers", Journal of Product and Innovation Management, 4, pp. 169-184, 1987.
31. Cooper, R.G., "The Dimensions of Industrial of Industrial New Product Success and Failure", Journal of Marketing, 43 (3), pp. 93-103, 1979.
32. Cushing, Katherine Kao; Heather McGray and Hongyan Lu, "Understanding ISO 14001 Adoption and Implementation in China", International Journal of Environment and Sustainable Development , 4(3): 246-268, 2005.
33. Dasgupta, Susmita; Benoit Laplante; Hua Wang and David Wheeler, "Confronting the Environmental Kuznets Curve", Journal of Economic Perspective, 16(1): 147-168, 2002.
34. Dean, T. and Brown, R., "Pollution Regulation as a Barrier to New Firm Entry: Initial Evidence and Implications for Future Research", Academy of Management Journal, 38(1), pp. 288-303, 1995.
35. DeCanio, Stephen J and William E. Watkins, "Investment in Energy Efficiency: Do the Characteristics of Firms Matter?", The Review of Economics and Statistics, 80: 95-107, 1998.
36. Delmas, Magali A., "Stakeholders and Competitive Advantage: The Case of ISO 14001: The Case of ISO 14001", Production and Operations Management, 10, no. 3: 343-358, 2001.
37. Eckel, L., Fisher, K., and Russell, G., "Environmental Performance Measurement", CMA Magazine, Mar, pp. 12-20, 1992.
38. Fielding, S., "Going for the Green", Industrial Management, 41(2), pp. 31-34, 1999.
39. Fineman, S. and K. Clarke, "Green Stakeholders: Industry Interpretations and Response", Journal of Management Studies, 33 (6), pp. 716-730, 1996.
40. Fineman, Stephen and Kutatásai Clarke, "Green Stakeholders: Industry Interpretations and Response", Journal of Management Studies, 33, no. 6: 715-730, 1996.
41. Fogler, H.R., and Nutt, F., "A Note on Social Responsibility and Stock Valuation", Academy of Management Journal, 18, pp. 155-160, 1975.
42. Freedman, M., and Jaggi, B., "The SEC's Pollution Disclosure Requirements – Are They Meaningful?", California Management Review, 24(2), pp. 60-67, 1982.

43. Freeman, D., “Cost/Benefit Analysis of ISO 14001 Implementation” , GETF http://www.iso14000.net/empire/?SubSystemID=1andComponentID= 15667, 1997.
44. Freeman, P.K., “Integrating Environmental Risk into Corporate Strategy”, Risk Management, 41(7), pp. 54-59, 1994.
45. Fullerton, R.R. and McWtters, C.S., “The production performance benefits from JIT implementation”, Journal of Operations Management, 19(1), pp. 81-96, 2001.
46. Gifford, D., “The Value of Going Green”, Harvard Business Review, 75(5), pp. 11-12, 1997.
47. Greeno, L., and Robinson, S.N., “Rethinking Corporate Environmental Management”, The Columbia Journal of World Business, 27 (3/4), pp. 222-232, 1992.
48. Hall, Bronwyn and John Van Reenen, “How Effective Are Fiscal Incentives for R&D? A Review of the Evidence”, Research Policy, 29: 449-469, 2000.
49. Hartman, R.S., M. Huq and D. Wheeler, “Why Paper Mills Clean Up: Determinants of Pollution Abatement in four Asian Countries”, Policy Research Working Paper , No. 1710, World Bank, Washington, D.C, 1997.
50. Henriques, Irene and Perry Sadorsky, “The Determinants of an Environmentally Responsive Firm: An Empirical Approach”, Journal of Environmental Economics and Management, 30: 381-395, 1996.
51. Ilinitch, A.Y., Soderstrom, N.S., and Thomas, T.E., “Measuring Corporate Environmental Performance”, Journal of Accounting and Public Policy, 17(4,5), pp. 383-408, 1998.
52. Industrial Development Bureau (IDB), Ministry of Economic Affairs (MOEA), Brochure of 2002 Development of Industries in Taiwan, 2-38, 2002.
53. Industrial Development Bureau (IDB), Ministry of Economic Affairs (MOEA), IDB Library Collection of Final Reports of ISO 14001 EMS Demonstration and Promotion Projects, 1996-2004, 2006.
54. ISO World, The Number of ISO 14001/EMAR Registration of the World, http://www.ecology.or.jp/isoworld/english/analy14k.htm (accessed May 6, 2006), 2005.
55. Jaffe, Adam; Steven Peterson; Paul Portney and Robert Stavins, “Environmental Regulation and the Competitiveness of US Manufacturing: What Does the Evidence Tell Us?”, Journal of Economic Literature, 33: 132-163, 1995.
56. Jaggi, B, “Impact of Pollution Performance of Pulp and Paper Firms on Their

Economic Performance", Working Paper, Rutgers University, 1993.
57. Jaggi, B., and Freedman, M., "An Examination of Impact of Pollution Performance on Economic and Market Performance: Pulp and Paper Firms", Journal of Business Finance and Accounting, 19(5), pp. 697-713, 1992.
58. Jiang, R. and P. Bansal, "Seeing the Need for ISO14001", Journal of Management Studies, 40(4), pp. 1047-1067, 2003.
59. Judge, W.Q., Jr. and Hemi, K., "An Empirical Investigation of the Scope of Firms' Enterprise Strategy", Business and Society, 33(2), pp. 167-91, 1994.
60. Katzell, M.E., Productivity: The Measure and the Myth, New York: Amacom, 1975.
61. King, Andrew and Michael Lenox, "Who Adopts Management Standards Early? An Examination of ISO 14001 Certifications", Proceedings of the Academy of Management Annual Conference, 1: A1-A6, 2001.
62. Klassen, R.D. and C.P. McLaughlin, "The Impact of Environmental Management on Firm Performance", Management Science, 42(8), pp. 1199-1214, 1996.
63. Konar, Shameek and Mark A. Cohen, "Does the Market Value Environmental Preformance?", Review of Economics and Statistics, 83(2): 281-289, 2001.
64. Magretta, M., "Growth Through Global Sustainability: An Interview with Monsanto's CEO", Harvard Business Review, Jan-Feb, pp. 78-90, 1997.
65. Mahaptra, S., "Investor Reaction to Corporate Social Accounting", Journal of Business Finance and Accounting, 11(1), pp. 29-40, 1984.
66. Miles et al., "The Impact of ISO14000 Environmental Standards on Small and Medium Sized Enterprises", Journal of Quality Management, 4(1), pp.111-122, 1999.
67. Miles, M.P., Manila, L. S., and Russell, G. R., "Marketing and Environmental Registration/Certification What Industrial Marketers Should Understand About ISO14000", Industrial Marketing Management, 26(4), pp. 363-370, 1997.
68. Mitchell, R. K., B. R. Agle and D. J. Wood, "Toward a Theory of Stakeholder Identification and Salience: Defining the Principle of Who and What Really Counts", Academy of Management Review, 22, pp. 853-886, 1997.
69. Mohamed, S.T., "The Impact of ISO14000 on Developing World Business", Renewable Energy, 23, pp. 579-584, 2001.
70. Montabon, F., Manly, S.A., Sroufe, R., and Clanton, R.C., "ISO14000: Assessing its Perceived Impact on Corporate Performance", Journal of Supply Chain Management, 36(2), pp. 4-16, 2000.
71. Montero, Juan, "Voluntary Compliance with Market-Based Environmental

Policy: Evidence from the U.S. Acid Rain Program", Journal of Political Economy, 107, no. 5: 998-1033, 1999.
72. Moskowitz, M. R., "Choosing Socially Responsible Stocks", Business and Society Review, 1(1), pp. 71-75, 1972.
73. Mulder, L., "Green Purchasing: Does It Make Sense, Electronics and The Environment", ISEE-1998, Proceedings of the 1998 IEEE International Symposium on, pp.123-128, 1998.
74. Nakamura, Masao ; Takuya Takahashi and Ilan Vertinsky, "Why Japanese Firms Choose to Certify: A Study of Managerial Responses to Environmental Issues", Journal of Environmental Economics and Management, 42: 23-52, 2001.
75. Nehrt, C., "Timing and Intensity Effects of Environmental Investments", Strategic Management Journal, 17, pp. 535-547, 1996.
76. Nehrt, C., "Maintainability of First Mover Advantages When Environmental Regulations Differ Between Countries", Academy of Management Review, 23(1), pp. 77-97, 1998.
77. New York Times, Bayer to Build Plant in Texas, Not Taiwan, March 19, 1998.
78. Noci, Giuliano and Roberto Verganti, "Managing Green Product Innovation in Small Firms", R & D Management, 29, no. 1: 3-15, 1999.
79. Oates, Wallace E., "A Reconsideration of Environmental Federalism", Resources for the Future, Discussion Paper no. 01-54., 2001.
80. Parket, I.R., and Eilbirt, H., "Social Responsibility: The Underlying Factors", Business Horizons, 18(4), pp. 5-10, 1975.
81. Porter, M.E., and van der Linde, C., "Green and Competitive: Ending the Stalemate", Harvard Business Review, September-October, pp.120-134, 1995.
82. Porter, Michael E. and Class van der Linde, "Toward a New Conception of the Environment-Competitiveness Relationship", Journal of Economic Perspectives, 9: 97-118, 1995.
83. Ranftl, R.M., "A Productivity Profile…Guidelines to Productive Management", Management Review, 68(11), pp. 49-54, 1979.
84. Rezaee, Z., "Help Keep the World Green", Journal of Accountancy, 190(5), pp.57-64, 2000.
85. Rockness, J., Schlachter, P., and Rockness, H.O., "Hazardous waste disposal, Corporate Disclosure, and Financial Performance in the Chemical Industry", In M. Neimark (Ed.), Advances in Public Interest Accounting, 1(1), pp. 167-191, Greenwich, CT: JAI Press, 1986.

86. Roht-Arriaza, Naomi, “Environmental Management Systems and Environmental Protection: Can ISO 14001 Be Useful Within the Context of APEC?”, Journal of Environment and Development, 6, no. 3: 292-316, 1997.
87. Schmidheiny, S., “Changing Course: A Global Business Perspective on Development and the Environment”, MIT Press, Cambridge, MA, 1992.
88. Shih, L.H., Huarng, F. and Kuo, M.S., “Environmental Performance and Corporate Strategy in Taiwan: a survey, Environmental and Resources Economics”, Management and System Analysis Conference(in Chinese), Taipei, 2000.
89. Spicer, B.H., “Investors, Corporate Social Performance and Information Disclosure: An Empirical Study”, Accounting Review, 53, pp. 94-111, 1978.
90. Spicer, B.H., “Market Risk, Accounting Data, and Companies’ Pollution Control Records”, Journal of Business, Finance, and Accounting, 5, pp. 67-83, 1978.
91. Steger, U., “Environmental Management System: Empirical Evidence and Further Perspectives”, European Management Journal, 18(1), pp. 23-37, 2000.
92. Stigson, B., “Sustainability in an era of Globalization: The Business Response In OECD, Globalization and the Environment: Perspectives from OECD and Dynamic Non-Member Countries” , OECD, Paris, pp. 59-64, 1998.
93. Sturdivant, F, D., and Ginter, J. L., “Corporate Social Responsiveness: Management Attitudes and Economic Performance”, California Management Review, 19(3), pp. 30-39, 1977.
94. Suchman, M. G., “Managing Legitimacy: Strategic and Institutional Approaches”, Academy of Management Review, 20, pp. 571-610, 1995.
95. “Suppliers into Environmental Management Processes”, International Journal of Purchasing and Materials Management, 34(2), pp. 2-11, 2001.
96. Tibor, T., and Feldman, I., ISO 14000: A Guide to the New Environmental Management Standards, Irwin Professional Publishing, Chicago, IL, 1996.
97. Ullman, A., “Data in Search of a Theory: A Critical Examination of the Relationship Among Social Performance, Social Disclosure, and Economic Performance”, Academy of Management Review, 10, pp. 540-577, 1985.
98. UN Department of Economic and Social Affairs, Division for Sustainable Development, Agenda 21, 1992.
99. Vance, S., “Are Socially Responsible Corporations Good Investment Risks?”, Managerial Review, 64(8), pp. 18-24, 1975.
100. Walley, N., and Whitehead, B., “It’s Not Easy Being Green”, Harvard

Business Review, 72(3), pp. 46-51, 1994.
101. Walton, S.V., Handfield, R.B., and Melnyk, S.A., The Green Supply Chain: Integrating, 1998.
102. Weizsacker, E.U., Lovins, A.B., and Lovins, L.H., "Factor Four: Doubling Wealth", Halving Resource Use, London: Earthscan Publications, 1998.
103. Wen, J.D., and Chen, M.K., "Implementation of ISO14000 in Taiwan", Chung Shan Management Review, 6(1), pp. 195-219 (in Chinese), 1998.
104. Wilson, Robert C., "The Developing World Looks to ISO14000 for Help", Pollution Engineering, 30, no. 2: 37-38, 1998.
105. Winsemius, P., and Guntram, U., "Responding to the Environmental Challenge", Business Horizons, 35(2), pp. 12-20, 1992.
106. Wiseman, J., "An Evaluation of Environmental Disclosures made in Corporate Annual Reports", Accounting, Organizations, and Society, 7, pp. 53-63, 1982.
107. World Commission on Environment and Development, Our Common Future, 1987.
108. Zirger, B. J., & Maidique, M., "A Model of New Product Development: An Empirical Test", Management Science, 36, pp. 867-883, 1990.

Appendix 1: Raw data (partial)

year	code	company	export	subsidy	north	middle	green	hq	site	county	city	city2	cement	food	plastic	textile	ee	appliance	chemistry	glass	paper	steel	rubber	auto	electronic	form	sen1	sen2	certification	ceryear	location	asset	lnasset	sales	cost	promotion	managerial	profit1-1	profit1-2	profit1-3	profit1-4
1996	1101	台泥	4.65	0	1	0	1	1	16	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1939	1	0	0	1998	0	35669677	17.39	16063125	13868784	.	.				11.29
1997	1101	台泥	5.92	0	1	0	1	1	16	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1939	1	0	0	1998	0	58409134	17.88	15708885	14177298	.	.			11.29	12.80
1998	1101	台泥	7.40	0	1	0	1	1	16	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1939	1	0	0	1998	0	66015668	18.01	17127795	15258587	.	.		11.29	12.80	12.92
1999	1101	台泥	7.75	0	1	0	0	1	16	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1939	1	0	0	1998	0	80156176	18.20	17200764	15565753	.	.	11.29	12.80	12.92	13.70
2000	1101	台泥	8.05	0	1	0	0	1	16	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1939	1	0	0	1998	0	93096593	18.35	17965395	17072199	.	.	12.80	12.92	13.70	7.05
2001	1101	台泥	10.17	0	1	0	0	1	16	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1939	1	0	0	1998	0	98029907	18.40	20244735	19819285	.	.	12.92	13.70	7.05	1.10
2002	1101	台泥	7.26	0	1	0	0	1	16	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1939	1	0	0	1998	0	101027776	18.43	24595720	23605540	.	.	13.70	7.05	1.10	1.29
2003	1101	台泥	10.96	0	1	0	0	1	16	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1939	1	0	0	1998	0	94574148	18.36	24420321	22821323	.	.	7.05	1.10	1.29	9.14
2004	1101	台泥	14.24	0	1	0	0	1	16	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1939	1	0	0	1998	0	94158098	18.36	24197991	21539174	56723	563252	1.10	1.29	9.14	19.23
1996	1102	亞泥	6.43	0	1	0	1	1	18	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1947	1	0	0	1996	0	45866090	17.64	15697394	11820990	.	.				24.38
1997	1102	亞泥	9.86	0	1	0	1	1	18	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1947	1	0	0	1996	0	52815526	17.78	15239194	12151850	.	.			24.38	30.59
1998	1102	亞泥	7.24	0	1	0	1	1	18	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1947	1	0	0	1996	0	53019730	17.79	14246810	11489468	.	.		24.38	30.59	18.86
1999	1102	亞泥	8.17	0	1	0	0	1	18	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1947	1	0	0	1996	0	55754388	17.84	12412596	10581905	.	.	24.38	30.59	18.86	29.62
2000	1102	亞泥	10.12	0	1	0	0	1	18	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1947	1	0	0	1996	0	52466703	17.78	10905103	9702159	.	.	30.59	18.86	29.62	1.61
2001	1102	亞泥	12.50	0	1	0	0	1	18	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1947	1	0	0	1996	0	53771442	17.80	9958340	9346545	.	.	18.86	29.62	1.61	3.56
2002	1102	亞泥	10.58	0	1	0	0	1	18	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1947	1	0	0	1996	0	55540477	17.83	11125879	9729777	.	.	29.62	1.61	3.56	11.88
2003	1102	亞泥	14.67	0	1	0	0	1	18	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1947	1	0	0	1996	0	58626138	17.89	9568946	8191001	.	.	1.61	3.56	11.88	36.22
2004	1102	亞泥	13.27	0	1	0	0	1	18	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1947	1	0	0	1996	0	62673751	17.95	10404881	8399809	.	.	3.56	11.88	36.22	64.70
1996	1216	統一	0.00	0	0	0	1	13	13	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1956	1	0	0	1997	0	40032857	17.51	26300153	19755287	3805009	2030734				11.71
1997	1216	統一	0.00	1	0	0	1	13	13	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1956	1	0	0	1997	0	47949432	17.69	26644484	19340262	4814343	2518643			11.71	29.45
1998	1216	統一	0.00	0	0	0	1	13	13	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1956	1	0	0	1997	0	54844762	17.82	29203880	21253357	5685733	2601826		11.71	29.45	14.95
1999	1216	統一	0.00	0	0	0	1	13	13	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1956	1	0	0	1997	0	62173164	17.95	30022143	21298944	6027067	1896285	11.71	29.45	14.95	11.21
2000	1216	統一	0.00	0	0	0	1	13	13	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1956	1	0	0	1997	0	70801656	18.08	32159019	22700687	6652476	2190480	29.45	14.95	11.21	10.11
2001	1216	統一	2.20	0	0	0	1	13	13	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1956	1	0	0	1997	0	72163028	18.09	33348556	24568492	6065629	2266662	14.95	11.21	10.11	9.12
2002	1216	統一	2.17	0	0	0	1	13	13	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1956	1	0	0	1997	0	68684241	18.05	34899175	26477729	5660561	1842280	11.21	10.11	9.12	4.87
2003	1216	統一	2.18	0	0	0	1	13	13	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1956	1	0	0	1997	0	73477382	18.11	37951951	30072825	5582315	1869840	10.11	9.12	4.87	7.85
2004	1216	統一	1.88	0	0	0	1	13	13	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1956	1	0	0	1997	0	74480967	18.13	40874802	33425708	5347921	1875503	9.12	4.87	7.85	6.74
1996	1232	大統益	0.00	0	0	0	1	13	13	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1971	0	1	0	2001	0	1930045	14.47	5154800	4766717	149380	57756				3.71
1997	1232	大統益	0.00	0	0	0	1	13	13	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1971	0	1	0	2001	0	3729592	15.13	5296592	4925075	192648	66641			3.71	2.82
1998	1232	大統益	0.00	0	0	0	1	13	13	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1971	0	1	0	2001	0	3468623	15.06	5695039	5312693	184340	75842		3.71	2.82	0.25
1999	1232	大統益	0.00	0	0	0	1	13	13	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1971	0	1	0	2001	0	3444922	15.05	5286169	4900073	188143	65760	3.71	2.82	0.25	2.32
2000	1232	大統益	0.00	0	0	0	1	13	13	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1971	0	1	0	2001	0	3630930	15.10	5437137	4889259	157539	72931	2.82	0.25	2.32	4.82
2001	1232	大統益	0.39	0	0	0	1	13	13	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1971	0	1	0	2001	0	3556831	15.08	6173896	5479027	185744	78206	0.25	2.32	4.82	6.51
2002	1232	大統益	0.37	0	0	0	1	13	13	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1971	0	1	0	2001	0	3423033	15.05	6950663	6222275	177876	77163	2.32	4.82	6.51	6.43
2003	1232	大統益	0.60	0	0	0	1	13	13	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1971	0	1	0	2001	0	4080051	15.22	8541489	7918882	169637	79702	4.82	6.51	6.43	4.56
2004	1232	大統益	0.91	0	0	0	1	13	13	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1971	0	1	0	2001	0	3494955	15.07	9722714	9223980	147420	83730	6.51	6.43	4.56	2.75
1996	1236	宏亞	0.00	0	1	0	1	2	3	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1965	1	0	0	1998	0	1663332	14.32	1423156	877837	280519	80306				10.39
1997	1236	宏亞	0.00	0	1	0	1	2	3	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1965	1	0	0	1998	0	1688230	14.34	1357056	859777	315608	94370			10.39	3.85
1998	1236	宏亞	1.82	0	1	0	1	2	3	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1965	1	0	0	1998	0	1630668	14.30	1098800	766309	287212	77304		10.39	3.85	-10.16
1999	1236	宏亞	0.00	0	1	0	1	2	3	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1965	1	0	0	1998	0	1500092	14.22	1316706	844382	287974	72533	10.39	3.85	-10.16	4.66
2000	1236	宏亞	0.00	0	1	0	1	2	3	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1965	1	0	0	1998	0	1506809	14.23	1325546	813126	276787	73600	3.85	-10.16	4.66	6.86
2001	1236	宏亞	0.99	0	1	0	1	2	3	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1965	1	0	0	1998	0	1453158	14.19	1181158	779847	238669	70928	-10.16	4.66	6.86	4.71
2002	1236	宏亞	0.68	0	1	0	1	2	3	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1965	1	0	0	1998	0	1461121	14.19	1282399	815397	282781	67678	4.66	6.86	4.71	8.05
2003	1236	宏亞	0.11	0	1	0	1	2	3	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1965	1	0	0	1998	0	1781505	14.39	1460434	892365	290482	74152	6.86	4.71	8.05	14.09
2004	1236	宏亞	0.41	0	1	0	1	2	3	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1965	1	0	0	1998	0	1654618	14.32	1486682	940151	306010	71050	4.71	8.05	14.09	11.32
1996	1301	台塑	16.72	0	0	0	1	16	15	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1943	1	0	0	1997	0	64566482	17.98	36327618	27616203	831137	2479690				19.95
1997	1301	台塑	17.33	0	0	0	1	16	15	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1943	1	0	0	1997	0	88593161	18.30	40000811	29811181	983105	2979755			19.95	10.41
1998	1301	台塑	21.91	0	0	0	1	16	15	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1943	1	0	0	1997	0	101211829	18.43	35804491	26748996	1100983	3407479		19.95	10.41	11.85
1999	1301	台塑	29.45	0	0	0	0	16	15	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1943	1	0	0	1997	0	141515134	18.77	41096143	30780529	1490816	3402488	19.95	10.41	11.85	15.20
2000	1301	台塑	36.78	0	0	0	0	16	15	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1943	1	0	0	1997	0	160703111	18.90	51773413	41543518	2002914	3691484	10.41	11.85	15.20	20.42
2001	1301	台塑	44.49	0	0	0	0	16	15	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1943	1	0	0	1997	0	164645253	18.92	59813814	49596510	2602083	2644535	11.85	15.20	20.42	9.28
2002	1301	台塑	46.04	0	0	0	0	16	15	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1943	1	0	0	1997	0	172276891	18.96	65710772	54322848	2751434	1999060	15.20	20.42	9.28	17.83
2003	1301	台塑	48.04	0	0	0	0	16	15	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1943	1	0	0	1997	0	183599804	19.03	84468581	69561123	3185915	2096164	20.42	9.28	17.83	19.75
2004	1301	台塑	47.45	0	0	0	0	16	15	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1943	1	0	0	1997	0	216767533	19.19	121938523	94826371	3524705	2664559	9.28	17.83	19.75	31.51
1996	1303	南亞	36.35	0	1	0	1	1	15	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1961	1	0	0	1996	0	110008560	18.52	88865489	70792194	3250104	5985811				9.45

Appendix 2: ISO14001-certified firms in Taiwan over the period of 1996-2004(partial)

公司名稱	驗證時間	公司名稱	驗證時間	公司名稱	驗證時間	公司名稱	驗證時間	公司名稱	驗證時間	公司名稱	驗證時間	公司名稱	驗證時間	公司名稱	驗證時間
一詮精密工業股份有限公司	90年07月	東友科技股份有限公司觀音廠	88年01月	台灣信越半導體股份有限公司	88年08月	富精電子股份有限公司桃園廠	89年02月	中鋼鋁業股份有限公司	93年03月	美格科技股份有限公司	88年05月	由鉅建設股份有限公司	88年05月	嘉泰化學工業股份有限公司	91年02月
一龍橡膠工業股份有限公司	91年01月	東台精機股份有限公司	92年03月	台灣信越矽利光股份有限公司	92年03月	富耀電子製品廠	88年08月	中想化學股份有限公司	93年03月	美隆電器廠股份有限公司	93年05月	禾伸堂企業股份有限公司	92年05月	嘉益工業股份有限公司	87年06月
九德電子股份有限公司	88年04月	東正元電路工業股份有限公司	90年07月	台灣保谷光學股份有限公司	92年03月	富驊企業股份有限公司	87年05月	中聯油脂股份有限公司台中港廠	90年02月	美齊股份有限公司	88年04月	禾昌興業股份有限公司	92年06月	嘉晶電子工業股份有限公司	92年03月
九德電子股份有限公司	92年03月	東貝光電科技股份有限公司	90年12月	台灣保谷眼鏡股份有限公司	92年03月	嵐強科技股份有限公司	90年03月	[illegible]司	92年03月	美齊股份有限公司高雄分公司	87年11月	立勝塑膠實業股份有限公司	90年07月	嘉聯益科技股份有限公司	91年07月
力大螺絲工廠股份有限公司	90年11月	廠	88年12月	台灣保來得股份有限公司	92年03月	復實股份有限公司	92年03月	廠	91年06月	致恩科技股份有限公司	90年05月	立敦科技股份有限公司	92年03月	彰源企業股份有限公司	88年07月
力山工業股份有限公司	92年03月	廠	88年11月	公司	89年04月	惠泰電實業股份有限公司	92年03月	互德科技股份有限公司	91年07月	致泰電子股份有限公司	92年03月	司	92年03月	處理廠	92年11月
力太電子股份有限公司	92年03月	東芝精密股份有限公司	92年04月	台灣玻璃工業(股)鹿港廠	92年03月	敦南科技股份有限公司	92年03月	仁大工業區環保組	92年07月	致勝科技股份有限公司	89年08月	立衛科技股份有限公司	90年08月	旗勝科技股份有限公司	89年11月
力成科技股份有限公司	92年03月	東南水泥股份有限公司	87年12月	廠	92年03月	敦陽化工股份有限公司	92年12月	仁寶電腦工業股份有限公司	86年10月	致福股份有限公司	88年11月	伍立實業股份有限公司	92年03月	廠)	86年12月
力信興業股份有限公司	90年04月	東南鹼業股份有限公司	92年03月	廠	92年03月	普立爾科技股份有限公司	93年01月	今仙電機股份有限公司	92年03月	茂一電子股份有限公司斗六廠	91年05月	光元股份有限公司平鎮廠	87年04月	榮成電機工業股份有限公司	86年09月
力捷紙品有限公司	89年06月	東展興業股份有限公司	87年03月	廠	92年03月	普迪精密工業股份有限公司	87年07月	今國光學工業股份有限公司	92年11月	茂林光電科技股份有限公司	91年10月	光成電腦股份有限公司	89年12月	榮星電線股份有限公司	92年03月
力晶半導體股份有限公司	87年05月	東訊股份有限公司	92年01月	台灣省菸酒公賣局南投廠	92年03月	普誠科技股份有限公司	91年10月	介明塑膠股份有限公司	92年01月	茂訊電腦股份有限公司	93年02月	光發鍍金股份有限公司	93年04月	榮剛材料科技股份有限公司	92年03月
力登電腦股份有限公司	92年03月	東培工業股份有限公司桃園廠	87年07月	台灣省菸酒公賣局中興啤酒廠	90年12月	晶達光電股份有限公司	92年01月	元智大學	91年07月	茂德科技股份有限公司	91年06月	光磊科技股份有限公司	91年07月	榮剛重工股份有限公司	88年04月
力鵬企業股份有限公司	92年03月	東莞志豐電子有限公司	93年11月	台灣省菸酒公賣局內埔菸廠	87年10月	景碩科技股份有限公司	92年03月	元華興業股份有限公司	92年05月	英全化學工業股份有限公司	92年06月	光聯科技股份有限公司	91年02月	榮眾科技股份有限公司	92年03月
力麗企業彰化一廠	92年01月	東莞矽德半導體有限公司	94年04月	台灣省菸酒公賣局包裝材料工廠	91年07月	智邦科技股份有限公司	91年03月	元際股份有限公司	92年03月	英業達股份有限公司	92年03月	兆良企業有限公司	93年07月	漢翔公司發動機製造處	92年03月
十美企業股份有限公司	92年03月	東陽三星工業股份有限公司	92年10月	台灣省菸酒公賣局台中酒廠	92年03月	智基科技開發股份有限公司	93年06月	元豐電子股份有限公司	92年03月	英業達股份有限公司(桃園廠)	87年01月	兆欣化學工業股份有限公司	89年02月	漢翔航空工業股份有限公司	88年12月
又興企業股份有限公司	91年06月	東陽實業廠股份有限公司	91年08月	台灣省菸酒公賣局台北酒廠	88年06月	智翎股份有限公司	90年11月	處	92年03月	英業達股份有限公司台北三廠	88年10月	兆勝科技股份有限公司	93年04月	漢磊科技股份有限公司研新廠	91年01月
三 有限公司二廠	92年03月	東隆興業股份有限公司-彰化廠	91年07月	台灣省菸酒公賣局竹南製瓶廠	92年03月	朝陽電裝股份有限公司	94年04月	內湖垃圾焚化廠	92年03月	英業達股份有限公司台北三廠	92年03月	全友電腦股份有限公司	92年01月	漢磊科技股份有限公司創新廠	90年10月
三五橡膠股份有限公司	92年03月	東雲股份有限公司	85年11月	台灣省菸酒公賣局花蓮酒廠	87年09月	植大橡塑膠業股份有限公司	91年03月	六和機械股份有限公司	92年01月	英群企業股份有限公司	92年03月	全日美實業股份有限公司	92年03月	碧悠電子工業股份有限公司	87年05月
三甲電子股份有限公司	92年03月	東遠企業股份有限公司	86年10月	台灣省菸酒公賣局屏東酒廠	92年03月	通力實業股份有限公司	89年10月	化新精密工業股份有限公司	90年12月	英誌企業股份有限公司	92年03月	全亞冠科技股份有限公司	92年03月	福佳建設股份有限公司	92年03月
三申機械工業股份有限公司	91年12月	東遠精技股份有限公司	92年11月	台灣省菸酒公賣局埔里酒廠	92年01月	堤躍建設股份有限公司	88年10月	友承股份有限公司	91年04月	虹光精密工業股份有限公司	89年01月	全拓股份有限公司	87年06月	福邑興業股份有限公司	92年03月
三匡科技股份有限公司	91年02月	東聯化學股份有限公司	92年03月	台灣省菸酒公賣局復興啤酒廠	89年08月	喜騰太陽能源工業股份有限公司	92年03月	友旺科技股份有限公司	92年03月	迪比恩科技股份有限公司	90年11月	全冠科技股份有限公司	90年04月	福宜化學工業股份有限公司	89年10月
三林粉末冶金股份有限公司	93年06月	司	86年04月	台灣省菸酒公賣局隆田酒廠	92年03月	翔昇電子股份有限公司	90年12月	友信國際股份有限公司	91年03月	音律電子股份有限公司	91年01月	全新光電科技股份有限公司	92年03月	福洋工業股份有限公司	87年01月
三芳化學工業股份有限公司	93年07月	松川精密股份有限公司	91年09月	台灣省菸酒公賣局彥農酒廠	92年03月	翔陽電機有限公司	91年01月	友訊科技股份有限公司	85年11月	飛宏企業股份有限公司	87年04月	全運通環保股份有限公司	88年07月	福特六和汽車股份有限公司	91年04月
三星五金工廠股份有限公司	92年03月	松和工業股份有限公司	89年10月	公司	92年04月	翔準先進光罩股份有限公司	92年12月	友達光電股份有限公司	90年02月	飛騰又昇股份有限公司	92年03月	全漢企業股份有限公司	93年09月	福特六和汽車股份有限公司	91年04月
三洋全能股份有限公司泰山工廠	90年03月	松際電腦股份有限公司	87年04月	台灣美加金屬股份有限公司	90年03月	翔瑞電梯股份有限公司	86年05月	友嘉實業工具機廠	92年08月	司台灣分公司(仁武焚化廠)	92年03月	全興工業股份有限公司	89年04月	福特六和股份有限公司	89年12月
三夏企業股份有限公司	91年01月	南區垃圾焚化廠	91年03月	台灣美加金屬股份有限公司	87年07月	菸酒公賣局台北菸廠	92年03月	天下電子股份有限公司	92年03月	香港商台灣兵兼股份有限公司	90年12月	全興方向盤股份有限公司	88年08月	福華電子股份有限公司	92年03月
三益制動科技股份有限公司	90年10月	欣鉑科技股份有限公司	93年08月	台灣美琪電子工業股份有限公司	92年03月	菸酒公賣局成功啤酒廠	92年03月	天助實業股份有限公司	92年03月	北分公司	90年12月	全興油封股份有限公司	87年06月	福隆玻璃纖維股份有限公司	92年01月
三勝製帽股份有限公司	92年03月	欣興電子股份有限公司	92年03月	台灣茂矽電子股份有限公司	87年06月	華上光電股份有限公司	90年03月	廠	88年03月	紹和纖維興業股份有限公司	89年06月	全興精機股份有限公司	89年04月	福業電子股份有限公司	91年07月
三陽工業股份有限公司	87年10月	欣興電子股份有限公司(合江廠)	90年07月	晶圓廠	92年07月	華升電子工業股份有限公司	85年12月	天域企業股份有限公司	93年01月	紹和纖維興業股份有限公司	91年08月	全懋精密科技股份有限公司	88年03月	福昇電子股份有限公司	90年08月
三陽能源開發股份有限公司	90年11月	凌電企業股份有限公司	92年08月	雄廠	92年11月	華友材料科技股份有限公司	92年08月	太乙印刷企業有限公司	92年03月	廠	88年06月	匠澤機械股份有限公司	87年10月	福裕事業股份有限公司	92年03月
三葉造漆工業股份有限公司	90年08月	潭分公司	92年03月	路廠	86年05月	華宇企業管理顧問股份有限公司	85年11月	太平洋汽門工業股份有限公司	92年07月	廠	91年08月	吉將環境工程有限公司	91年03月	福益實業股份有限公司	92年03月
三福化工股份有限公司竹北廠	88年12月	泛亞聚酯工業股份有限公司	92年07月	台灣飛利浦電子工業(股)中壢廠	92年03月	華宇企管顧問有限公司	89年01月	漢工廠	86年12月	紹昕實業股份有限公司	87年07月	吉將環境工程有限公司	91年03月	福雷電子股份有限公司	90年02月
三福化工股份有限公司善化廠	88年12月	矽成精體電路股份有限公司	93年01月	司大鵬廠	87年03月	華宇電腦股份有限公司	92年03月	園工廠	86年12月	倫飛電腦實業股份有限公司	90年09月	同泰保長國際股份有限公司	92年03月	福聚公司高雄廠	92年03月
三龍產業股份有限公司	87年07月	矽品精密工業股份有限公司	92年03月	大園廠	90年08月	華邦電子股份有限公司	93年07月	公司	93年07月	倉佑實業股份有限公司	92年08月	同欣電子工業股份有限公司	91年07月	福誼化學工業股份有限公司	92年02月
上欣製品廠	87年06月	分公司	91年07月	台灣食益補股份有限公司	90年06月	華亞電子股份有限公司	92年04月	太洋新技股份有限公司	88年10月	凌巨科技股份有限公司	92年03月	同智股份有限公司	89年07月	福興電業工廠股份有限公司	89年03月
上河/美河工業股份有限公司	91年07月	矽統半導體股份有限公司	93年04月	台灣神戶電池股份有限公司	90年03月	華東先進電子股份有限公司	89年10月	太煌有限公司	87年11月	凌華科技股份有限公司	91年06月	同隆螺絲工業有限公司	93年12月	福鎮環保工程股份有限公司	88年08月
上祈企業股份有限公司	年月	矽統科技股份有限公司	93年07月	台灣神戶電池股份有限公司	93年04月	華冠通訊股份有限公司	92年03月	文信電子有限公司	90年03月	凌群電機有限公司	92年07月	名傑營造股份有限公司	92年03月	精英電腦股份有限公司	89年05月
上海印刷廠股份有限公司	90年08月	空軍第一後勤指揮部	92年06月	廠	90年03月	華城電機股份有限公司	87年08月	日友環保科技股份有限公司	89年12月	原聚化學工業股份有限公司	93年03月	名岫企業股份有限公司	87年06月	綠春生技有限公司	94年02月
上銓環保科技股份有限公司	92年03月	空軍第三後勤指揮部	91年07月	台灣康旭股份有限公司	90年08月	華城電機股份有限公司第二廠	87年08月	日月光半導體股份有限公司	92年11月	[illegible]司	91年03月	合信汽車工業股份有限公司	92年09月	綠晶電機有限公司	91年12月
上晉電子股份有限公司	87年12月	維修工廠	91年07月	南科分公司	92年11月	華美電子股份有限公司	93年03月	日月欣半導體股份有限公司	91年11月	夏普電子股份有限公司	92年03月	合泰半導體股份有限公司	87年07月	綠電再生股份有限公司	93年02月
上銀科技股份公司	86年02月	花王(台灣)股份有限公司	87年09月	台灣理光股份有限公司彰化工廠	87年06月	華夏海灣塑膠股份有限公司	92年01月	日能企業有限公司	89年03月	家旺精機股份有限公司	90年11月	合晶科技股份有限公司	90年06月	聚鼎科技股份有限公司	91年04月
久尹股份有限公司	92年03月	迎廣科技股份有限公司	92年03月	台灣理研電線股份有限公司	89年02月	華容股份有限公司	87年10月	分公司	92年03月	展華化學工業股份有限公司	92年03月	合華科技股份有限公司	89年11月	臺唐工業股份有限公司	90年02月
久津實業股份有限公司	91年06月	金山實業股份有限公司	85年07月	台灣盛力電信科技股份有限公司	85年10月	部	92年01月	日勝化工股份有限公司	89年10月	崴新電腦股份有限公司	92年03月	合華電腦股份有限公司	87年06月	臺群纖維股份有限公司	92年03月
久登欣業有限公司	92年03月	金利橡膠股份有限公司	91年01月	台灣通用器材股份有限公司	92年03月	華特電子工業股份有限公司	92年03月	比偉工業股份有限公司	87年04月	振禪電子股份有限公司	92年03月	合勤科技股份有限公司	89年11月	遠見科技股份有限公司	90年02月
久陽精密工業股份有限公司	91年10月	金車股份有限公司	89年07月	訊廠)	87年03月	華洲電機工業股份有限公司	89年12月	永木製造廠有限公司	90年09月	晉禾企業股份有限公司	91年08月	合璧工業股份有限公司	92年03月	遠東企士頓科技股份有限公司	91年01月
久陽螺栓股份有限公司	89年10月	金和利股份有限公司	92年03月	台灣通信工業股份有限公司	86年06月	華通電腦股份有限公司	87年05月	丙辛西環保企業股份有限公司	92年02月	晉倫科技股份有限公司	92年03月	好而優工業股份有限公司	93年10月	遠東紡織股份有限公司內壢廠	89年07月
久曜彈簧有限公司	94年02月	金居開發銅箔股份有限公司	90年11月	台灣麥特化學工業股份有限公司	87年04月	華通電腦股份有限公司大園廠	89年09月	世大照明有限公司	87年06月	晉建工程股份有限公司	92年02月	好邦工業股份有限公司	92年03月	遠東紡織股份有限公司化纖廠	86年04月

Source: Taiwan Environmental Management Association

作 者 簡 歷

姓名：劉子衡

學歷：私立東海大學 環境科學系學士
美國 Pennsylvania State University 校本部 環境污染防治研究所碩士
美國 Pennsylvania State University 校本部 企業管理研究所碩士
國立交通大學 管理科學研究所博士

經歷：中國技術服務社污染防治中心 副工程師(1993-1995)
工業技術研究院化工所 副研究員/研究員(1995-1999)
工業技術研究院環安中心 研究員(2000-2002)
工業技術研究院環安中心 經理(2003-2004)
工業技術研究院能環所 主任(2005~迄今)

發表著作一覽表

A. 期刊論文

1. 朱博湧、熊杏華、林裕凌、劉子衡 (2005)，『非營利研發機構之智慧資本與績效評估—工研院之實證研究』，管理學報，第二十二卷，第三期，277-293 頁。(TSSCI)
2. Chu, Po-Young, Yu-Ling Lin, Hsing-Hwa Hsiung, and Tzu-Yar Liu (2006), "Intellectual Capital: An Empirical Study of ITRI," Technological Forecasting and Social Change, 73, 7, 886-902. (SSCI)
3. 朱博湧、林裕凌、熊杏華、劉子衡 (2007)，『工研院整體效益評估』，交大管理學報，第二十七卷，第二期。(TSSCI)
4. Chu, Po-Young, Yu-Ling Lin, Chi-Hung Huang, and Tzu-Yar Liu (2007), "Externality Evaluation: An Empirical Study of ITRI," International Journal of Technology Management, (SSCI) (已接受)
5. Wu, Shih-Ying, Po-Young Chu, Tzu-Yar Liu (2007), "Determinants of A Firm's ISO14001 Certification," Pacific Economic Review, (SSCI)(已接受)

B. 專書及專書論文

1. 朱博涌、熊杏華、林裕凌、劉子衡 (2006)，「非營利研發机构之智慧資本与績效評估-工研院之實証研究」，中國科技發展精典文酷，第一卷-科教興國，第七章科技研發与應用。

C. 技術報告及其它

1. 朱博湧、林裕凌、劉子衡、熊杏華(2003)，『工研院效益評估模式與實證』，工研院三十周年計畫，執行期間 2002 年 11 月~2003 年 6 月。