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DETERMINANTS OF A FIRM'S ISO 14001 CERTIFICATION: AN EMPIRICAL STUDY OF TAIWAN

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Abstract. Only rarely have empirical studies analysed 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 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 any significant impact of local governors' political party affiliation on firms' ISO 14001 certifications.

1. INTRODUCTION

Growing environmental pollution and ecological destruction have 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; rather, it focuses on management processes rather than specific environmental outcomes (Bansal and Bogner, 2002).[1] ISO 14001 is designed to be applicable to all types and sizes of organizations, and to accommodate diverse geographical, cultural

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[1] ISO 14001 describes the basic elements of an effective EMS, including creating an environmental policy, identifying firm impact on the environment, recognizing legislative requirements, setting environmental objectives and targets, implementing environmental programs to achieve those objectives, monitoring and measuring their effectiveness, correcting nonconformance and reviewing EMS to improve its environmental performance.

and social conditions; it thus offers a more flexible standard than alternatives such as the Eco-Management and Audit Scheme (EMAS).

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,b). The implementation of ISO 14000 may provide a means of establishing a national policy of self-governance, especially in countries that lack environmental regulation or enforcement capabilities (Wilson, 1998).

Since the late 1990s, 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 levels by passing a third party certification and/or to themselves by self-declaration. Compared with 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 US Acid Rain Program reveal that voluntary participation behaviour 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 US 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.[2] 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, General Motors, Xerox, Honda, Toyota, Hewlett Packard and Squibb, face pressure to pursue environmental certifications when 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).

[2] The USA, 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.

As of April 2005, the number of ISO 14001 certified facilities in Taiwan totalled 1463, ranking 14th worldwide (ISO world, 2005).[3]

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 (Arora and Cason, 1995; Henriques and Sadorsky, 1996; DeCanio and Watkins, 1998; 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 US firms in the Green Lights programme. Moreover, empirical studies have investigated the factors driving firms to seek ISO 14001 certification in developing economies such as China and Hong Kong (Chan and Li, 2001; Christmann and Taylor, 2001; Cushing *et al*., 2005). 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 Taiwan's political agenda. 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.

This study examines the factors driving Taiwanese firms to seek ISO 14001 certification. Particularly, it analyses whether or not international trade and local governors' party affiliation influence a firm's likelihood of adopting ISO 14001. The rest of this paper is organized as follows. Section 2 first discusses pertinent literature and then presents different hypotheses. Section 3 then describes the econometric specification, data sources, and explanatory variables. Subsequently, the estimation results are then provided and discussed in the results and discussion section. Conclusions are finally drawn.

2. LITERATURE

2.1. *International trade*

Reduced barriers to trade and foreign direct investment have increased globalization. Consequently, some are concerned that countries with lax environmental

[3] As of April 2005, the number of ISO 14001-certified organizations worldwide reached 88,800.

regulations might become 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 USA generally demand a higher environmental standard for imported products. Therefore, this study proposes that firms with higher ratios of products exported to the EU, Japan and the USA are more likely to seek ISO 14001 certification than those with lower export ratios.

2.2. *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 al.*, 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 4000 residents of the area around the proposed plant site.[4] 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*, 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 with 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 of 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 or not firms adjust their environmental strategies in response to demands from various local policymakers. As noted above, local policymakers may choose different environmental standards to promote the wellbeing 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.

2.3. *Certification subsidy*

The Taiwanese government began to promote various programmes for improving the environmental performance of industry during the mid-1980s. Notably, the

[4] 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.

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, 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 in 1996–2000 and up to a maximum of US$6000 per case since 2001.[5]

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, 2006). 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.

2.4. *Firm attributes*

We also account for firm level determinants in analysing 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 *et al.* 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 compared with 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 certification 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$5000 to US$10,000. Developing, certifying

[5] The government budgets appropriated for subsidizing ISO certification were US$277,000, US$267,000, US$243,000, US$173,000, US$207,000, US$257,000, US$143,000, US$170,000 and US$147,000 for the years ranging from 1996 to 2004, respectively (Source: Taiwan Environment Management Association). The exchange rate over this period was around NT$30 per US dollar.

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) found 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 the 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 of 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 neighbouring 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 both 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.

3. METHOD AND DATA

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,

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

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.[6]

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.[7]

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

[6] The maximum likelihood estimates for the firm specific fixed effects η_i and $\tilde{\beta}$ are inconsistent 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.

[7] 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.

at most one observation of ISO 14001 certification. Following this procedure, we have a final sample of 6692 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,[8] 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 US 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.

[8] The Chinese National Accreditation Board has been transformed into the Taiwan Accreditation Foundation since 2004.

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 $6000 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.[9] 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 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.[10]

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

[9] Returns on assets are based only on current year data.

[10] The categorization in this study is based on the definition of an urban area from http://www.dgbas.gov.tw/.

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 1 lists the summary statistics for the final sample of 6692 observations 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 1 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 10% 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.

We also provide the summary statistics for each of the six industries with observations more than 200 in Table 2.[11] Table 2 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 14010

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

Table 1. Descriptive statistics

	Whole sample				*Certified firms*			
Variables	*Mean*	*S.D.*	*Min.*	*Max.*	*Mean*	*S.D.*	*Min.*	*Max.*
Binary dependent variable								
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	6692				332			

Notes: 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 USA. The statistics for a four-year averaged ratio of profit to sales are based on a subsample of 6627 observations after observations with larger losses are excluded.

Table 2. Descriptive statistics by industry

Variables	*Mean*	*S.D.*	*Min.*	*Max.*	*Mean*	*S.D.*	*Min.*	*Max.*
	Plastics industry				*Textile industry*			
Binary dependent variable								
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)	14.912	1.504	12.58	19.61	14.924	1.060	12.44	18.16
Profitability								
Current year ratio of profit to sales	0.037	0.215	–2.47	0.47	–0.012	0.194	–1.68	–/41
4-year averaged ratio of profit to sales	0.043	0.148	–0.99	0.46	0.004	0.136	–0.93	0.35
Current year return on asset	0.077	0.064	–0.17	0.26	0.056	0.075	–0.24	0.31
Current year return on equity	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)	30.384	9.896	12	61	31.259	9.842	13	61
Urban	0.663	0.474	0	1	0.667	0.472	0	1
Observations		223				474		
	Machinery industry				*Chemical industry*			
Binary dependent variable								
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)	14.365	0.842	12.29	17.26	14.129	0.012	0.11	0.18
Profitability								
Current year ratio of profit to sales	0.073	0.130	–1.10	0.47	0.010	0.661	–8.73	2.15
4-year averaged ratio of profit to sales	0.074	0.096	–0.38	0.37	0.012	0.443	–4.20	1.15
Current year return on asset	0.106	0.087	–0.30	0.58	0.097	0.101	–0.58	0.61
Current year return on equity	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)	27.313	10.173	7	60	29.945	14.001	4	61
Urban	0.718	0.451	0	1	0.643	0.480	0	1
Observations		422				526		
	Metals industry				*Electronics industry*			
Binary dependent variable								
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)	15.226	1.117	12.4	19.12	14.191	1.301	9.14	19.99

Table 2. Continued.

Variables	*Mean*	*S.D.*	*Min.*	*Max.*	*Mean*	*S.D.*	*Min.*	*Max.*
	Metals industry				*Textile industry*			
Profitability								
Current year ratio of profit to sales	0.008	0.137	–1.20	0.36	0.031	0.501	–9.66	4.12
4-year averaged ratio of profit to sales	0.003	0.085	–0.57	0.20	0.008	0.431	–4.97	2.55
Current year return on asset	0.064	0.068	–0.27	0.32	0.114	0.134	–1.16	1.15
Current year return on equity	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)	29.008	9.422	8	45	17.993	9.337	1	65
Urban	0.622	0.486	0	1	0.910	0.286	0	1
Observations		246				4308		

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

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.

4. RESULTS AND DISCUSSION

Table 3 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 assets and return on equity. The estimates in column (5) are from a regression based on the observations for the electronics industry. Table 3 indicates that ISO 14001 certification is significantly correlated to export ratio, subsidy, firm size, R&D and location in THE 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.[12] Firms do not spend less in environmental protection to reduce production costs when facing competition in foreign markets. This

[12] To avoid the endogeneity problem of current year export ratios, we also conducted an estimation with the export ratio replaced with the one-year lag values. However, the estimates are similar to those based on current year export ratios.

Table 3. Results of the random effects probit regressions

	Current year ratio of profit to sale		*4-year averaged ratio of profit to sale*		*Current year return on asset (ROA)*		*Current year return on equity (ROE)*		*Current year ratio of profit to sale – the electronics industry*	
	(1)		*(2)*		*(3)*		*(4)*		*(5)*	
Variables	*Estimate*	*t-values*	*Estimate*	*t-values*	*Estimate*	*t-values*	*Estimate*	*t-values*	*Estimate*	*t-values*
Main variables										
Weighted export ratio	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		

Table 3. Continued.

	Current year ratio of profit to sale		*4-year averaged ratio of profit to sale*		*Current year return on asset (ROA)*		*Current year return on equity (ROE)*		*Current year ratio of profit to sale – the electronics industry*	
	(1)		*(2)*		*(3)*		*(4)*		*(5)*	
Variables	*Estimate*	*t-values*	*Estimate*	*t-values*	*Estimate*	*t-values*	*Estimate*	*t-values*	*Estimate*	*t-values*
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: The measures of profitability utilized for the estimates in columns (1), (2), (3) and (4) are current year ratio of profit to sale, four-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. The symbols ***, **, and * represent statistical significance at the level of 1%, 5% and 10%, respectively.

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 (Chan and Li, 2001; Cushing *et al.*, 2005). Firms need to meet environmental concerns 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 fulfil 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$6000 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 firms' incentive to become ISO 14001 certified owing to the endogeneity problem.[13]

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

[13] Alternatively, we can utilize the exogenous variation in the government subsidy budget and include the values of budget for each year in the regressions to estimate the incentive effects. However, the values of budget for each year are collinear with year dummies, making it impossible to identify the budget effects from the year effects.

and up to a maximum of US$6000 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 3 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 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 behaviour (Fineman and Clark, 1996; Christmann and Taylor, 2001), 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.[14] 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 industry and the food industry 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.

5. CONCLUSION

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 Taiwan's political agenda.

Despite firm responses to environmental issues being an important aspect of environmental management, rare empirical studies have analysed the responses of Taiwanese manufacturing firms to ISO 14001. This study investigates the determinants of Taiwanese firms' decisions to voluntarily adopt environmental standards, and thus can provide implications regarding future environmental

[14] The authors thank the reviewer for suggesting this possible reason.

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 US 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.

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.

REFERENCES

Aragon-Correa, J. A. (1998) 'Strategic Proactivity and Firm Approach to the Natural Environment', *Academy of Management Journal* 41, 556–67.

Arora, S. and T. N. Cason (1995) 'An Experiment in Voluntary Environmental Regulation: Participation in EPA's 33/50 Program', *Journal of Environmental Economics and Management* 28, 271–86.

Bansal, P. (2002) 'The Corporate Challenges of Sustainable Development', *Academy of Management Executive* 16, 122–31.

Bansal, P. and W. C. Bogner (2002) 'Deciding on ISO 14001: Economics, Institutions, and Context', *Long Range Planning* 35, 269–90.

Bansal, P. and T. Hunter (2003) 'Strategic Explanations for the Early Adoption of ISO 14001', *Journal of Business Ethics* 46, 289–99.

Bruce, D. (2000) 'Effects of the United States Tax System on Transition into Self-Employment', *Labour Economics* 7, 545–74.

Brunnermeier, S. B. and M. A. Cohen (2003) Determinants of Environmental Innovation in US Manufacturing Industries', *Journal of Environmental Economics and Management* 45, 278–93.

Chamberlain, G. (1980) 'Analysis of Covariance with Qualitative Data', *Review of Economic Studies* 47, 225–38.

Chan, K. Y. and X. D. Li (2001) 'A Study of the Implementation of ISO 14001 Environmental Management Systems in Hong Kong', *Journal of Environmental Planning and Management* 44, 589–601.

Chapple, W., A. Cooke, V. Galt and D. Paton (2001) 'The Characteristics and Attributes of UK Firms Obtaining Accreditation to ISO 14001', *Business Strategy and the Environment* 10, 238–44.

Christmann, P. and G. Taylor (2001) 'Globalization and the Environment: Determinants of Firms Self-Regulation in China', *Journal of International Business Studies* 32, 439–58.

Chu, P. Y., M. J. Teng, C. H. Huang and H. S. Lin (2005) 'Virtual Integration and Profitability: Some Evidence from Taiwan's IC Industry', *International Journal of Technology Management* 29, 152–72.

Clark, D. (1999) 'What Drives Companies to Seek ISO 14000 Certification?', *Pollution Engineering* Summer, 14–18.
Cushing, K. K., H. McGray and H. Lu (2005) 'Understanding ISO 14001 Adoption and Implementation in China', *International Journal of Environment and Sustainable Development* 4, 246–68.
Dasgupta, S., B. Laplante, H. Wang and D. Wheeler (2002) 'Confronting the Environmental Kuznets Curve', *Journal of Economic Perspective* 16, 147–68.
DeCanio, S. J. and W. E. Watkins (1998) 'Investment in Energy Efficiency: Do the Characteristics of Firms Matter?', *Review of Economics and Statistics* 80, 95–107.
Delmas, M. A. (2001) 'Stakeholders and Competitive Advantage: The Case of ISO 14001: The Case of ISO 14001', *Production and Operations Management* 10, 343–58.
Fineman, S. and K. Clarke (1996) 'Green Stakeholders: Industry Interpretations and Response', *Journal of Management Studies* 33, 715–30.
Freeman, D. (1997) 'Cost/Benefit Analysis of ISO 14001 Implementation', GETF http://www.iso14000.net/empire/?SubSystemID=1andComponentID=15667.
Hall, B. and J. Van Reenen (2000) 'How Effective Are Fiscal Incentives for R&D? A Review of the Evidence', *Research Policy* 29, 449–69.
Hartman, R. S., M. Huq and D. Wheeler (1997) 'Why Paper Mills Clean Up: Determinants of Pollution Abatement in four Asian Countries', *Policy Research Working Paper* 1710, Washington, D.C.: World Bank.
Henriques, I. and P. Sadorsky (1996) 'The Determinants of an Environmentally Responsive Firm: An Empirical Approach', *Journal of Environmental Economics and Management* 30, 381–95.
Industrial Development Bureau (IDB), Ministry of Economic Affairs (MOEA) (2002) *Brochure of 2002 Development of Industries in Taiwan*, 2–38.
Industrial Development Bureau (IDB), Ministry of Economic Affairs (MOEA) (2006) *IDB Library Collection of Final Reports of ISO 14001 EMS Demonstration and Promotion Projects*, 1996–2004.
ISO World (2005) *The Number of ISO 14001/EMAR Registration of the World*. http://www.ecology.or.jp/isoworld/english/analy14k.htm (accessed May 6, 2006).
Jaffe, A., S. Peterson, P. Portney and R. Stavins (1995) 'Environmental Regulation and the Competitiveness of US Manufacturing: What Does the Evidence Tell Us?', *Journal of Economic Literature* 33, 132–63.
Jiang, R. J. and P. Bansal (2003) 'Seeing the Need for ISO 14001', *Journal of Management Studies* 40, 1047–67.
King, A. and M. Lenox (2001) 'Who Adopts Management Standards Early? An Examination of ISO 14001 Certifications', *Proceedings of the Academy of Management Annual Conference* 1, A1–A6.
Konar, S. and M. A. Cohen (2001) 'Does the Market Value Environmental Preformance?', *Review of Economics and Statistics* 83, 281–9.
Montero, J. (1999) 'Voluntary Compliance with Market-Based Environmental Policy: Evidence from the U.S. Acid Rain Program', *Journal of Political Economy* 107, 998–1033.
Nakamura, M., T. Takahashi and I. Vertinsky (2001) 'Why Japanese Firms Choose to Certify: a Study of Managerial Responses to Environmental Issues', *Journal of Environmental Economics and Management* 42, 23–52.
New York Times (1998) 'Bayer to Build Plant in Texas, Not Taiwan', March 19.
Noci, G. and R. Verganti (1999) 'Managing Green Product Innovation in Small Firms', *R & D Management* 29, 3–15.
Oates, W. E. (2001) 'A Reconsideration of Environmental Federalism', *Discussion Paper* 01–54, Washington, DC: Resources for the Future.
Porter, M. E. and C. van der Linde (1995a) 'Toward a New Conception of the Environment-Competitiveness Relationship', *Journal of Economic Perspectives* 9, 97–118.
Porter, M. E. and C. van der Linde (1995b) 'Green and Competitive: Ending the Stalemate', *Harvard Business Review* 73, 120–34.
Roht-Arriaza, N. (1997) 'Environmental Management Systems and Environmental Protection: Can ISO 14001 Be Useful Within the Context of APEC?', *Journal of Environment and Development* 6, 292–316.
Suchman, M. C. (1995) 'Managing Legitimacy: Strategic and Institutional Approaches', *Academy of Management Review* 20, 571–610.
Wilson, R. C. (1998) 'The Developing World Looks to ISO 14000 for Help', *Pollution Engineering* 30, 37–8.