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Which "green" is better? An empirical study of the impact of green activities on firm performance

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ABSTRACT

This study aims to distinguish an array of green activities (ISO 14000, green processes, pollution prevention, and green certifications) and analyze their relationships with firm performance. Employing data from the sampled publicly listed firms in Taiwan and regressions to examine the hypotheses, we find that the degree of a firm's R&D investment fails to affect companies' choice of green activities; however, the degree of firm internationalization can. That is, more internationalized firms are also more likely to employ green certifications among these activities. In terms of the impacts of these green activities on firm performance, a company employing green processes can perform better, followed by ISO 14000, pollution prevention, and lastly, green certifications.

1. Introduction

Green activities have received growing attention in the wake of climate change (Bhuian, Joonas, & Ruiz, 2007). Eco-friendly products may reduce a customer's price consciousness (Hunt & Auster, 1990; Hur, Kim, & Park, 2013), while green strategies may improve a firm's competitive advantage (Hart, 1995; Marti, Rovira-Val, & Drescher, 2013). Environmental awareness is on the rise and firms that opt for green solutions can not only respond to customer demands, but also improve their profitability. McWilliams and Siegel (2001) supported this argument, outlined environmental social responsibility, and highlighted that companies going beyond environmental regulatory compliance should earn more returns.

Prior research on green activities has emphasized various subjects such as product and market strategies (Menon & Menon, 1997), firms' motivation to conduct green activities (Buysse & Verbeke, 2003; Sully de Luque, Washburn, Waldman, & House, 2008; Waldman, Siegel, & Javidan, 2006), sources of competitive advantages (Hart, 1995; Jennings & Zandbergen, 1995; McWilliams, Van Fleet, & Cory, 2002) or supply chain management (Lee, 2008). Although discussions on green activities have been provocative, their heterogeneity receives less attention.

In particular, research on green studies has been popularly associated with competitive advantage (Hart, 1995; Jennings & Zandbergen, 1995; McWilliams et al., 2002). Hart (1995) used a resource-based view to explain the relationship between environmental opportunities and competitive advantage, and Russo and Fouts (1997) analyzed 243 firms to prove that high-level environmental performance will enhance firm profitability. However, different green activities produce different kinds of competitive advantage, which bears investigation (Porter & Linde, 1995; Siegel, 2009; Sully de Luque et al., 2008). Olson (2008) advanced an enterprise-level green activity that leads to cost-down effectively. Siegel (2009) observed that green activity can promote a company's image to increase profitability.

Companies with competitive advantage should be able to outperform their competitors (Porter, 1985). That is, competitive advantage is important for a firm to perform better, and green strategies should improve a firm's competitive advantage, but different strategies create different competitive advantages for the company (Porter & Linde, 1995). Hence, firms with different competitive advantage should perform well but differently.

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However, empirical evidence in this regard is scarce, and this article attempts to fill this void.

Hart (1995) developed a resource-based view with the nature of firms, and considered that green activities could form competitive advantage for companies. McWilliams et al. (2002) and Siegel (2009) found that green activities could improve intangible resources to increase competitive advantage to thereby increase performance; that said, less attention has been paid to issues concerning which green activities can lead to better firm performance. In short, there is a need for research about the strength of performance produced from different green activities. This article aims to classify green activities and find the relationships between firm characteristics and the types of green activities. Further, this article aims to discover what green activity can cause better firm performance. Hence, the main research objectives of this study include the following two main research questions: Does a firm's characteristics affect its green strategy decisions? Does its green activities affect firm performance?

This study has multifold contributions. First, it emphasizes heterogeneity in green activities and analyzes how firm characteristics can react to different green strategies. Second, it fills the gap in the relationships between green activities and firm performance. It makes an early attempt to define the relationships between each of different green activities and firm performance. Third, this study provides empirical evidence concerning whether firms employing green activities should correct those activities' defects and implement green processes to improve their performance. The findings provide the top management team with evidence regarding its efforts to depend on green activities for better performance and provide the boards of directors with evidence regarding their knowledge and practices in strategizing a firm's green activities under different firm characteristics.

This article's first section introduces the main research agenda and contributions. The second section addresses related theories to further develop the hypotheses. The third addresses the methodology used and data analyzed from Taiwanese firms. The fourth explains the results. The fifth addresses the conclusion and implications based on the empirical findings. The final section addresses limitations for future research.

2. Literature and hypotheses

Prior research has investigated what motivates a firm's green activities. Bansal and Roth (2000) found that competitiveness, legitimization, and ecological responsibility are the main three drivers of corporate ecological responses. Buysse and Verbeke (2003) found a strong association between stakeholders and proactive green activities. Furthermore, other researchers also discovered CEO leadership's influence on green activities (Sully de Luque et al., 2008; Waldman et al., 2006). That is, various reasons can motivate a firm to conduct green activities.

2.1. Environmental awareness and green activities

Among various motivations for green activities, the rise of environmental awareness can be critical to the development of a firm's green strategies. For example, pollution has been a major concern to the public, and many governments have passed a series of bills with unprecedented regulations of air and water quality. King (1994) and Porter and Linde (1995) further argued that pollution hid wasted resources and effort, and could lead to inefficiency. Thus, in the 1990s, the International Organization of Standardization (ISO) developed ISO 14000 standards relating to environmental management. More and more firms and supply chains have adopted the ISO 14001 certification, which sets the basic standards of firms' environment (Castka & Balzarova, 2006). There are two kinds of technical structures in ISO 14000: One is environmental management systems (EMSs) and the other is life-cycle assessments. ISO 14000 family certifications reveals that "a firm has a well-documented consistent EMS," but "does not in itself say anything about a firm's environmental impact" (Albuquerque, Bronnenberg, & Corbett, 2007, p. 452), and firms have to submit to reinspection every three years to maintain their certification (Albuquerque et al., 2007). A firm pursues ISO 14000 certifications for various reasons including company image, environmental protection, and marketing advantage (Pan, 2005). That is, ISO 14000 certifications respond to society's expectations. In the international market, price and quality are the important factors in the selection of suppliers, but an EMS is often considered (Bellesi, Lehrer, & Tal, 2005). Hence, using EMSs increases a firm's competitiveness (Leal, Casadesús, & Pasola, 2003). Next, through life-cycle assessments, Braungart, McDonough, and Bollinger (2007) developed the idea further with the "Cradle to Cradle" concept, arguing that any product design must begin with means to naturally and constantly recycle products and retain value. This new design framework for product and process promotes environmental health and economic growth.

Menon and Menon (1997) responded to the rise of environmental awareness and stated that environmental concerns had changed global competence, and environmental regulations had impacted firms' strategies, which should reflect the confluence of environmental concerns for the benefit of the ecosystem. Olson (2008) further argued that green activity should influence a firm's strategic formulation and operations, and firms should build a culture of awareness about greenness and actions to facilitate environmental decisions and transformation initiatives for better performance.

Hence, *green activity* can be defined as a company's environmental behavior, including extensively environmental activities, which can assist a firm in its decision-making process and can benefit the environment. Accordingly, we can use two important dimensions to further identify types of green activities: products and supporting infrastructure. In terms of the first dimension on product, scholars have suggested different strategies about products; for example, developing new green products (Menon & Menon, 1997; Braungart et al., 2007; Olson, 2008; Siegel, 2009), or renewing the efficiency process to manufacture original products (Nehrt, 1996; Olson, 2008; Porter & Linde, 1995; Siegel, 2009). In terms of the second dimension on supporting infrastructure, Porter (1985) considered that any changes of strategies need fundamental infrastructure to support these changes, such as developing new products needing renewable equipment. Based these two dimensions, we identify four different types of green activities as follows:

Type 1: ISO 14000. When a corporation seeks ISO 14000 certifications, it needs to upgrade its software. Because ISO 14001 concerns the execution of an EMS, the company will need to buy software to adapt to the EMS. Moreover, ISO argues that the EMS can reduce costs and waste. The ISO 14000 certifications emphasize that companies should establish an environmental mission to improve products by changing the processes or innovating new green products.

Type 2: green processes. This type of green activities includes a whole new green product and renewal process. Hart (1995) and Braungart et al. (2007) claimed that a company's product development should include a life-cycle assessment. The company should consider its products from the materials used to a nonpolluting recycling process. Therefore, when companies decide to develop and manufacture a new green product, they

often need to change their materials and hardware to support this strategy. Hart (1995) noted that a company can use total quality management (TQM) to reduce waste and costs, and Olson (2008) noted that Six Sigma can help a company enhance its manufacturing efficiency and decrease emissions. TQM and Six Sigma emphasize the manufacturing process and improve production efficiency by reducing costs. Both the new green product and renewal process require changes in production, and need new company software to support them.

Type 3: pollution prevention. Companies manufacture an original product, and use large equipment to store, treat, and recycle emissions. Thus, strategies to prevent pollution require setting up new hardware to recycle pollutants after manufacturing the products.

Type 4: green certifications. Green certifications (e.g., WEEE and RoHS) certify a firm's green actions. Electrical manufacturers exporting their products to the European Union (EU) need to observe RoHS, which pushes them to avoid contaminated matter. Hence, this article includes green certifications in the study of green activities because these certifications should be able to attest to the environmentalism of products.

Some scholars argued that green activities can give a firm competitive advantage (Hart, 1995; Porter & Linde, 1995; Olson, 2008; Siegel, 2009). Based on resource-based view theory, firms with distinctive sources and capabilities have key competitive advantages. Ansoff (1965) and Hofer and Schendel (1978) confirmed this. Corporations should emphasize value, rareness, inimitability, and insubstitutability to establish and sustain competitive advantage (Barney, 1986; Coyne, 1986). A firm's core ability and competency can also benefit its performance and profitability (De Carolis, 2003; Grant, 1991; Lu & Yang, 2004). That is, competitive advantage from green activities should be able to predict companies' performance. Hart (1995) used a resource-based view of the firm to explain green activity, developed the theory to include the opportunities offered by the biophysical environment, and further expanded three green interconnected activities concerning pollution prevention, product stewardship, and sustainability, each of which can improve competitive advantage differently to bring a different level of profitability.

Apart from gaining competitive advantage, firms can gain a good image in the community and improve their reputation (Siegel, 2009). That is, corporate social responsibility should include a firm's green strategy. Through taking responsibility for the environment, firms should be able to build their reputation and can attract socially responsible consumers, who expect such actions. Hence, environmental concerns have begun to influence firms' strategies. Green renewal processes can earn a firm cost-leadership advantage (Porter & Linde, 1995), while differentiated strategies on new green products can lead to different competitive advantage (Menon & Menon, 1997). Furthermore, ISO 14000 can enhance companies' reputation and cut their costs (Welch, Rana, & Mori, 2003). Instituting pollution control can also improve companies' image (Makower, 2009). In short, companies employing green activities should obtain competitive advantage and perform better.

2.2. Firm characteristics and green activities

Prior research has posited that degree of research and development (R&D) and internationalization should influence firms' decisions to adopt green activities. That is, firms with a high degree of R&D investment were highly likely to find technological solutions for pollution problems (Nakamura, Takahashi, & Vertinsky, 2001); firms in export-oriented countries were more likely to seek ISO 14000 (Roht-Arriaza, 1997). Therefore, R&D and internationalization are discussed as follows.

2.3. Investment in R&D and green activities

Discussions on resources have varied. Barney (1991) differentiated resources into three types: physical capital, workforce capital, and organizational capital; Collis and Montgomery (1995) classified them into tangible resources, intangible resources, and organizational capability; while Chatterjee and Wernerfelt (1991) categorized resources as physical, intangible, and financial. Competitive capabilities may result from a firm's intangible capital, which includes technological capability, innovational capability, and patent rights. Therefore, degree of investment in R&D should influence the resources and competitive capabilities of a firm because R&D investment is critical to build a firm's technological capabilities. Since resources and capabilities play a key role in a firm's environmental policies (Russo & Fouts, 1997), investment in R&D should influence a firm's choice to adopt different types of green activities.

2.3.1. Internationalization and green activities

Internationalization should affect many business activities (Phatak, 1992), and international diversification can be seen as the "expansion across the borders of global regions and countries into different geographic locations or markets" (Hitt, Hoskisson, & Kim, 1997, p. 767). More and more, international companies need to face competitors from all over the world. Multinational corporations must adopt differences in factor costs across borders and develop distinct core competencies to gain competitive advantage. International society also puts pressure on multinational firms to improve their environmental performance and produce green products. Hence, internationalization should influence the greenness of a firm's activities because global consumers demand greenness more when they purchase and some international markets (such as the EU) have established stricter green laws to limit products sold to their markets. Thus, companies must conform to this green trend to respond to increasing environmental pressure and challenges.

Therefore, as global competition increases, firms must accumulate capabilities and resources to form core competencies (Prahalad & Hamel, 1990). Hart (1995) noted that companies depend on their resources to develop green activities. Those resources should thus affect the selections of various green activities. If a firm has abundant resources in R&D, the firm should lean toward different types of green activities. Of the four types we mention, pollution prevention may demand the least resources because firms adopting it need only to build "end-of-pipe" capitals. End-of-pipe solutions are often ready-made technologies (Christmann, 2000). Hence, these firms depending on pollution prevention do not need to increase investment in R&D, but may continue to accumulate more pollution control equipment. Therefore, we establish the following hypothesis:

H1a. A firm investing to a lesser degree in R&D may adopt pollution prevention.

Many businesses are internationalizing, whether privately or publicly owned (Phatak, 1992). Due to the rise of environmental awareness, companies have spent more on environmental protection implementations, and enterprises have started to renew processes or create green products to ensure that their goods will adhere to the related regulations. That is, the more a firm is exposed to the international market, the greener it should be to enter the respective market (e.g., the aforementioned EU market). Hence, among the four different types of green activities, green

certifications should most concern an international company. If an export-oriented firm expects to sell its electronic products to Europe, it must respond to the respective regulations with some proofs (certifications). Therefore, if a company has internationalized more, it is most likely to choose green certifications among other green options. Thus, we establish the following hypothesis:

H1b. A more international firm is more likely to seek green certifications.

2.4. Green activities and firm performance

This article analyzes green activities from four different types: Type 1 is ISO 14000. Companies establish the EMS to seek ISO 14000 certifications to help develop green products and promote product efficiency. Type 2 is green processes that include new green products and renewal processes. Companies create new clean products or renew their processes to become more efficient. Type 3 is pollution prevention. Companies recycle waste products after production. Type 4 is green certifications. Products that pass green certifications prove that they are clean for consumers and able to export to other countries. Corporations employing different green activities can earn different competitive advantage discussed in detail below.

In terms of Type 1 activities, companies adopting ISO 14000 certifications may perform better than companies adopting other green activities. ISO 14000 international standards are established to include environmental perspectives among firm operations and standards of products. ISO 14001 requires companies to establish and maintain EMSs, and asks companies to define their environmental policies according to the standards. Welch et al. (2003) felt that ISO 14000 certifications create a good reputation for companies and increase their environmental performance. Because ISO is an international organization with great authority, ISO 14000 certifications can increase companies' reputation more than other green certifications. Companies seeking ISO 14000 certifications can also create differential advantage. ISO 14000 certifications can respond to customers' demands and help companies develop new green products. Furthermore, ISO 14000's multinational acceptance aids the export process (Tibor & Feldman, 1996) and attracts more customers (Makower, 2009). Thus, ISO certifications are the most efficient green activity to better company performance.

Companies that adopt green processes (Type 2) will earn more performance value than those adopting pollution prevention (Type 3). Green processes include renewal processes and new green products. Renewal processes can cut costs, and operational processes' causal ambiguity often makes them hard for competitors to copy. New green products can earn market share and form barriers to entry. Moreover, green processes also need large distinctive resources to support them. These resources involve intangible and tangible resources, such as technology, equipment, R&D, and human resources. When companies form distinctive competitive advantage, they make it more difficult for competitors to compete and thus gain more profitability. Menon and Menon (1997) considered that new green products can use or focus differentiation strategies to improve performance. In addition, corporations can build preemptively to perform better. Early entrants into new markets obtain an enduring competitive advantage over late entrants (Bain, 1956; Kettinger, Grover, Guha, & Segars, 1994). New green products also increase market share (Siegel, 2009). Porter and Linde (1995) proposed that increased efficiency can reduce waste. Renewal processes can reduce waste, prevent pollution, and improve companies' manufacturability. Therefore, companies can gain more reputation and perform better than companies only preventing pollution.

Companies with other types of green certifications can perform better than companies that adopt green processes or pollution prevention. Green certifications focus on nontoxic, pollution-free end products. Firms that earn green certifications can prove their efforts in environmental protection and have preemptive advantage over other companies (Kettinger et al., 1994). Firms gain better reputation than do companies employing green processes. Moreover, enterprises with green certifications can get into specific markets, such as the European market. Since the EU enforced WEEE and RoHS, companies selling electronic products to Europe must own related green certifications. For these reasons, enterprises with green certifications can perform better than companies with green processes or pollution prevention.

Thus, based on the aforementioned discussions over activities of Type 1 to Type 4, we propose the following hypothesis:

H2. Firms adopting different green activities gain different levels of advantage: the most lucrative is ISO 14000, then green certifications, then green processes, and the lowest is pollution prevention.

3. Methodology

3.1. Data and sample

We tested our hypotheses with data from firms in the electronic industry in Taiwan. We collected data from the *Taiwan Economic Journal* (TEJ) and official websites of the sampled firms. We also reviewed the disclosure of these firms' annual reports and compiled the data according to their self-descriptions to identify what kinds of green activities each company has adopted. We only analyzed companies that had adopted green activities. The sample size for examining Hypothesis 1 is 599, and the sample size for examining Hypothesis 2 is 627.

3.2. Variables – dependent variables

Green activities. Green activities served as dependent variables (Models 1 and 2) and independent variables (Model 3) for the present study. Based on previous research (e.g., Braungart et al., 2007; Olson, 2008; Porter & Linde, 1995; Welch et al., 2003), we define and categorize these four types of green activities accordingly (i.e., *Type 1*: *ISO 14000*; *Type 2*: *green processes*; *Type 3*: *pollution prevention*; *Type 4*: *green certifications*). Data came from the disclosures on the annual reports and official websites. Each activity uses a dummy variable that is equal to 1 to identify that the firms have employed green activities; otherwise, 0. Additionally, the total number of activities a company adopts measures the variable of green activities. For example, companies may have employed two or more green activities; we code them two or more times, accordingly, if these green activities are not employed at the same time.

Performance. The dependent variable is a company's return on equity (ROE). ROE can measure whether a company's use of funds is efficient. Kettinger et al. (1994) argued that strategic systems typically have a one-to-two-year startup period. Therefore, measure of performance three years after startup can facilitate the analysis of companies' competitive positions. Thus, we measure ROE after a three-year startup period to evaluate a company's performance. We collected data of ROE from 1996 to 2008 to examine the hypotheses.

3.3. Variables — independent variables

We characterize firms with the following two categories: *Degree of R&D* and *degree of internationalization*.

Degree of R&D. Past empirical studies use the R&D intensity (expense in R&D/sales) to be a proxy variable (Ito & Rose, 1999; Sougiannis, 1994). However, the R&D intensity may lag in impact, so most research uses previous R&D intensity to measure the degree of R&D investment. Therefore, we employ the average R&D intensity in the previous three years to measure this variable.

Degree of internationalization. Internationalization can influence firm performance (Collins, 1990; Gomes & Ramaswamy, 1999). Thus, the present study includes this variable. There are various proxies to measure it (Sullivan, 1994). Of these, we employ the average of export sales as a percentage of total sales (ESTS) in the previous three years to measure a firm's degree of internationalization.

We collected data of R&D intensity and ESTS from 1996 to 2008 because the first company in the electronic industry started to adopt green activities in 1993. Therefore, we have different sample sizes for testing Hypotheses 1a, 1b and Hypothesis 2.

3.4. Variables — control variables

Firm size. Firm size may affect firm core resources, which strongly correlate to corporate performance (Choonwoo, Kyungmook, & Pennings, 2001). Thus, the present study includes firm size and measures it by the natural logarithm of a firm's total assets.

Timing. The time a company first employs green activities may affect its performance due to first-mover advantage or disadvantage (Lieberman & Montgomery, 1988). The present study includes timing as a control variable to identify when a company starts to adopt green activities. In our sample, the earliest implementation of green activities began in 1993, and we collected data up to 2006. Furthermore, we found that many companies started to employ green activities in 2000. Therefore, we divided companies into two groups: early adopters and late adopters, separating them by dummy variables of 1 and 0 respectively.

Industry sectors. Companies in different industry sectors may perform differently. In our data, the TEJ classifies companies into seven sectors in the electronic industry (i.e., *Industry Sector 1*: semiconductors; *Industry Sector 2*: computers and peripheral equipment; *Industry Sector 3*: optoelectronics; *Industry Sector 4*: communications and Internet; *Industry Sector 5*: electronic parts and components; *Industry Sector 6*: electronic production distribution). Therefore, this study includes six dummy variables to identify each of these different industry sectors, each coded 1 only if it matches the industry type of that company and 0 otherwise.

3.5. Models

The tested models appear below. Expression (1) describes Model 1 to examine Hypothesis 1a, which is to examine whether a firm investing to a lesser degree in R&D may adopt pollution prevention.

$$\log\left(\frac{\pi_{ij}}{\pi_{ij^*}}\right) = X_i\beta_j, \quad j \neq j^* \tag{1}$$

while j^* indicates the reference category that is Type 3: pollution prevention, X_i stands for the control variables and independent variables; π stands for green activity; i stands for firms, and j stands for types of green activities.

Expression (2) describes Model 2 to examine Hypothesis 1b, which is to examine whether a more internationalized firm is more likely to seek green certifications.

$$\log\left(\frac{\pi_{ij}}{\pi_{ij^*}}\right) = X_i\beta_j, \quad j \neq j^* \tag{2}$$

while j^* indicates the reference category that is Type 4: green certifications; X_i stands for the control variables and independent variables; π stands for green activity; i stands for firms, and j stands for types of green activities.

Expression (3) describes Model 3 to examine Hypothesis 2, examining whether and how adopting different green activities (Type 1: ISO 14000; Type 2: green processes; Type 3: pollution prevention; Type 4: green certifications) affects firms' performances.

$$\begin{aligned}\text{Performance}_i = {} & \beta_0 + \beta_1(\text{Type 1 : ISO 14000}_i) + \beta_2\,(\text{Type 2} \\ & : \text{Green Processes}_i) + \beta_3\,(\text{Type 3} \\ & : \text{Pollution Prevention}_i) + \beta_4\,(\text{Type 4} \\ & : \text{Green Certifications}_i) + \beta_5\,(\text{Timing}_i) \\ & + \beta_6\,(\text{Degree of R\&D}_i) \\ & + \beta_7\,(\text{Degree of Internationalization}_i) \\ & + \beta_8\,(\text{Firm Size}_i) + \beta_9\,(\text{Industry Sector1}_i) \\ & + \beta_{10}\,(\text{Industry Sector2}_i) \\ & + \beta_{11}\,(\text{Industry Sector3}_i) \\ & + \beta_{12}\,(\text{Industry Sector4}_i) \\ & + \beta_{13}\,(\text{Industry Sector5}_i) \\ & + \beta_{14}\,(\text{Industry Sector6}_i) + \varepsilon \end{aligned} \tag{3}$$

while i stands for firms.

Table 1
Descriptive statistics and correlation matrix (models 1 and 2) (variables employed to test Hypothesis 1a and Hypothesis 1b).

Variables	Mean	SD	1	2	3	4	5	6	7	8	9
1. Firm Size	6.61	0.62									
2. Industry Sector 1: Semiconductors	0.19	0.39	0.232*								
3. Industry Sector 2: Computers and Peripheral Equipment	0.15	0.35	0.123*	−0.205*							
4. Industry Sector 3: Optoelectronics	0.18	0.38	0.017	−0.226*	−0.197*						
5. Industry Sector 4: Communications and Internet	0.10	0.29	−0.129*	−0.159*	−0.139*	−0.153*					
6. Industry Sector 5: Electronic Parts and Components	0.27	0.44	−0.191*	−0.298*	−0.260*	−0.287*	−0.202*				
7. Industry Sector 6: Electronic Production Distribution	0.04	0.19	−0.015	−0.099*	−0.086*	−0.095*	−0.067	−0.125*			
8. Degree of R&D	9.11	49.03	−0.105*	−0.003	−0.045	0.174*	−0.004	−0.079*	−0.036		
9. Degree of Internationalization	63.37	27.07	0.185*	−0.213*	0.305*	0.007	0.044	−0.025	−0.231*	−0.197*	
10. Green Activities	2.54	1.15	0.102*	0.041	−0.048	−0.010	−0.019	0.018	0.024	−0.027	0.042

*$p < 0.05$ (2-tailed); N = 627.

4. Results

4.1. Data analysis

The descriptive statistics analysis and correlation matrix appear in Tables 1 and 2. Table 1 represents green activities, degree of R&D, degree of internationalization, and control variables including firm size and industry sectors. Table 2 represents different types of green activities, performance, and control variables, including firm size, timing, degree of R&D, degree of internationalization and industry sectors 1–6. We found some control variables and independent variables to be highly correlated. But in the regression analysis, the collinearity among variables is not significant on the grounds that the VIF values are below 10.

4.2. Findings

To test H1a and H1b, we used multiple logistic regressions. Model likelihood statistics of two models are significant (Model 1: $p < 0.05$; Model 2: $p < 0.01$). This represented that against one in which all the parameter coefficients are zero, and the two models are outperforming the null. In Table 3, we adopted pollution prevention as a reference category and found that R&D intensity was not significant in Model 1a, Model 1b, or Model 1c (Model 1a: $\beta = -0.001$, $p > 0.1$; Model 1b: $\beta = -0.001$, $p > 0.1$; Model 1c: $\beta = -0.013$, $p > 0.1$); accordingly, this result does not support H1a.

We used green certifications as a reference category in Table 4. Table 4 told us that degree of internationalization was weakly significant in models 2a and 2b, and significant in Model 2c (Model 2a: $\beta = -0.008$, $p < 0.1$; Model 2b: $\beta = -0.009$, $p < 0.1$; Model 2c: $\beta = 0.016$, $p < 0.01$). These figures prove clearly that more internationalized firms preferred to adopt green certifications more than they preferred adopting ISO 14000, green processes, and pollution prevention. Therefore, we can say that this result supports H1b. Tables 3 and 4 show the practical results of the multinomial logistic regression models. We found the percent correctness of the model was 33.49%, especially the percent correct in green certifications (up to 60.87%). The reason our predictions were more correct in green certifications is that more internationalized firms preferred to adopt green certifications. Less international companies may be too hard to predict.

As displayed in Table 5 for Model 3, we found a negative relationship with weak significance between ISO 14000 and performance ($\beta = -2.764$, $p < 0.1$), a significant negative relationship between pollution prevention and performance ($\beta = -4.233$, $p < 0.05$), and a significant negative relationship between green certifications and performance ($\beta = -4.604$, $p < 0.01$). However, we found a significant and positive relationship between green processes and performance ($\beta = 3.547$, $p < 0.05$). Therefore, we can confirm that companies adopting green processes improve their performance more than companies adopting ISO 14000, pollution prevention, or green certifications. Companies adopting ISO 14000 improve their performance more than those using pollution prevention and green certifications, and companies adopting pollution prevention improve their performance more than companies adopting green certifications. These results do not support H2.

5. Conclusion and discussion

As far as the degrees of R&D and of internationalization are concerned, the results show that the effect of the degree of R&D is not significant, but the effect of the degree of internationalization is significant. This means that the degree of R&D does not affect a

Table 2
Descriptive statistics and correlation matrix (Model 3) (variables employed to test Hypothesis 2).

Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Timing	0.907	0.291														
2. Degree of R&D	3.572	5.475	0.019													
3. Degree of Internationalization	60.773	29.176	−0.044	−0.070												
4. Industry Sector 1: Semiconductors	0.175	0.381	0.118*	0.155*	−0.191*											
5. Industry Sector 2: Computers and Peripheral Equipment	0.142	0.349	−0.215*	0.020	0.270*	−0.187*										
6. Industry Sector 3: Optoelectronics	0.157	0.364	0.139*	0.052	0.033	−0.199*	−0.175*									
7. Industry Sector 4: Communications and Internet	0.100	0.300	0.012	0.089*	0.037	−0.154*	−0.136*	−0.144*								
8. Industry Sector 5: Electronic Parts and Components	0.299	0.458	−0.028	−0.158*	0.008	−0.301*	−0.265*	−0.282*	−0.218*							
9. Industry Sector 6: Electronic Production Distribution	0.047	0.211	0.017	−0.128*	−0.232*	−0.102*	−0.090*	−0.096	−0.074	−0.145*						
10. Firm Size	6.61	0.62	0.064	0.009	0.068	0.154*	0.061	0.036	−0.026	−0.152*	−0.045					
11. Type 1: ISO 14000	0.599	0.490	−0.110*	−0.092*	0.204*	−0.071	0.127*	−0.013	0.012	0.095*	−0.206*	0.102*				
12. Type 2: Green Processes	0.506	0.500	0.187*	−0.037	−0.006	−0.001	0.038	−0.033	−0.104*	−0.019	0.156*	0.003	−0.079			
13. Type 3: Pollution Prevention	0.551	0.498	0.217*	0.056	−0.165*	0.107*	−0.258*	0.094*	0.089*	0.135*	−0.182*	0.101*	−0.019	−0.087*		
14. Type 4: Green Certifications	0.386	0.487	0.254*	0.004	0.189*	0.086*	0.022	−0.021	−0.047	−0.015	−0.013	0.116*	0.067	0.166*	0.033	
15. Performance	9.288	19.041	−0.017	0.006	−0.105*	0.015	−0.077	−0.104*	0.034	0.074	0.018	0.008	−0.088*	0.077*	−0.070	−0.121*

*$p < 0.05$ (2-tailed); N = 599.

Table 3
Results of the multinomial logistic regressions for Hypothesis 1a (Model 1).

Dependent Variable	Reference Category: Type 3: Pollution prevention		
	Type 1: ISO 14000 (Model 1a)	Type 2: Green processes (Model 1b)	Type 4: Green certifications (Model 1c)
Control Variables			
Firm Size	−0.045	0.208	0.488*
Industry Sector 1: Semiconductors	−0.640	−1.246*	−0.850
Industry Sector 2: Computers and Peripheral Equipment	0.628	−0.168	0.077
Industry Sector 3: Optoelectronics	−0.758	−1.297*	−1.174*
Industry Sector 4: Communications and Internet	−0.393	−1.141†	−0.726
Industry Sector 5: Electronic Parts and Components	−0.409	−0.975†	−0.537
Industry Sector 6: Electronic Production Distribution	−0.182	0.517	0.460
Independent Variable			
Degree of R&D	−0.001	−0.001	−0.013
Intercept	0.883	−0.172	−2.154

†$p < 0.1$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

firm's adopting green activities, and companies seeking green activities (e.g., ISO 14000 certifications) do not require more investment in R&D. However, more internationalized firms prefer employing green certifications. As mentioned, internationalization deeply affects firms' green intentions. More and more enterprises develop their business globally to adapt to new business norms. This means they must face different situations and local laws; therefore, when national environmental awareness is raised and more environmental laws are established, companies have to change to accommodate local laws. For this reason, firms must comply with WEEE, RoHS, and other environmental standards set by the EU. The higher the degree of firm internationalization, the more likely a company is to assume green certifications.

As far as the relationships between green activities and performance are concerned, the results showed that the best way for companies to employ green activities for better performance is green processes, followed by ISO 14000 certifications, pollution prevention; and lastly, green certifications. This means that green processes can create more competitive advantage to earn more performance for any enterprise that adopts them. As mentioned above, Porter and Linde (1995) argued pollution's costs are hidden throughout a product's life cycle. Companies develop new products or renewal processes to improve quality while actually reducing costs. Moreover, Menon and Menon (1997) thought that companies' entry into new green markets by developing new products can establish first-mover advantage, raise rivals' costs through new technology, and lower a company's own costs. That is why companies adopting green processes perform better than companies adopting other green activities.

The main reason companies employing ISO 14000 fail to perform better than those employing green processes is that ISO 14000 focuses on the EMS to reduce environment influences; however, the standard of ISO 14000 is suitable only for specific firms, not entire industries (Makower, 2009). Moreover, the system may not be effective. An ISO 14000-certified company may still cause pollution (Makower, 2009). The cost of seeking ISO 14000 certifications may also lower performance and profit.

That said, firms that introduce pollution prevention need to establish pollution-controlling equipment. Companies may invest great resources, but may not improve their public image because pollution may hide wasted resources and effort (King, 1994; Porter & Linde, 1995). Thus, companies using this strategy in the long term may decline in performance.

Companies seeking green certifications may not differentiate advantage. Green certifications may be more important to export-oriented companies. Moreover, most electronic companies in Taiwan seeking green certifications started around the same time, so green certifications may only help these firms hold competitive parity, instead of advantage. In addition, companies seeking green certifications may need to spend more resources to improve their products to meet the standards. Companies need to develop more environmental products to conform to the conditions of green certifications, and spend more resources than expected to seek green certifications. Therefore, companies seeking green certifications fail to perform better than those pursuing other activities.

In short, in terms of the relationship between firm characteristics and firm strategy decisions, the degree of a firm's R&D investment fails to affect companies' choice of green activities; however, the degree of firm internationalization can, and more internationalized firms will be more likely to employ green certifications. In terms of the relationships between green activities and firm performance, each green activity can create a different

Table 4
Results of the multinomial logistic regressions for Hypothesis 1b (Model 2).

Dependent Variable	Reference Category: Type 4: Green certifications		
	Type 1: ISO 14000 (Model 2a)	Type 2: Green processes (Model 2b)	Type 3: Pollution prevention (Model 2c)
Control Variables			
Firm Size	−0.496*	−0.237	−0.392†
Industry Sector 1: Semiconductors	0.074	−0.541	0.587
Industry Sector 2: Computers and Peripheral Equipment	0.619	−0.178	0.103
Industry Sector 3: Optoelectronics	0.409	−0.140	1.173†
Industry Sector 4: Communications and Internet	0.359	−0.392	0.762
Industry Sector 5: Electronic Parts and Components	0.039	−0.529	0.421
Industry Sector 6: Electronic Production Distribution	−1.019	−0.327	−1.103
Independent Variable			
Degree of Internationalization	−0.008†	−0.009†	−0.016**
Intercept	3.463**	2.381†	2.658†

†$p < 0.1$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Table 5
Results of the regressions for Hypothesis 2 (Model 3).

Dependent Variable: Performance	Hypothesis 2	
	Model 3a	Model 3b
Control Variables		
Timing	−1.224 (−0.444)	0.190 (0.065)
Degree of R&D	0.049 (0.332)	0.039 (0.271)
Degree of Internationalization	−0.061* (−2.114)	−0.052† (−1.756)
Firm Size	0.000 (0.787)	0.000 (1.492)
Industry Sector 1: Semiconductors	−3.083 (−0.914)	−1.090 (−0.325)
Industry Sector 2: Computers and Peripheral Equipment	−5.483 (−1.576)	−5.021 (−1.457)
Industry Sector 3: Optoelectronics	−7.150* (−2.110)	−5.440 (−1.608)
Industry Sector 4: Communications and Internet	−0.621 (−0.168)	1.696 (0.459)
Industry Sector 5: Electronic Parts and Components	−0.382 (−0.124)	1.838 (0.593)
Industry Sector 6: Electronic Production Distribution	−2.722 (−0.590)	−5.303 (−1.148)
Independent Variables		
Type 1: ISO 14000		−2.764† (−1.673)
Type 2: Green Processes		3.547* (2.212)
Type 3: Pollution Prevention		−4.233* (−2.469)
Type 4: Green Certifications		−4.604** (−2.726)
N	599	599
R-square	0.030	0.065
Adjusted *R*-square	0.013	0.042
F-value	1.815†	2.895***

†$p < 0.1$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$. Numbers in the parentheses are *t*-value.

competitive advantage for companies and thus, change performance. Among the tested four green activities, companies adopting green processes perform best, followed by those pursuing ISO 14000, pollution prevention, and green certifications.

5.1. Managerial implications

Literature on green activities has paid great attention to the motives of firms before they adopt green activities, and the benefits they enjoy afterward. The current study's results show that enterprises should introduce green processes among other green activities for better performance. Companies seeking ISO 14000 to increase company reputation must innovate green products or environmental processes. Further, according to our results, companies building pollution control equipment fail to deliver good performance because they may be viewed as inefficient polluters. That is, enterprises make efforts to establish waste and pollution prevention, but customers may not easily perceive such efforts. Therefore, companies that aim to enhance their performance must improve green processes ahead of other options. Companies seeking green certifications may require many resources to become certified; however, since the companies for the present study are mostly certified already, seeking certifications may only help these firms obtain competitive parity.

6. Limitations and directions for future research

There are some limitations for this study: first, expert opinions can be subjective due to budget and time constraints. Second, green strategies are not easily measurable and the data for the presents study are collected from the annual reports, which can also be subjective.

Therefore, first, future research should divide the classification of green activities into more types. Although researchers have paid great attention to green activities, there is still no consensus about their classifications. Hence, we chose the most extensive standard to divide green activities, but for future studies, researchers may try additional categories or measures of activities. Second, in this article, we listed only the electronics industry in Taiwan. Future researchers may study other sectors, such as the service industry. Third, future research may include companies that do not employ green activities; in this article, we adopted only companies employing green activities, although previous studies have proven green activities improved company performance.

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