

Green Innovation Performance: Antecedent and Consequence

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Abstract--This study utilizes structural equation modeling (SEM) to explore the positive effect of corporate environmental ethics on competitive advantage in the Taiwanese manufacturing industry via the mediator: green innovation performance. This study divides green innovation into green product innovation and green process innovation. The empirical results show that corporate environmental ethics positively affects green product innovation and green process innovation. In addition, this study verifies that green product innovation performance mediates the positive relationship between corporate environmental ethics and competitive advantage, but green process innovation performance does not. The research results are beneficial to the manufacturing industry of Taiwan.

I. INTRODUCTION

Green innovation has become one of important strategic tools to obtain sustainable development in manufacturing industries because of the increasing environmental pressure. In previous times, investing in environmental activities is an unnecessary investment. However, the strict environmental regulations and popular environmentalism have changed the competitive rules and patterns for companies [21]. Green innovation can be divided into green products and processes, including the innovation in technologies that are involved in energy-saving, pollution-prevention, waste recycling, green product designs or corporate environmental management [7]. If companies are willing to undertake green innovation enthusiastically, they can obtain the advantage of differentiation and even change the existing competitive rules to become one of successful companies [26, 15].

Previous research argues that the relationship between green innovation and competitiveness is positive [7]. Green innovations can enhance the product value, and thus offset the costs of environmental investments. Eventually, green innovations improve resources productivity and make companies more excellent [26]. Therefore, developing green innovations is a win-win solution for the conflict between economic development and environmental protection.

Investing resources on environmental management would not only avoid the trouble of protests or punishment about environmental protection, but also enhance their production efficiency, develop new environmental markets, and thereby increase their capabilities of green innovation [25]. Being green is a catalyst for continuous innovation, new market opportunity, and wealth creation [8]. Environmental management is getting important for companies in the dynamic global environment, and more companies are willing to put more efforts on developing green innovations. Furthermore, green innovations may embody the concept of environmental protection into the design and package of products to increase their differentiation advantages [4, 7].

Green innovation is the best way to improve the

performance of environmental management to satisfy the requirement of environmental regulations [7]. However, research which deals with the antecedent of green innovation is scant in professional literature. This study examines corporate environmental ethics as an antecedent of green innovation, thereby providing insight into green innovation which plays a mediating role between corporate environmental ethics and competitive advantage. The structure of this study is as follows. A literature review is discussed in section 2, and five hypotheses are also proposed in this section. In section 3, this study describes the methodology, the sample and data collection, and the measurements of the constructs. In section 4, the descriptive statistics, reliability of the measurement, factor analysis, correlation coefficients between constructs, and the results of measurement and structural model are shown. In section 5, this study mentions the discussions about the findings and implications, and possible directions for future studies.

II. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

A. *The Positive Effect of Corporate Environmental Ethics on Green Product and Process Innovation*

Green innovation is the improvement of products or processes about energy-saving, pollution-prevention, waste recycling, green product designs and corporate environmental management in the field of environmental management [7]. This study divides green innovation into green product innovation and green process innovation. Green innovation can enhance the performance of environmental management to satisfy the requirements of environmental protection. A company devotes to developing green innovation can not only meet the environmental regulations but also build up the barriers to the other competitors [2, 7]. Previously, many companies thought investing in environmental management was an unnecessary investment [26]. Recently, there are more positive associations between corporate environmental ethics and green innovation [7, 16, 26]. Companies should change their strategies and operations so that they can comply with the trend of environmentalism. Companies with high environmental ethics are prone to increase resource productivity through green innovation to make up the environmental costs [7]. Green innovation can improve product value, and thus offset the costs of improving environmental impact. Ultimately, green innovation can further raise resources productivity and make companies more competitive [26].

Companies require the motivation and ability to produce creative and innovative ideas to develop new products or processes [16]. Previous studies pointed out that the well-defined policies and processes in companies have

positive effect on their innovation [19]. Therefore, well-defined environmental policies can facilitate and integrate the operations among different departments in companies and solve the environmental problems [26]. Corporate environmental ethics highlights the role of proactive environmental management [13]. The environmental ethics in a company can influence innovation of environmental technology and business operation [22, 31]. This study argues that corporate environmental ethics plays an important role in the green innovation of a company. Top management concerns relate positively to the scope and speed of a firm's responses to environmental issues [11]. The role of management is crucial in establishing a company's norms and expectations about ethics [30]. Based on resource-based view (RBV), outstanding corporate culture which is typically valuable, rare, inimitable, and non-substitutable can be viewed as one of key resources to generate sustainable competitive advantage [6]. Corporate environmental ethics is regarded as one kind of superior corporate culture to attain sustainable development. Hence, corporate environmental ethics of companies can stimulate their proactive environmental actions that can facilitate their green innovations [7, 26]. Consequently, this study implies the following hypothesis:

Hypothesis 1: *Corporate environmental ethics is positively associated with green product innovation.*

Hypothesis 2: *Corporate environmental ethics is positively associated with green process innovation.*

B. The Positive Effect of Green Product and Process Innovation on Competitive Advantages

Competitive advantages is defined as a condition which competitors are not able to replicate its competitive strategies executed by the company, nor are competitors able to acquire the benefit that the company obtains by means of its competitive strategies [2, 23, 28]. Value, rareness, inimitability, and unsubstitutability are the characteristics of resources of companies which are helpful for innovation and companies can exploit them to gain competitive advantages [15, 18]. Innovation can create "isolation mechanisms" which protect profit margins and allow benefits to be gained for companies. Innovation is a key source of competitive advantage in the era of knowledge economy [24, 32]. Innovation enables companies to create and deploy their capabilities that support the long-run business performance [1]. Successful innovation can make external imitation more difficult and allow firms to sustain their advantages better [25].

Companies pioneering in the green innovation can obtain the competitive advantages, and enable them to sell their environmental technologies or services, to improve their corporate images, and even to create new markets [7, 15, 16, 20, 21]. Companies investing more commitments in environmental management and green innovation actively can not only minimize production waste, but also enhance the overall productivity, increase corporate reputation, and thereby increase corporate competitive advantages under the trends of the popular environmentalism of consumers and severe international regulations of environmental protection

[4, 7, 21]. Moreover, green innovation can create "isolation mechanisms" which protect profit margins and allow benefits to be gained for companies. In this study, green innovation can be divided into green product innovation and green process innovation. Therefore, this study implies the following hypothesis:

Hypothesis 3: *Green product innovation is positively associated with competitive advantages.*

Hypothesis 4: *Green process innovation is positively associated with competitive advantages.*

C. The Positive Effect of Corporate Environmental Ethics on Competitive Advantages

Corporate environmental ethics is the total ethical belief, value, and norm of environmental concerns within a company [34]. Corporate environmental ethics includes six elements: ethics codes, ethics committees, ethics communication systems, ethics officers, ethics training programs, disciplinary processes [33]. In the concerns about global environmental impacts, corporations should invest resources to achieve their goal of sustainable development. Corporate environmental ethics formalize company values and expectations for ethical behavior. Companies that have high environmental ethics standards can not only avoid the troubles that come with environmental protection protests, but also improve their corporate images [7]. Therefore, environmental management may lead to long-term economic gains. Competitive advantages are a condition under which companies occupy some niche positions where their competitors cannot imitate their successful environmental strategies and they can gain the sustainable benefits [21, 23]. A company devoted to developing its corporate environmental ethics can not only meet the environmental regulations but also build up the barriers to the other competitors. Companies can enhance competitive advantage through improving their intangible assets, such as environmental ethics. Companies can occupy some positions about environmental protection where their competitors cannot copy their successful environmental strategies and gain the sustainable benefits from these successful environmental strategies. Therefore, this study proposes the following hypothesis:

Hypothesis 5: *Corporate environmental ethics is positively associated with competitive advantages.*

D. The Research Framework of the Study

This study summarizes the literature of environmental management and green innovation into a new managerial framework. The main purpose of this study is to explore the positive effect of corporate environmental ethics on competitive advantage in the Taiwanese manufacturing industry via the mediator: green innovation performance. This study also wants to explore whether green innovation has a partial mediation effect between corporate environmental ethics and competitive advantages. In this study, green innovation can be divided into green product innovation and green process innovation. This study shows the research framework in Fig. 1.

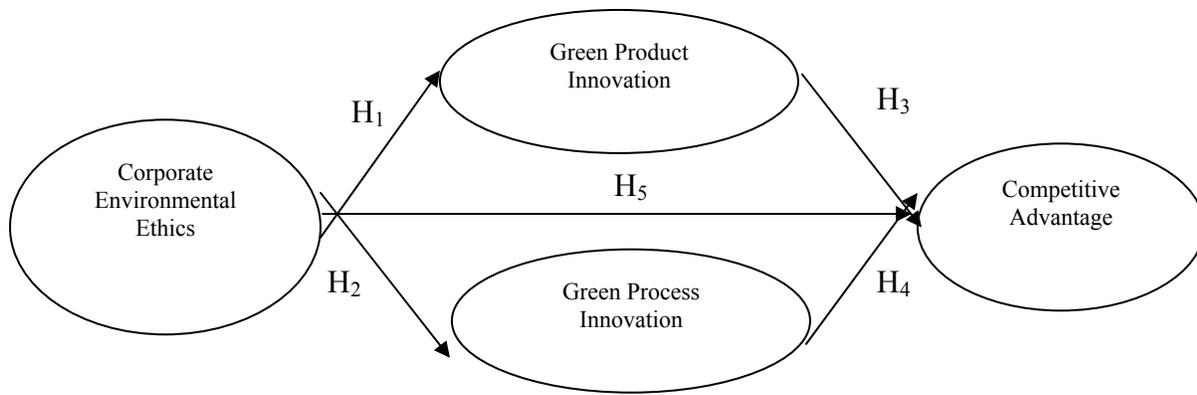


Fig. 1 Research framework

III. METHODOLOGY AND MEASUREMENT

A. Data collection and the sample

The unit of analysis in this study is the business level. This research employed an empirical study, which collected data from companies in the manufacturing industry of Taiwan. The sample is randomly selected from “2008 Business Directory of Taiwan.” The respondents of the questionnaires are the CEOs or the managers of environmental protection, marketing, production, human resource, or R&D departments in Taiwanese manufacturing companies. To heighten the valid survey response rate, the research assistants called to each company which is sampled, explained the objectives of the study and the questionnaire contents, and confirmed the names and job titles of the respondents prior to questionnaire mailing. The respondents were asked to return the completed questionnaires within two weeks through mailing.

The study refers to the past literatures to design questionnaire items for the survey. Prior to mailing to the respondents, seven experts and scholars were asked to modify the questionnaire in the first pretest. Subsequently, the questionnaires were randomly mailed to twelve CEOs or the managers of environmental protection, marketing, production, human resource, or R&D departments in different Taiwanese manufacturing companies, and they were asked to fill in the questionnaire and to identify the ambiguities in terms, meanings and issues in the second pretest. High content validity is a necessary requisition for the questionnaire in this study. To avoid common method variance (CMV), the respondents of different constructs in this study were different. The respondents of “corporate environmental ethics” are managers of environmental protection or human resource departments; those of “green product innovation” are managers of marketing or R&D departments; those of “green process innovation” are managers of R&D or production departments; those of “competitive advantage” are top managers or CEOs in Taiwanese manufacturing companies. 500 questionnaires are sent to CEOs or the managers of environmental protection, marketing, production, human resource, or R&D departments. There are 106 valid questionnaires, and the effective response rate is 21.2%.

B. Definitions and measurements of the constructs

The measurement of the questionnaire items in this study is by use of “five-point Likert scale from 1 to 5” rating from strongly disagreement to strongly agreement. The questionnaire comprises five parts. The first part of the questionnaire is the measurement of the descriptive data of companies (including the number of employees, year founded, industry sector, etc.); the other four parts are corporate environmental ethics, green product innovation, green process innovation and competitive advantage, respectively. The measurements of the constructs are further defined as follows.

Corporate environmental ethics: The measurement of corporate environmental ethics includes four items: (1) the company has clear and concrete environmental policies; (2) the company’s budget planning includes the concerns of environmental investment or procurement; (3) the company has integrated its environmental plan, vision or mission to its marketing events; (4) the company has integrated its environmental plan, vision or mission to company’s culture[17].

Green product innovation: The measurement of green product innovation includes three items: (1) the company chooses the materials of the product that produce the least amount of pollution for conducting the product development or design; (2) the company uses the fewest amount of materials to comprise the product for conducting the product development or design; (3) the company would circumspectly deliberate whether the product is easy to recycle, reuse, and decompose for conducting the product development or design [31].

Green process innovation: The measurement of green process innovation includes three items: (1) the manufacturing process of the company effectively reduces the emission of hazardous substances or waste; (2) the manufacturing process of the company reduces the consumption of water, electricity, coal, or oil; (3) the manufacturing process of the company reduces the use of raw materials [31].

Competitive advantage: The measurement of competitive

advantage includes six items: (1) the quality of the products or services that the company offers is better than that of the competitor's products or services; (2) the company is more capable of R&D than the competitors; (3) the company has better managerial capability than the competitors; (4) the company's profitability is better; (5) the corporate image of the company is better than that of the competitors; (6) the competitors are difficult to take the place of the company's competitive advantage [2, 8, 21].

IV. EMPIRICAL RESULTS

This study utilizes Structural Equation Modeling (SEM) to verify the research framework and hypotheses, and applies Amos 7.0 to obtain the empirical results. SEM is a statistical technique for testing and estimating causal relationships in a more powerful way which takes into account the modeling of interactions, nonlinearities, correlated independents, measurement error, correlated error terms, multiple latent independents each measured by multiple indicators, and one or more latent dependents also each with multiple indicators. The antecedent of the research framework in this study is corporate environmental ethics, and the consequent is competitive advantage, while green product and process innovation are mediators between corporate environmental ethics and competitive advantage. SEM of this study includes two levels of analysis - the measurement model and the structural model.

A. The Results of the Measurement Model

This study demonstrates the means and standard deviations of the constructs and the correlations among them in Table 1. There are positive correlations among the four constructs: corporate environmental ethics, green product innovation, green process innovation, and competitive advantage. This study shows the result of factor analysis in Table 2. Every construct in this study can be classified into only one factor in Table 2. This study applies confirmatory factor analysis (CFA) to verify the validity and reliability in the measurement model. The results of the CFA indicate that the measurement model exhibits the acceptable levels of the model fit ($\chi^2=151.8$, d.f.=97, $\chi^2/d.f.=1.565$, CFI= 0.941, IFI=0.943, RMSEA= 0.073).

There are several measures to confirm the reliability and validity of the measurement. One measure of reliability is to

examine the loadings of each of the constructs' individual items. With respect to the quality of the measurement model, the loadings (λ) of items of the constructs listed in Table 3 are all significant. Table 3 lists the Cronbach's α coefficients for the measure of reliability. In general, the minimum requirement of the Cronbach's α coefficient is 0.7 [14]. Because the Cronbach's α coefficients of the four constructs are more than 0.7, the measurement of this study is acceptable in reliability. In addition, it is also important to verify whether the validity of the measurement is acceptable. There are three ways to verify the validity of the measurement. First, the study refers to previous studies to design questionnaire items. Prior to mailing to the respondents, seven experts and scholars modified the questionnaire in the first pretest. Subsequently, the authors distributed the questionnaires to twelve CEOs or the managers of environmental protection, marketing, production, human resource, or R&D departments in different Taiwanese manufacturing companies. They fill in the questionnaires and to identify ambiguities in terms, meanings, and issues in the second pretest. The questionnaire of this study has high level of content validity. Second, this study applies Fornell and Larcker's measure of average variance extracted (AVE) to access the discriminative validity of the measurement [11]. The AVE measures the amount of variance captured by a construct through its items relative to the amount of variance due to the measurement error. To satisfy the requirement of the discriminative validity, the square root of a construct's AVE must be greater than the correlations between the construct and other constructs in the model. For example, the square roots of the AVEs for the two constructs, corporate environmental ethics and green product innovation, are 0.765 and 0.778 in Table 3 which are more than the correlation, 0.574, between them in Table 1. This demonstrates there is adequate discriminative validity between corporate environmental ethics and green product innovation. The square roots of all constructs' AVEs in Table 3 of this study are all more than the correlations among all constructs in Table 1. Therefore, the discriminative validity of the measurement in this study is acceptable. Third, the AVEs of the four constructs are more than 0.5 in Table 3. It means that the convergent validity of the four constructs is acceptable. In sum, there are adequate reliability and validity in the measurement of this study according to the above analysis.

TABLE 1. MEANS, STANDARD DEVIATIONS, AND CORRELATIONS OF THE CONSTRUCTS

Constructs	Mean	Standard Deviation	(A)	(B)	(C)
(A) Corporate Environmental Ethics	3.875	0.727			
(B) Green Product Innovation	3.953	0.623	0.574**		
(C) Green Process Innovation	4.019	0.655	0.443**	0.464**	
(D) Competitive Advantage	3.692	0.687	0.500**	0.536**	0.321**

Note: ** p<0.01.

TABLE 2. FACTOR ANALYSIS OF THIS STUDY

Constructs	Number of Items	Number of factors	Accumulation percentage of explained variance
Corporate Environmental Ethics	4	1	72.459%
Green Product Innovation	3	1	70.504%
Green Process Innovation	3	1	72.172%
Competitive Advantage	6	1	66.935%

TABLE 3. THE ITEMS' LOADINGS (λ) AND THE CONSTRUCTS' CRONBACH'S α • COEFFICIENTS AND AVEs

Constructs	Items	λ	Cronbach's α	AVE	The square root of AVE
Corporate Environmental Ethics	CEE1	0.734	0.872	0.585	0.765
	CEE2	0.859**			
	CEE3	0.699**			
	CEE4	0.769**			
Green Product Innovation	GPD11	0.862	0.781	0.605	0.778
	GPD12	0.909**			
	GPD13	0.497**			
Green Process Innovation	GPRI1	0.787	0.806	0.583	0.764
	GPRI 2	0.775**			
	GPRI 3	0.728**			
Competitive Advantage	CA1	0.800	0.901	0.588	0.769
	CA2	0.798**			
	CA3	0.737**			
	CA4	0.716**			
	CA5	0.756**			
	CA6	0.790**			

Note: ** p<0.01.

A. The Results of the Structural Model

This study verifies the empirical results of the hypotheses in this section. The results of the structural model are presented in Table 4 and Figure 2. The measures of overall fit indicate the fit of the structural model is acceptable ($\chi^2=93.654$, d.f.=90, $\chi^2/d.f.=1.041$, GFI= 0.907, CFI= 0.996, NFI=0.911, RMSEA= 0.020). Adding or deleting any paths in this research framework would not significantly improve the fit. The residuals of the covariance are also small and centered near 0. All of the five paths are in Table 4. The results of the full model are shown in Figure 2. According to

in Table 4 and Figure 2, the results indicate broad support for most of the hypothesized effects in the research model. Therefore, this study verifies that corporate environmental ethics is a positive driver for green product innovation. This study finds out green product innovation partially mediates the positive relationship between corporate environmental ethics and competitive advantage. This study also verifies that corporate environmental ethics is a positive driver for green process innovation and competitive advantage. However, green process innovation is not supported to be significantly associated with competitive advantage.

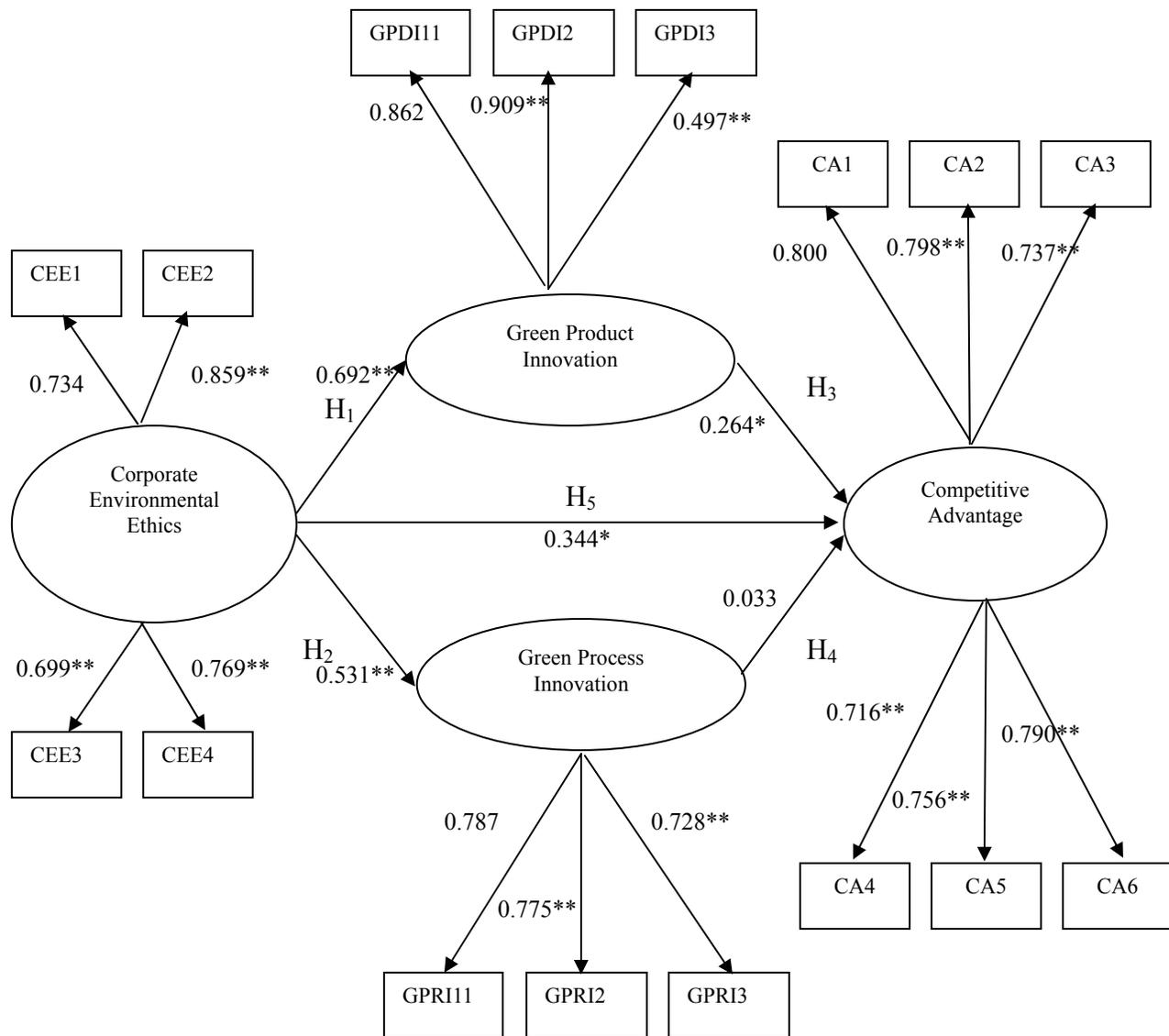


Fig. 2 Path coefficients

TABLE 4. THE RESULTS OF THE STRUCTURAL MODEL

Hypothesis	Proposed effect	Path coefficient	Results
H ₁	+	0.692**	H ₁ is supported
H ₂	+	0.531**	H ₂ is supported
H ₃	+	0.264*	H ₃ is supported
H ₄	+	0.033	H ₄ is not supported
H ₅	+	0.344*	H ₅ is supported

Note: * p<0.05, ** p<0.01.

V. CONCLUSION AND IMPLICATIONS

This study utilizes structural equation modeling (SEM) to explore the positive effect of corporate environmental ethics on competitive advantage in the Taiwanese manufacturing industry via the mediator: green innovation performance. In this study, green innovation is divided into green product innovation and green process innovation. Although many

previous studies explored the issues of innovation and competitive advantages, few researches explored the relationship between corporate environmental ethics and competitive advantage and discussed the mediation role of green innovation.

The results of this study indicate that corporate environmental ethics of companies are positively related to green product and process innovation. Green product

innovation plays a mediation role between corporate environmental ethics and competitive advantage, but green process innovation does not. For Taiwanese manufacturing companies, green product innovation is the differentiation strategy which enables them to create new businesses. Green product innovation is able to seize opportunities or to lead in the market. Environmental consciousness of consumers facilitates the companies to redesign existing products or to develop new ones which meet the environmental regulations [19]. If companies are willing to undertake green product innovation, they can obtain the advantage of differentiation and even change the existing competitive rules to become one of successful companies [22, 26]. Furthermore, the design and package of green products can increase their differentiation advantages [4, 7, 26, 27].

On the other hand, green process innovation does not play a mediation role between corporate environmental ethics and competitive advantage in this study. Green process innovation is regarded as a low cost strategy in the Taiwanese manufacturing industry. Companies develop eco-friendly raw materials and components to reduce waste. The initial aim is usually to create a better image, but most corporations end up reducing costs or creating new businesses as well. However, it is hard for consumers to understand how much effort that the companies put in the process improvement. Hence, there is no positive relationship between green process innovation and competitive advantage.

The subject of this study covers the issues of corporate environmental ethics, green innovation and competitive advantages, which respond to the new concept of "green management" caring both aspects of environmental protection and economic development. Most of Taiwanese manufacturing companies have few resources to deploy and thereby often fail to meet the requirements and regulations of environmental protection. This would bring Taiwanese manufacturing companies serious damages that resulted from the failure to comply with the international environmental regulations. However, this study finds that investing many resources and efforts in the corporate environmental ethics could eventually enhance their green product innovation and competitive advantages in the Taiwanese manufacturing industry. Therefore, this result can contribute to Taiwanese manufacturing companies as reference. Businesses should not shirk their duties under the trends of strict environmental conventions and the popular environmentalism of consumers. These environmental trends could be turned into the momentum that drives them to carry out environmental ethics, green innovation and further create competitive advantages. The research object of this study is the manufacturing industry of Taiwan, so the future studies can focus on other industries or areas and compare with this study. This study verifies hypotheses by use of questionnaire survey, only providing cross-sectional data, so that this study can not observe the dynamic changes of environmental ethics, green innovation and competitive advantages in the different stages of the development of the Taiwanese industry through

longitudinal data. Therefore, future studies can set forth toward the longitudinal study to find out the differences of environmental ethics, green innovation and competitive advantages in the different stages of the development of the manufacturing industry of Taiwan. Finally, this study hopes the research results are beneficial to managers, researchers, or policy makers in the manufacturing industry of Taiwan, and contribute to relevant studies and future researches as reference.

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