Proceedings of 2013 International Conference on
Technology Innovation and Industrial Management
29-31 May 2013, Phuket, Thailand

MARKET DEMAND, GREEN INNOVATION, AND FIRM PERFORMANCE: EVIDENCE FROM HYBRID VEHICLE INDUSTRY

Ru-Jen Lin, Lunghwa, University of Science and Technology, Taiwan
rjlin@mail.lhu.edu.tw

Rong-Huei Chen, Lunghwa, University of Science and Technology, Taiwan
ronghuei@mail.lhu.edu.tw

Thao-Minh Ho, Chung Hua, University, Hsinchu, Taiwan
sissi_hai@yahoo.com

ABSTRACT

Purpose: *Despite the stimulating roles of market demand and green issues to green innovation and business success, the relationships among these aspects remains controversial. The lack of the consensus on these links causes a missing research gap in the extant literature. This study aims to examine the mediating effect of green innovation and environmental performance on the relationship between market demand and firm performance in Taiwanese hybrid vehicle industry.*
Design/methodology/approach: *The Taiwanese hybrid vehicle industry was targeted as the main research scope. Using random sampling method, survey questionnaires were distributed to retailers, wholesalers, and component sale firms in the automobile industry through post, e-mails, and fax. The Structural Equation Modeling (SEM) approach was used to test the hypotheses and the theoretical model.*
Findings: *The findings prove the significant impacts between market demand and green innovation as well as environmental performance to firm performance; however, the mediating effects of green innovation and environmental performance remain insufficient.*
Practical implications: *The results strongly suggests firms to make more efforts to understand customer needs and excel their competencies in innovating products and processes in a green manner to better align green innovation initiatives with consumer values to promptly satisfy market demand and achieve more effective competitive advantages.*
Originality/value: *This research is the first of its kind to establish the theoretical model for investigating the links among market demand, green innovation, environmental performance, and firm performance in Taiwanese hybrid vehicle industry, which contributes to the understanding of green issues in this competitive industry. As such, the findings helpfully provide effective guidelines for firms in achieving first-mover advantages, market leadership, and sustainable competitiveness.*

Keywords: market demand, green innovation, firm performance, process innovation, product innovation
Paper type: Research paper

INTRODUCTION

Facing currently intense customers' green demands and global environmental concerns, green innovation has been touted as an effective approach for firms to achieve a win-win status of being green and sustainably competitive (Porter and van der Linde, 1995; Pujari, 2006). Nonetheless, a continual debate on what actually composes green products has also been observed (Berchicci and Bodewes, 2005).

Worth noticing, the relationships among firms' green innovation capabilities, market demand, and performances remain controversial. Although green innovation does explicitly address environmental issues, it is far from certain whether green products can truly achieve market success (Pujari, 2006). Additionally, while market demand is suggested to be an important factor inducing green innovation (Wei and Morgan, 2004), Berthon et al. (1999) argue that listening too closely to customer voice may impair innovative sustainable product development capabilities. Simultaneously, whereas some empirical findings confirm the positive relationship between green innovation and firm performance, a major of studies have indicated otherwise (Koellinger, 2008).

Despite numerous studies on the links between green issues and performance or competitive advantage (Chiou et al., 2011), the conflicting findings have considerably illustrated a research gap on the links among market demand, green innovation, and firm performance. Therefore, this study aims to examine the link between market demand and firm performance with green innovation and environmental performance as the mediators in Taiwanese hybrid vehicle industry. As such, based on the database on Taiwan's Top 5000 largest enterprises from Taiwan Ministry of Economic Affairs, survey questionnaires were randomly conducted with retailers, wholesalers, and component sale firms in the automobile industry through mails, e-mails, and fax. By utilizing the Structural Equation Modeling (SEM) approach to test the theoretical model, this study attempts to address the following research questions:
(a) How does market demand affect green innovation and environmental performance?
(b) How can green innovation affect firm performance?

In essence, since sufficient understanding of green issues can beneficially assist firms in establishing successful operational and new product development strategies, this study provides firms with useful references for improving overall performance, gaining first-mover competitive advantages and market leadership. The findings also contribute to the knowledge of green innovation and green demands in Taiwanese hybrid vehicle industry since these issues are currently both challenges and opportunities in this competitive market.

Taiwanese hybrid vehicle industry was chosen to be the research focus for several compelling reasons. First, this important industry is currently making great efforts to apply advanced technologies in product and process development for both environmental protection and industrial advancement (Chou and Hsiao, 2005). Second, under intense pressures from green regulations, customers, and especially tremendous carbon dioxide level from vehicle exhaust, the hybrid vehicle technology in Taiwan has become a promising solution to significantly decrease reliance on oil supplies, fuel consumption, and CO2 emission as well as enhance energy efficiency and firms' green image (Fontaras and Samaras, 2007). Finally, due to several common development patterns with regional developing countries, the achieved experience in Taiwan can usefully shed light on future firm growth in Asia.

The remainder of this research begins with a brief literature review, followed by empirical research method, data analysis, results, and discussions. Finally, the study ends with conclusions, implications, and recommendations for future research.

LITERATURE REVIEW

1. Market demand

In this customer-oriented era, since customer preferences keep changing constantly, firms' capabilities in satisfying market demand refer to the extent firms understand customer needs to better anticipate their preferences and gain competitive advantage (Zhou et al., 2009).

Regarding market demand, customers are the key element driving firms' eco-innovation with the aim of delivering more value-added customer benefits (Kammerer, 2009; Horbach et al., 2012). For instance, along with current green trends, customers are observed to keep modifying their positive behaviors to reduce environmental damage, even are willing to pay higher prices for green and energy-efficient products (Chen, 2008; Chiou et al., 2011). To satisfy these green demands, firms have to innovate products and processes through implementing green technologies, eco-design, and international environmental management systems (Zhu et al., 2008; Hsu and Hu., 2011). Hence, market demand is assumed to be the key factor stimulating green innovation through inducing successful new product performance (Wei and Morgan, 2004; Chiou et al., 2011).

2. Green innovation

Increasing green concerns from public, regulations, and governments worldwide have strongly enforced firms to achieve competitive sustainability through developing new green products and advancing new green manufacturing processes to satisfy stringent green regulations and green demands and overcoming competitors with differentiation strategies (Porter and van der Linde, 1995; Pujari, 2006; Huang and Wu, 2010). Due to environmental concerns in Taiwanese hybrid vehicle industry, this study adopts the ideas of Chen et al. (2006), Chen (2008), Oltra and Saint Jean (2009), and Halila and Rundquist (2011) to define green innovation as the development and implementation of new products and processes which contribute to a sustainable environment through facilitating eco-target achievements and ecological footprint reduction throughout the entire manufacturing processes and product life cycle, which in turns effectively help firms promote productivity, corporate reputation, and image, develop new markets, and achieve first-mover advantages.

2.1 Green product innovation

Chen et al. (2006), Kammerer (2009), and Carrillo-Hermosilla et al. (2010) identify green product innovation to be the introduction of new or significantly improved products for environmental concerns (i.e. raw material use efficiency, green design, energy saving, recycling, waste minimization), being conducted under pressures of shortened product life cycle and increasing competition. With green attributes, green product innovation is perceived to be the cost-effective means for both consumers and producers (Pujari, 2006).

2.2 Green process innovation

Green process innovation is defined as the modifications in manufacturing processes and systems to produce environmentally friendly products which are closely related for eco-targets (e.g. energy saving, pollution prevention, waste recycling, and no toxicity) (Meeus and Edquist, 2006).

3. Environmental performance

Environmental performance is considered the impact of firms' activities on the natural milieu (Klassen and Whybark, 1999). In the context that the global economic growth is currently encountering extreme threats of fossil fuel exhaustibility, energy shortage, and high gas and electricity prices, energy-saving and environmental performance management have become the top-concerned priorities worldwide (Du and Liu, 2011).

4. Firm performance

This study proposes firm performance includes market share (Rex and Baumann, 2007; Li et al., 2010) and reputation (Chen, 2008; Oltra and Saint Jean, 2009) since they are considered the most important competitive factors for manufacturing firms. Interestingly, firms' reputation and environmental endeavors considerably affect customer preferences and purchasing behaviors (Oltra and Saint Jean, 2009).

4.1 Market share

The positive impacts of green innovation on corporate competitive advantages and market share enhancement have been widely confirmed (Chen et al., 2006; Iwu, 2010; Chiou et al., 2011). In support, Rubik et al. (2005) point out the main motivation for firms to conduct green innovation is to promote more transactions. As such, market share is referred to as the useful means for addressing potential aspects of consumer needs and better sales volume (Rex and Baumann, 2007; Chen, 2008).

4.2 Reputation

Reputation is considered an important intangible resource considerably affecting firms' market performance and distinguishing firms in the marketplace (Juma and Payne, 2004). In the extant literature, firm reputation has been perceived as an important basis for customers to evaluate product quality (Chang and Fong, 2010) and helps firms enhance corporate image and market value (Kwansa et al., 2008) as well as gain better customer satisfaction and loyalty and sustainable competitive advantages (Martenson, 2007).

In sum, to address the research questions, this study aims to verify the effects of market demand on firm performance through green innovation and environmental performance. Accordingly, the research framework is established as in Figure 1.

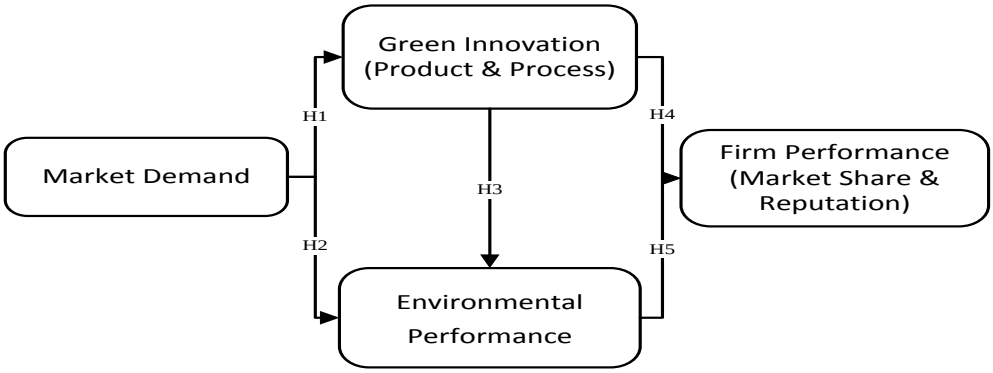


Figure 1. Research Framework

HYPOTHESIS DEVELOPMENT

1. Market demand and Green innovation

In this era, green-conscious customers have expressed more demands for energy-efficient and innovative green products (Chiou et al., 2011), even are willing to pay higher prices (Chen et al., 2008). For effective response, firms must innovate manufacturing processes and products using environmental management (Hsu and Hu., 2011). In other words, innovative product or process development undertaken for environmental reasons is strongly stimulated by market demand (Chiou et al., 2011). Accordingly, the following hypotheses are proposed.

H1-a: Market demand positively affects green product innovation.
H1-b: Market demand positively affects green process innovation.

2. Market demand and Environmental performance

Currently intense green demands have strongly enforced firms to conduct flexible and energy-efficient manufacturing strategies through adopting green management to reduce environmental damage (Chiou et al., 2011; Hsu and Hu., 2011). Since environmental performance is identified to be environmental management output (Klassen and Whybark, 1999), green management practice implementation typically improves firms' environmental performance (Zhu and Sarkis, 2004). Hence, the following hypothesis is suggested.

H2: Market demand positively affects environmental performance.

3. Green innovation and Environmental performance

Meeus and Edquist (2006) argue that firms conduct green innovation to manufacture environmentally-friendly products that can effectively eliminate environmental damage. Hence, since being closely associated with corporate environmental management and eco-target achievements (i.e. raw material use efficiency, energy saving, pollution prevention, waste minimization, reuse, and recycling), green innovation has been widely believed to

stimulate firms' environmental performance (Chen et al., 2006; Kammerer, 2009). Moreover, Carrion-Flores and Innes (2010) suggest green innovation spurs demands for improved environmental performance. Accordingly, two hypotheses are proposed.

H3-a: Green product innovation positively affects environmental performance.
H3-b: Green process innovation positively affects environmental performance.

4. Green innovation and Firm performance

Green innovation through minimizing environmental impact, CO2, and waste efficiently helps firms avoid environmentalists' protests or penalties, increase productivity, improve corporate reputation, green image, and market performance, develop new markets, and achieve first-mover competitive advantages (Porter and van der Linde, 1995; Pujari, 2006; Mu et al., 2009). Additionally, Bonini and Oppenheim (2008) verify that eco-innovation practices on energy-efficient products help firms minimize waste and promote brands, which in turn efficiently stimulate market share and new business opportunities, being reflected through the case of Toyota Prius Hybrid which has become status symbols for green-labeling products strategies. Hence, following hypotheses are established.

H4-a: Green product innovation positively affects market share.
H4-b: Green product innovation positively affects reputation.
H4-c: Green process innovation positively affects market share.
H4-d: Green process innovation positively affects reputation.

5. Environmental performance and Firm performance

Better environmental performance has been widely proven to bring numerous sustainable benefits regarding firm performance such as low-cost, differentiation, better social reputation, and legitimization (Porter and van der Linde, 1995; Lopez-Gamero et al., 2009) as well as market share and profitability enhancement (Wahba, 2008). Obviously, firms with lower emission level and better waste treatment will be able to outperform rivals with first-mover advantages and more reliable green reputation; hence, environmental performance plays a critical role to firm sustainability (Claver et al., 2007). Recent studies also confirm better environmental performance beneficially helps firms attract more resources and social support as well as expand market opportunities (Jacobs et al., 2010). Therefore, following hypotheses are put forward.

H5-a: Environmental performance positively affects market share.
H5-b: Environmental performance positively affects reputation.

RESEARCH METHODOLOGY

1. Taiwan hybrid vehicle industry

In recent years, the transport sector alarmingly accounts for 27% of the world's total energy consumption and 33.7% of total green house gas emission (Tie and Tan, 2013). Additionally, fossil fuel scarcity and environmental pressures keep increasing dramatically to unsustainable levels in a global scale (Nilsson et al., 2012). In this context, energy saving, air pollution, and

CO2 emission in the transport sector has become extremely important issues and principal governance challenges (Hui, 2010).
The Taiwanese hybrid vehicle industry was chosen for several crucial reasons. First, in addition to alarming global warming and numerous environmental threats, Taiwan is currently suffering from heavy environmental burdens due to limited land and a strong emphasis on economic development and serious air pollution and CO2 emission derived from vehicle exhaust, which in turn has placed significant pressures on vehicle manufacturers to develop environmentally friendly and energy-efficient vehicles (Pongthanaisawan and Sorapipatan, 2010). Second, Taiwan hybrid vehicle industry possesses much potential for development since manufacturing firms are becoming more social responsible and green-conscious under significant pressures from environmental regulations and green customers. Moreover, being one of the major vehicle producers worldwide, Taiwan is now attempting to apply advanced technologies in new product and process development for not only environmental protection but also industrial advancement (Chou and Hsiao, 2005). Finally, since sharing common development patterns with regional developing countries; the achieved experience in Taiwan usefully shed light on future firm growth in Asia.

2. Data collection

For empirical analysis, this study aimed to collect data from firms that were listed in Taiwan's Top 5000 largest enterprises by Taiwan Ministry of Economic Affairs in 2012. The firms chosen must have achieved certain green levels and well-recognized in the market. Survey questionnaire was employed as main research instrument. The chosen items were adopted from existing literature related to green innovation, market demand, environmental performance, and firm performance. Prior to data collection, the questionnaire was pre-tested for content validity in two stages. First, based on the idea of Cooper and Schindler (2001), two scholars in the field of green supply chain were asked to assess all construct items for ambiguity, clarity, and appropriateness; then, the questionnaire was further modified. Second, the questionnaire was mailed to three management executives in the hybrid vehicle industry to review the structure, readability, ambiguity and completeness.

Using random sampling method, questionnaires were sent to respondents that were retailers, wholesalers, and component sale firms in the automobile industry in Taiwan through post, e-mails, and fax. Out of 1000 distributed questionnaires, 223 valid questionnaires were obtained, achieving the response rate of 22.3%.

3. Questionnaire design and measures

The questionnaire (as in Table 1) contained five sections. The first section comprised basic descriptive data of participant firms. The following sections were the measurements of market demand, green innovation, environmental performance, and firm performance. All items were assessed using Likert 5-point scale (1= "strongly disagree", 5= "strongly agree").

4. Methodology

Structural Equation Modeling (SEM) methodology was utilized to test the proposed hypotheses and the theoretical model in Figure 1. SEM was selected for its capability of

incorporating incorporate both latent and observed (i.e. measured) variables while other multivariate techniques were only based on observed measurements (Byrne, 2006).

Since the measurement scales for market demand, green innovation, environmental performance, and firm performance in this research were integrated from the extant literature, it was necessary to test the appropriateness of these scales (Wong and Law, 2002). As such, this study adopted exploratory factor analysis (EFA) to test construct items, using maximum likelihood method with varimax rotation. Then, AMOS 5.0 was employed as the main statistical assessment tool. To demonstrate a reasonable model fit, a number of fit indicators were computed, including Chi-square/degrees of freedom (χ^2/d.f), Goodness-of-fit Index (GFI), Adjusted Goodness-of-fit Index (AGFI), the Normed Fit Index (NFI), Comparative Fit Index (CFI), and Root Mean Square of Approximation (RMSEA).

EMPIRICAL RESULTS AND DISCUSSIONS

1. Descriptive analysis

The main purpose of conducting demographic characteristics analysis was to briefly summarize participant firms' background features. Regarding participant firms' background, the results showed that the majority of respondent firms were with more than 25 years of operation (41.3%), turnover rate from $NT 1.5 to 5 billion (54.3%), capital of more than $NT 70 million (69.4%), and more than 201 employees in total (69.5%).

Table 1. Questionnaire constructs and variables

Constructs	Variables	References
Market demand	Customer demand	Oltra & Saint Jean (2009)
	External pressures	Zhou et al. (2009)
	Competitor pressures	
Green innovation	Green product innovation	Chen et al. (2006), Chen (2008),
	Green process innovation	Huang & Wu (2010)
Environmental	Reduction of air emission	Wang et al. (2004)
performance	Reduction of hazardous waste/scrap	Awasthi et al. (2010)
	Less consumption of gasoline/fuel	Chiou et al. (2011)
	Environmental compliance	
Firm	Market share	Rex & Baumann (2007)
performance	Reputation	Li et al. (2010)

In accordance with research purposes, the mean and standard deviations were calculated to further explain the current situation of market demand, green innovation, environmental performance, and firm overall performance in Taiwan hybrid vehicle industry. The achieved mean values in Table 2 range from 3.74 to 4.44, indicating that a wide range of Taiwanese hybrid vehicle manufacturers have already implemented and made great efforts in enhancing green innovation (4.36) and environmental management (4.44) in daily operational activities, thus have gained considerable achievements regarding firm performance (4.33). However, although market demand (3.90) has attracted increasing attention from business operators, its role on green innovation and firm performance has not been sufficiently emphasized.

2. Reliability and validity

Since the measurement scales for research constructs were adopted from previous literature, the constructs were indicated to have content validity (Wong and Law, 2002). In order to assess the scale appropriateness, this study additionally adopted an exploratory analysis (EFA), using maximum likelihood method with varimax rotation. In terms of market demand, the EFA results of 19 items showed that KMO and Bartlett test were significant (KMO=0.95, p<0.000) and two factors with eigenvalue greater than 1 were extracted. Out of 19 items, the first 7 items achieved factor loading greater than 0.5 on factor 1, indicating customer demand pressure. 12 remaining items achieved factor loading greater than 0.5 on factor 2, representing competitor pressures. Similarly, EFA results for other constructs' measurement scales showed that green innovation was consisted of green production innovation (6 items) and green process innovation (6 items). Environmental performance (5 items) and firm performance (10 items) was proven to be single factors.

Table 2. Descriptive statistics, Reliability and validity tests

Constructs	Mean	Std. Dev.	Cronbach's α
Market demand	3.90	0.91	0.899
Customer demand pressures	4.11	0.85	
External pressures	3.86	1.03	
Competitor pressures	3.74	1.09	
Green innovation	4.36	0.79	0.884
Green product innovation	4.37	0.76	
Green process innovation	4.36	0.74	
Environmental performance	4.44	0.67	0.962
Firm performance	4.33	0.77	0.885
Market share	4.23	0.89	
Reputation	4.43	0.73	

The measurement model was then tested for reliability by Cronbach's α values. As shown in Table 2, the achieved Cronbach's α values for market demand, green innovation, environmental performance, and firm performance respectively were 0.90, 0.88, 0.96, and 0.89, which were all greater than the threshold 0.7 (Nunnally, 1978; Bagozzi and Yi, 1988), indicating high internal consistency, thus reliability for all measurement indicators.

3. SEM results

3.1 Model fit test

A set of goodness-of-fit indices were calculated to demonstrate a reasonable model fit. The results of Table 3 showed the achieved values ($\chi 2/df = 2.515$, GFI= 0.99, AGFI= 0.92, NFI= 0.99, CFI= 0.99, RMSEA= 0.083), were all greater than the recommended values, indicating good model fit of the final structural model.

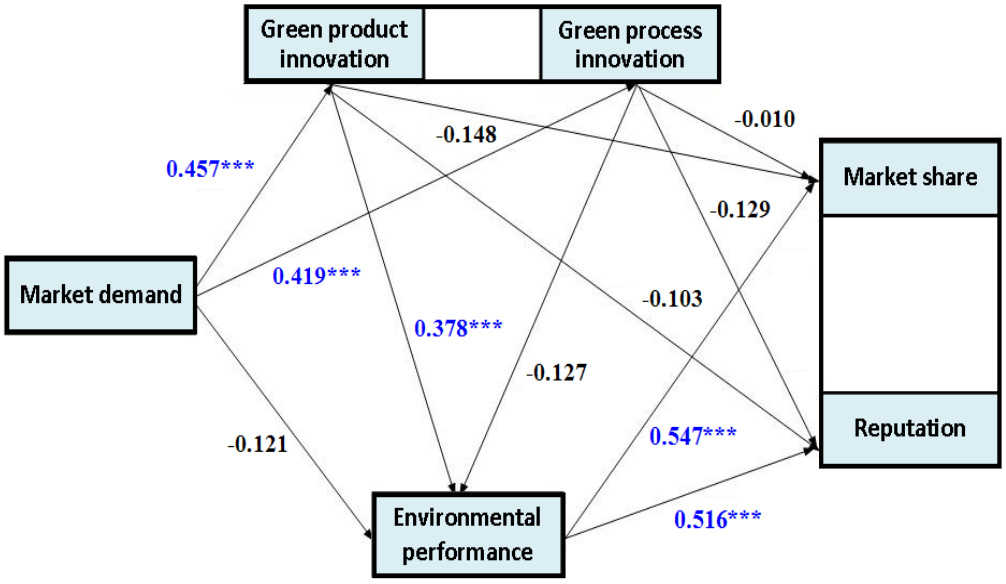
Table 3. Model fit test

	χ^2/d.f	GFI	AGFI	NFI	CFI	RMSEA
Final structural model	(5.030/2)= 2.515	0.993	0.922	0.993	0.996	0.083
Recommended values	<3	>0.9	>0.8	>0.9	>0.9	<0.1

3.2 SEM results

The structural model was used to test the proposed hypotheses and the theoretical model in Figure 1. AMOS 5.0 was utilized as the main statistic analysis tool. The final structural model with all path coefficients was illustrated in Figure 2.

The achieved results supported five out of 11 proposed hypotheses, as shown in Table 4. Specifically, market demand was found to have significant impact on green product innovation (β=0.457, p<0.001), green process innovation (β=0.419, p<0.001); hence, hypotheses H1a and H1b were supported. Additionally, green product innovation had significant impact on environmental performance (β =0.378, p<0.001), supporting hypothesis H3a. Finally, environmental performance exerted significant effects on market share (β=0.547, p<0.001) and reputation (β=0.516, p<0.001), confirming hypotheses H5a and H5b.



Note: p<0.001***

Figure 2. SEM results with path coefficient between latent constructs

However, in contrast with research expectation, no significant relationships were found between market demand and environmental performance (β=-0.121, p=0.056), green process innovation and environmental performance (β=-0.127, p=0.170), which in turn disapproved hypotheses H2 and H3b, respectively. Most surprisingly, the link between green innovation and firm performance was found to be non-significant, reflected through non-significant path coefficients between green product innovation and market share (β=-0.148, p=0.092) as well as reputation (β=-0.103, p=0.233), simultaneously between green process innovation and market share (β=-0.010, p=0.909) and reputation (β=-0.129, p=0.120), indicating hypotheses H4a, H4b, H4c, and H4d were rejected.

Table 4. Hypothesis support: Path coefficients (β)

	Hypothesis	β	Supported
H1-a	Market demand → Green product innovation	0.457***	Yes
H1-b	Market demand → Green process innovation	0.419***	Yes
H2	Market demand → Environmental performance	0.121	No
H3-a	Green product innovation → Environmental performance	0.378***	Yes
H3-b	Green process innovation → Environmental performance	0.127	No
H4-a	Green product innovation → Market share	0.148	No
H4-b	Green product innovation → Reputation	0.103	No
H4-c	Green process innovation → Market share	0.010	No
H4-d	Green process innovation → Reputation	0.129	No
H5-a	Environmental performance → Market share	0.547***	Yes
H5-b	Environmental performance → Reputation	0.516***	Yes

Note: $p<0.001$***

CONCLUSIONS, DISCUSSIONS, AND RECOMMENDATIONS

Concerning the impact of market demand, the empirical findings prove that market demand have a significant impact on green innovation. These findings are consistent with previous studies that market demand acts as the key factor stimulating green innovation through inducing successful new product development and enforcing firms to implement flexible manufacturing strategies (Chiou et al., 2011; Hsu and Hu., 2011). Nonetheless, no significant relationship was found between market demand and firms' environmental performance. After discussions with experts, this study finds that despite customer demand for vehicles with better energy-efficiency, lower air pollution and prices; however, without the implementation of green innovation, firms cannot achieve higher level of environmental performance as expected.

Regarding the impact of environmental performance on firm performance, the results strongly support previous studies (Claver et al., 2007; Wahba, 2008; Jacobs et al., 2010) by confirming its benefits in assisting firms in leading the market, outperforming rivals with of low-cost and differentiated strategies, achieving more reliable green reputation, attracting more customers, and expanding market share.

Worth noticing, this study found that green innovation had partly positive impact on environmental performance through green product innovation, but not through green process innovation. After discussion with industrial experts, green product innovation is perceived to easily and directly help firms satisfy green requirements and enhance environmental performance since being closely associated with eco-targets; meanwhile, improving the manufacturing process is considered costly projects and is not easy to implement.

Surprisingly, this study found out no significant relationships between firms' green innovation and firm performance, which in turn contributes to the existing debate in the literature. It is noted that the implementation of new green manufacturing processes and product development can be costly, which in turn sharply increase product prices. Hence, although green innovation helps firm address environmental issues, it is not ensured that the manufactured green products can truly achieve market success and higher reputation (Pujari,

2006) since customers' preferences and actual purchase behaviors sometimes conflict with their price-consciousness (Prakash, 2002; Zhou et al., 2009). Moreover, Rehfeld et al. (2007) state that there is not always strong stimulus for eco-innovation from the demand side since green products are still expensive and not all customers are willing to trade off product qualities for green attributes.

Regarding these non-significant results, after discussions with experts, these findings can be explained due to the small sample size in this study, which in turn may constraints the evaluation. Moreover, since the Taiwanese hybrid vehicle industry is still in its initial stage of replacing fuelled vehicles, customers remain low perception and favor toward its green benefits, thus results in low purchase intention and low reputation.

This research is the first of its kind to investigate the links among market demand, green innovation, environmental performance, and firm performance in Taiwan hybrid vehicle industry, which is now an important and promising industry in Taiwan society and one of the major vehicle producers worldwide. Hence, the findings beneficially contribute to the knowledge of green innovation and green demands, which in turn effectively assist firms in carrying out outstanding, differentiated, and feasible strategies to achieve better sustainability and market leadership in this competitive market.

With achieved results, this study has provided the hybrid vehicle industry in particular and all businesses in general with useful managerial focuses and guidelines for performance enhancement. By confirming the significant impact of market demand on firms' green innovation, this study strongly recommends firms to make more efforts to understand customer needs and expectations in order to better anticipate their changing preferences and align green product innovation initiatives with consumer values to promptly satisfy market demand, thus gain better performance. In addition, since market demand can be influenced by price, firms should attempt to reduce any unnecessary costs in the entire manufacturing processes to maintain stable and reasonable prices in consistent with customer needs. Moreover, since green innovation has been indicated to be an important strategy for hybrid vehicle firms to gain better sustainable advantages and attract more customers, this study implies that firms should pay more attention to excel their competencies in innovating their products and processes once attempting to lead the market. Finally, environmental performance has been proven to be adequately crucial to firm performance stimulation and business success, implying that hybrid vehicle manufacturing firms should emphatically enhance product quality and attributes in a green manner in order to produce new environmentally friendly vehicles that significantly help firms surpass competitors, grasp more customer attention, satisfaction, and purchase intention, and promote market leadership.

Nonetheless, this research remains limitations. The use of single industry has partly restricted finding generalization. Hence, future studies can expand the research scope to other Asian or international hybrid vehicle markets to achieve better findings. Additionally, since small sample size has considerably restricted the findings, this study strongly encourage the continuous collecting of data in order to complete the investigation in a more holistic way.

REFERENCES

1. Bagozzi, R.P., and Yi, Y. (1988), "On the evaluation of structural equation models", *Journal of the Academy of Marketing Science*, Vol. 16, pp. 74-94.
2. Berchicci, L., and Bodewes, W. (2005), "Bridging environmental issues with new product development", *Business strategy and the Environment*, Vol. 14 No. 5, pp. 272-285.
3. Berthon, P., Hulbert, J.M., and Pitt, L.F. (1999), "To serve or create? Strategic orientations toward customers and innovation", *California Management Review*, Vol. 42 No. 1, pp. 37-52.
4. Bonini, S.M.J., Oppenheim, J.M. (2008), "Helping green products grow", *McKinsey Quarterly*, 1-8.
5. Byrne, B.M. (2006), *Structural Equation Modeling with AMOS: Basic concepts, applications, and programming*, Lawrence Erlbaum, Mahwah, NJ.
6. Carrillo-Hermosilla, J., del Rio, P., and Konnola, T. (2010), "Diversity of eco-innovations: Reflections from selected case studies", *Journal of Cleaner Productio*n, Vol. 18, pp. 1073-1083.
7. Carrion-Flores, C.E., and Innes, R. (2010), "Environmental innovation and environmental performance", *Journal of Environmental Economics and Management*, Vol. 59, pp. 27-42.
8. Chang, N.J., and Fong, C.M. (2010), "Green product quality, green corporate image, green customer satisfaction, and green customer loyalty", *African Journal of Business Management*, Vol. 4 No. 13, pp. 2836-2844.
9. Chen, Y.S. (2008), "The driver of green innovation and green image: Green core competence," *Journal of Business Ethics*, Vol. 81, pp. 531-543.
10. Chen, Y.S., Lai, S.B., and Wen, C.T. (2006), "The influence of green innovation performance on corporate advantage in Taiwan", *Journal of Business Ethics*, Vol. 67 No. 4, pp. 331-339.
11. Chen L.Y., Hwa M.Y., Lee Y.C., Yu T.Y., and Wu C.T. (2008), "Particle size distribution of exhaust stream from in-use motorcycles", *Journal of Environmental Engineering and Management*, Vol. 18 No. 6, pp. 397-402.
12. Chiou, T.Y., Chan, H.K., Lettice, F., and Chung, A.H. (2011), "The influence of greening the suppliers and green innovation on environmental performance and competitive advantage in Taiwan", *Transportation R*esearch Part E (Article in press).
13. Chou J.R., and Hsiao S.W. (2005), "Product design and prototype making for an electric scooter", *Materials and Design*, pp. 439-449.
14. Claver, E., López, M.D., Molina, J.F., and Tarí, J.J. (2007), "Environmental management and firm performance: A case study", *Journal of Environmental Management*, Vol. 84, pp. 606-619.
15. Cooper, D.R., Schindler, P.S. (2001), Business Research Method, seventh ed. McGraw-Hill Book Co.
16. Du, C., and Liu, Y. (2011), "Constructing energy saving system based on low-carbon economy," *Energy Procedia*, Vol. 5, pp. 1998-2002.
17. Fontaras, G., and Samaras Z. (2007), "A quantitative analysis of the European automakers' voluntary commitment to reduce CO2 emissions from new passenger cars based on independent experimental data", *Energy Policy*, Vol. 35, pp. 2239-2248.
18. Halila, F., and Rundquist, J. (2011), "The development and market success of eco-innovations: a comparative study of eco-innovations in Sweden", *European Journal*

of Innovation Management, Vol. 14 No. 3, pp. 278-302.
19. Horbach, J., Rammer, C., and Rennings, K. (2012), "Determinants of eco-innovations by type of environmental impact - The role of regulatory push/pull, technology push and market pull", *Ecological Economics*, Vol. 78, pp. 112-122.
20. Huang, Y.C., and Wu, Y.C.J. (2010), "The effects of organizational factors on green new product success. Evidence from high-tech industries in Taiwan," *Management Decision*, Vol. 48 No. 10, pp. 1539-1567.
21. Hsu C.W., and Hu A.H. (2011), "Applying hazardous substance management to supplier selection using analytic network process", *Journal of Cleaner Production*, Vol. 17 No. 2, pp. 255-264.
22. Hui, S. (2010), "Multi-objective optimization for hydraulic hybrid vehicle based on adaptive simulated annealing genetic algorithm", *Engineering Applications of Artificial Intelligence*, Vol. 23, pp. 27-33.
23. Iwu, C.G. (2010), "Impact of product development and innovation on market share", *African Journal of Business Management*, Vol. 4 No. 13, pp. 2659-2667.
24. Jacobs, B.W., Singhal, V.R., and Subramanian, R. (2010), "An empirical investigation of environmental performance and the market value of the firm", *Journal of Operations Management*, Vol. 28 No. 5, pp. 430-441.
25. Juma, N., and Payne, G. (2004), "Intellectual capital and performance of new venture high-tech firms", *International Journal of Innovation Management*, Vol. 83, pp. 297-318.
26. Kammerer, D. (2009), "The effects of customer benefit and regulation on environmental product innovation. Empirical evidence from appliance manufacturers in Germany", *Ecological Economics*, Vol. 68, pp. 285-2295.
27. Klassen, R.D., and Whybark, D.C. (1999), "The impact of environmental technologies on manufacturing performance," *Academy of Management Journal*, Vol. 42 No. 5, pp. 599-615.
28. Koellinger, P. (2008), "The relationship between technology, innovation, and firm performance: Empirical evidence from e-business in Europe", *Research Policy*, Vol. 37, pp. 1317-1328.
29. Kwansa F.A., Mayo, C., and Demirciftci, T. (2008), "Chapter 8 - The importance of intangible assets: trends and patterns". *Handbook of Hospitality Strategic Management*, pp. 181-202.
30. Li, Y., Su, Z., and Liu, Y. (2010), "Can strategic flexibility help firms profit from product innovation?", *Technovation*, Vol. 30, pp. 300-309.
31. Lopez-Gamero, M. D., Molina-Azorin, J. F., and Claver-Cortes, E. (2009), "The whole relationship between environmental variables and firm performance: Competitive advantage and firm resources as mediator variables", *Journal of Environmental Management*, Vol. 90, pp. 3110-3121.
32. Martenson, R. (2007), "Corporate brand image, satisfaction and store loyalty: A study of the store as a brand, store brands and manufacturer brands", *International Journal of Retail Distribution Managemen*t, Vol. 35 No. 7, pp. 544-555.
33. Meeus, M.T.H., and Edquist, C. (2006), "Introduction to part 1: Product and process innovation", in Hage, J., and Meeus, M.T.H. (Eds.), *Innovation, science and institutional change*, Oxford: Oxford University Press.
34. Mu, J., Peng, G., and MacLachlan, D.L. (2009), "Effect of risk management strategy on NPD performance", *Technovation*, Vol. 29, pp. 170-180.
35. Nilsson, M., Hillman, K. and Magnusson, T. (2012), "How do we govern sustainable

innovations? Mapping patterns of governance for bio-fuels and hybrid-electric vehicle technologies," *Environmental Innovation and Societal Transitions*, Vol. 3, pp. 50-66.
36. Oltra, V., and Saint Jean, M. (2009), "Sectoral systems of environmental innovation: An application to the French automotive industry", *Technological Forecasting & Social Change*, Vol. 76, pp. 567-583.
37. Nunnally, J. C. (1978), *Psychometric Theory*, McGraw-Hill, New York, NY.
38. Pongthanaisawan, J., and Sorapipatana, C. (2010), "Limiting the fossil-fueled alternatives could be highly effective in forcing the market penetration of electric vehicles. Relationship between level of economic development and motorcycle and car ownerships and their impacts on fuel consumption and greenhouse gas emission in Thailand", Renewable and Sustainable Energy Reviews, Vol. 14, pp. 2966-2975.
39. Porter, M.E., and van der Linde, C. (1995), "Green and competitive: Ending the stalemate," *Harvard Business Review*, Vol. 73 No. 5, pp. 120-134.
40. Prakash, A. (2002), "Green marketing, public policy and managerial strategies", *Business Strategy and the Environment*, Vol. 11 No. 5, pp. 285-297.
41. Pujari, D. (2006), "Eco-innovation and new product development: understanding the influences on market performance," *Technovation*, Vol. 26 No. 1, pp. 76-85.
42. Rehfeld, K.M., Rennings, K., and Ziegler, A. (2007), "Integrated product policy and environmental product innovations: An empirical analysis," *Ecological Economics*, Vol. 61 No. 1, pp. 91-100.
43. Rex, E., and Baumann, H. (2007), "Beyond Eco-labels: what green marketing can learn from conventional marketing", *Journal of Cleaner Production*, Vol. 15 No. 6, pp. 567-576.
44. Rubik, E.F., Frankl, E.P. (2005), "The future of eco-labeling", Greenleaf Publishing, Sheffield: 60.
45. Tie, S.F., and Tan, C.W. (2013), "A review of energy sources and energy management system in electric vehicles", *Renewable and Sustainable Energy Reviews*, Vol. 20, pp. 82-102.
46. Wahba, H. (2008), "Does the market value corporate environmental responsibility? An empirical examination," *Corporate Social Responsibility and Environmental Management*, Vol. 15, pp. 89-99.
47. Wang, Y., Lo, H., and Yang, Y. (2004), "The constituents of core competencies and firm performance: Evidence from high-technology firms in China", *Journal of Engineering and Technology Management*, Vol. 21, pp. 249-280.
48. Wei, Y., and Morgan, N.A. (2004), "Supportiveness of organizational climate, market orientation, and new product performance in Chinese firms", *Journal of Product Innovation Management*, Vol. 21, pp. 375-388.
49. Wong, C.S., and Law, K.S. (2002), "Development of an emotional intelligence instrument and an investigation of its relationship with leader and follower performance and attitudes", *The Leadership Quarterly*, Vol. 13, pp.1-32.
50. Zhou, K.Z., Brown, J.R., and Dev, C.S. (2009), "Market orientation, competitive advantage, and performance: a demand-based perspective", Journal of Business Research, Vol. 62, pp. 1063-1070.
51. Zhu, Q., and Sarkis, J. (2004), "Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises," *Journal of Operations Management*, Vol. 22, pp. 265-289.
52. Zhu, Q., Sarkis, J., and Lai, K.H. (2008), "Green supply chain management implications

for closing the loop", *Transportation Research Part E: Logistics and Transportation Review*, Vol. 44 No. 1, pp. 1-18.