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# THE RELATIONSHIPS AMONG GREEN OPERATIONS, GREEN INNOVATION, AND ENVIRONMENTAL PERFORMANCE

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## ABSTRACT

***Purpose*** *– The purpose of this study is to investigate the relationships among green operations, green innovation, and environmental performance.*
***Design/methodology/approach*** *– Data from 141 Taiwan high-tech manufacturers are collected. SEM analysis is employed to examine the relationships among green operations, green innovation, and environmental performance.*
***Findings*** *– This study finds that Taiwan high-tech manufacturers perform various levels of green operations and, consequently, display different levels of effects on green innovation and environmental performance. In addition, positive relationships were found between green operations and green innovation and environmental performance (i.e. environmental operational performance, environmental managerial performance) and between green innovation and environmental performance.*
***Practical implications*** *–By putting forward that the integrating of green operations and green innovation affects organizational environmental performance more positively than the sole impact of green operations on organizational environmental performance, this study has suggested manufacturers should pay more attention to develop related strategies to cope with customer demand, thus achieve better customer satisfaction and sustainable operation.*
***Originality/value*** *– In the context that green issues are currently the novel theme for research and have attracted increasing attention from managers but there remains the lack of empirical studies among green operations, green innovation, and environmental performance, this study has contributed to the extant literature with the model combining these aspects. As such, the research findings have provided helpful academic references and managerial guidelines for firms in gaining competitive environmental performance.*

**Keywords:** Green Operations, Green Innovation, Environmental Performance
**Paper type:** Research paper

## INTRODUCTION

The rapid economic growth worldwide and constantly changing advanced technologies have placed tremendous burderns on the earth's ecosystems and limited natural resources. In recent years, due to an increased environmental awareness and a goal of sustainable manufacturing, many national governments have introduced laws to reduce unnecessary environmental harm and to regulate green products, such as Waste Electrical and Electronic Equipment (WEEE) and the Restriction of Hazardous Substance (RoHS). Such these directives have strongly enforced manufacturers to focus more on green production or else lose their competitiveness. As a result, green operations have been increasingly attracting more attention and discussions worldwide. Concerning Taiwan context, since this country acts as one of the world largest export-oriented electronic OEM and ODE and has close relationships with the European Union (EU), the United States of America (USA), and Japan, environmental issues cannot be ignored due to their dramatic effects on indistries' financial performance. Hence, in order to achieve sustainable competitiveness and customer satisfaction and market leadership, Taiwanese manufacturers need to pay more attention to environmental legislation during manufacturing processes and the development of green operational models.

Green operational management refers to the close cooperatation between up-stream and down-stream manufacturers to reduce environmental damage and to use "green" as a prerequisite to extend Supply Chain Management (SCM) issues. In addition to the original emphases of SCM on cost, flexibility, speed, and quality, green operational management adds environmental criteria into raw-materials purchasing, packaging, design, manufacturing, reuse and recycling for achieving energy-conservation, emission-reduction and promoting overall environmental quality. It also takes a holistic operational model into practice and meets legislative requirements. The final goals will be improved environmental performance, increased product values, and environmental impact reduction.

Current industries worldwide are facing tremendous enforcement for the implementation of green concept into products and services, thus they have started to ask suppliers and customers to pay more attention to environmental issues. In this context, innovative product processes will effectively help solve operational and administrative burdens through reducing negative environment impact. A review on the extant literature shows that there have been numerous studies on SCM and organizational performance (Zhu and Sarkis, 2004; Hervani et al., 2005; Chien and Shih, 2007); simultaneously, green innovation has become one of critical research issues (Rao and Hult, 2005; Qi et al., 2010). Nonetheless, missing in literature is studies investigating whether the launching of green operations would affect green innovation and organizational environmental performance. Hence, this study aims at the impact of green operations on green innovation and organizational environmental performance. The achieved findings provide useful references for the industry and experts with green operations implementation and environmental protection.

## LITERATURE REVIEWS AND RESEARCH HYPOTHESIS

### 1. Green Operations

Green operations have been lauded as an effective approach to enhance sustainability programs and to open up the distribution channel from manufacturers to suppliers (Cooper and Ellram, 1993; Van Weele, 2002). Recently, since firms worldwide have been strongly affected by shortened product life cycles and increasing amount of waste caused by the expansion of high-tech industries, firms have paid more attention to environmental protection and the search for effective GSCM (Geyer and Jackson, 2004; Hanna and Newman, 1995), aiming to better manage raw material purchasing, enhance product recycle, reuse, and remanufacture as well as economic green packaging, thus provides businesses with numerous opportunities to achieve more sustainable competitiveness and environmental damage reduction (Green et al., 1996; Narasimhan and Carter, 1998).

Green operations put environmental protection into the management system by taking "green" notions into the supply chain (Winn and Roome, 1993). Hence, through taking internal organizational practices and external relationships with suppliers into deeper consideration, green operations have been widely perceived to be closely associated with product design, raw material purchasing, product manufacturing, recycle control, and effective reduction of hazardous materials (Sarkis, 2003). In other words, green operations are an operational process from up-stream suppliers and manufacturers to down-stream customers by mutural cooperatation.

In the extant literature, the concept of green operations covers a wide range of aspects due to the existence of various GSCM practices. Due to the focus on exploring internal operationsal management process, this study defines this process as "green operations" (Zhang and Li, 2009). Frentzel and Sease (1996) refers to the ideal green operations is that each indurtry devotes to enhance cooperative relationships among employees through information sharing since this endeavor can expand green operations to the ultimate attainment.

To summarize, green operations include green design, green production, green marketing, and reverse logistics (Bhamra, 2004; Peattie, 1992; Hervani et al. 2005). Green design refers to the design of products that emphatically consider the environement impact of raw resources during the entire product life cycle through deeper focuses on product function, quality, and cost to proceed to superior quality. In other words, green design reviews product life cycle from sustainsuable angles and directly imports 3R (reduce, reuse, recycling) into the product development stage for reducing negative environmental impact (Gupta, 1995). Chen et al. (2006) regards green marketing as arousing industrial intuitive ability to reduce harmful environment factors and produce green product, to plan recycle, reuse, and renew system, establish environment-oriented and public welfare image. Drawing the blueprint of sustainable development pattern, green marketing can conduct consummers into green consumption mainstream, and promote industrial competitiveness. Fleischmann et al. (1997) defines reverse logistics as the process of transforming used products into re-usable products. Hervani et al. (2005) propose that reverse logistics differ from traditional logistics through condersidering cost and recycle value of products and components at the lowest cost to conduct the higest reuse

value.

## 2. Green Innovation

Green innovation is defined as organizations' implementation and introduction of new ideas, products and processes which contribute to environmental impact reduction or to specified eco-targets (Klemmer et al., 1999; Rennings, 2000; Chen, 2008; Oltra and Saint Jean, 2009). It is further involved with energy-saving, pollution prevention, waste recycling, green product designs, and corporate environmental management (Chen et al., 2006).

This study investigates environmental issues in Taiwan since Taiwanese firms have conducted green issues and most of them are OEM organizations, thus they have to meet the regulations from downstream customers. This study adopts the idea of Klemmer et al. (1999), Rennings (2000), Chen (2008), and Oltra and Saint Jean (2009) that green innovation is consisted of green product innovation, green process innovation, and green administrative innovation. Green product innovation is defined to be product innovation which is closely associated with environmental concerns (i.e. energy saving, pollution prevention, waste recycling, no toxicity, and green product designs) (Chen et al., 2006). In other words, green product innovation is viewed as a means of reducing environmental impacts during green products' entire life cycle by reducing toxics and materials used, controlling power consumption and emission release, and extending the use phase in term of recyclability (Kammerer, 2009). Green process innovation refers to the modification of the current operating processes and systems, aiming to produce new or significantly improved green products which can reduce environmental impact (Meeus and Edquist, 2006). Birkinshaw et al. (2008) refer green administrative innovations to the update of organizations' management practices using a new and eco method, thus leads to environmental impact reduction.

## 3. Environmental Operational Performance and Environmental Managerial Performance

According to ISO14030, orginizatinal environmental performance refers to a systematic procedure of measuring and assessing environmental performance on industry. Accordingly, ISO 14031 defines environemtal Environmental Performance Indicators (EPIs) to include Operational Performance Indicators (OPIs) and Management Performance Indicators (MPIs). Environmental operational performance reflects environmental performance on the process of operations, such as import raw material, engery, and service. It belongs to organizational facilities' hardware and design, install, operation, and maintance and the output during operational process (e.g. product, service, waste, emission (Papadopoulos and Giama, 2007). Environmental managerial performance reflects the efforts of management echelon on improving environmental operational performance. It benefits management efficiency evaluation and improving environmental performance dicesion-making and motivation (Chien and Shih, 2007). For instance, managerial performance and orginizational stratum policy, members, legislative activities, measures, procudures, decision can provide and improve the capabilities and efforts on business aspects, such as the modified measures of training, legislative demand, resource usage, environmental cost management, purchase, product R&D, and electronic-document which can affect environmental performance.

In sum, in this study, organizational environmental performance is reffered to as performance assessment focusing on environment. Hence, this study adopts Papadopoulos and Giama (2007) and Chien and Shih (2007)'s ideas to divide environmental performance into environmental operational performance and environmental managerial performance. Environmental operational performance refers to measure performance of energy and resource usage, reduce air, water, toxic waste, $CO_2$ emission. Environmental managerial performance points to measure improving the relationship between manufacturers and communities, and promoting industrial image.

## 4. Hypotheses Development

### 4.1 Green Operations and Green Innovation

Shrivastava (1995) points out the integration of enivironmental protection concepts into design build up the concepts for green product design, which in turn reinforences green product innovation. The main aim of green product innovation is to minimize environmental harm through green production. In support, Marcus (2007) indicates that firms' engagement in green production and green marketing will positivily affect their green manufacturing innovation and green administrative innovation. Concerning green administration innovation, Winn and Roome (1993) propose that of industry should expand this concept to the whole supply chain management and throughout green marketing to promote industrial green image and administrative innovation. As such, green marketing will bring about greater demands to customers; that is to say, green marketing has a positive impact on green product innovation (Belz and Bilharz, 2005).

In response to environmental pressures, industries need to implement green marketing to better reinforence green administrative innovation and promptly solve environmental protection problems. It is also noted that green marketing positively reinforces green administrative innovation (Newman and Breeden, 1992; Peattie, 1992; Marcus, 2007). As a result, this study establishes the first hypothesis as follows:

**H1 -** Green operations have a positive impact on green innovation.

### 4.2 Green Innovation and Environmental Performance

Porter (1991) proposes that pressures from regulation, cost reduction, and the need for environmental operational performance improvement have strongly enforced industries to develop green innovation through green product innovation, green manufacturing innovation, and green adminnistrive innovation. In addition to meet the requirement of regulation, it can reduce cost and improve. In addition, Geffen and Rothenberg (2000) point out that green product innovation, green manufacturing innovation, and green administrative innovation are the main sources of improving enivornmental operational performance. Specifically, green product innovation helps firm meet regulation requirements, promote effective resource application and industrial image (Rosa and Pierpaolo, 2010) as well as reduce different environmental problems during product life cycle through minimizing toxic material and electric comsumption (Kammerer, 2009). In other words, green product innovation has a positive impact on

environmental operational performance on each stage throughout product life cyle. In addition, green manufacturing innovation has been widely perceived as an effective means for firms in improving environmental operational performance through cleaner production, green manufacturing processes, and waste reduction (Klassen and McLaughlin, 1996), thus facilitate firms to achieve unique competitiveness and promote environmental operational performance (Edeltraud and Lilly, 2006). In line with this, Tao (2009) claims that green manufacturing innovation effectively decreases gas emission and increases energy utility rate in petrochemistry industry. Finally, Chen et al. (2006) and Shrivastava (1995) address green administrative development as a tool to help firms increase competitive benefits, reduce cost, enhance product and manufacturing innovation, increase industrial image, and promote environmental managerial performance. It is also noted that green managerial innovation positively influences envrironmental managerial performance (Kim and Srivastava, 1998). Therefore, this study proposes the following hypotheses:

**H2 -** Green innovation has a positive impact on environmental operational performance.

**H3 -** Green innovation has a positive impact on environmental managerial performance.

### 4.3 Green Operations and Environmental Performance

Steger (1993) propose that green operations can help firms save cost, increase market opportunity, promote usable resource efficiency, and prevent pollution which would benefits industry with better regulation compliance, higher employee motivation and effective organization, lower risk and environmental responsibility and information flow distribution. Schoell and Guiltinan (1993) indicate green marketing enhances organizational environmental image. Taylor (1992) suggests that green environmental management emphizes the adoption of positive and active attitude in order to better response to possible problems during marketing processes. It has been also widely perceived that industries which implement green environmental management and green innovation can efficiently promote environmental operational performance, reduce cost, achieve more effective environmental protection that help firms avoid the expense of environmental dispute, environmental accident, environmental ban, and the loss from customer boycott (Taylor, 1992). Moreover, Ken and Martin (2007) address that green marketing mainly focuses on minimizing negative environmental impact throughout product life cycle, implying its positive impact on environmental operational performance.

The main purpose of green operations is to manufacture green products that are closely associated to practices of renew, recycling, reuse, and resuseable disposal in the end of product life. That is to say, green products can facilitate the reduction of materials, waste, and pollution emission as well as the enhancement of resource application. Chien and Shih (2007) find that green production positively influences environmental operational and managerial performance. Tsoulfas and Pappis (2006) address that the reuse of materials can considerably save internal cost, exploit new market, and achieve competitive advantage. Theyel (2001) and Rao and Holt (2005) propose that once taking green recycle and reuse into practice, industries can effectively save material, water, and energy, thus improve oginizational environmental performance. As a result, this study establishes the following hypotheses:

**H4 -** Green operations have a positive impact on environmental operational performance.

**H5 -** Green operations have a positive impact on environmental managerial performance.

Figure 1 shows the research framework that illustrates the relationships among the green operations, green innovation, and environmental performance.

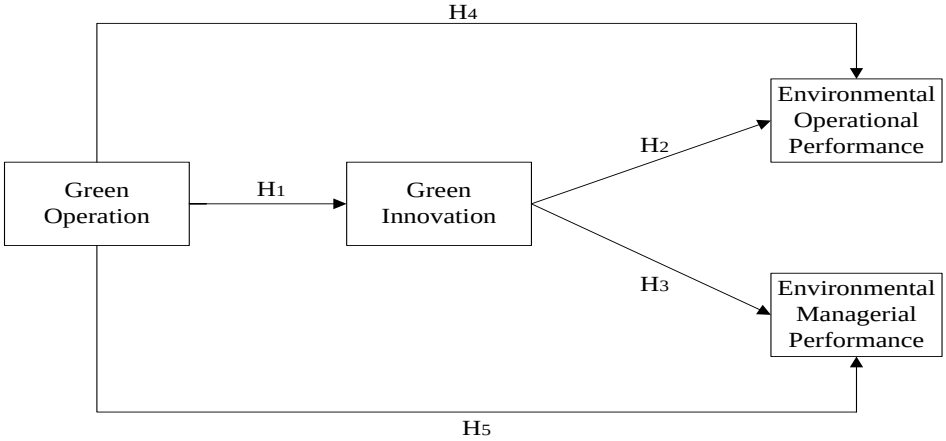



Figure 1 Conceptural Framework

## RESEARCH METHODOLOGY

### 1. Pre-test and Questionnaires Development

The questionnaire consisted of four sections: (1) Green operations: reducing environmental impacts and testing top manager's and employee's eco-friendly concepts; (2) Green innovation: minimizing environmental pollution in SCM process compared with competitors; (3) Environmental operational performance; and (4) Environmental managerial performance. The items were modified based on pre-test interviews with five managers from the semi-conductor and computer related industries experts mentioned. Following the procedure recommended by Churchill (1979), the pre-test interviews indicated that questionnaire was appropriate to test the mediating effect of green innovation on green operations and environmental performance. A five-point Likert scale (1- "totally disagree" to 5- "totally agree") was used to measure items for green operations, green innovation, and environmental performance.

### 2. Data Collection

The population for this study was managers from the semi-conductor, information communication technology, and computer-related industries in Taiwan. Taiwan was chosen as the main research scope since this country is one of the major hi-tech original equipment manufacturers (OEMs) worldwide and environmental issues are currently perceived as greatly important to the above industries (Russo and Fouts, 1997). Questionnaires were sent to 587 general managers from the list of "Largest 5000 Corporations in the ranking of Taiwan". 141 valid responses were obtained from 150 received questionnaires, indicating a valid response rate of 24%.

## 3. Reliability and Validity Analysis

This study used SPSS12.0 and AMOS18.0 to analyze the data. For each latent construct, reliability and validity were assessed based on two-step procedure with sturctural equation modeling (SEM) approach which includes measurement model and structural model (Anderson and Gerbing, 1988). The results show that the factor loading coefficients were above 0.5, which fit the benchmark of 0.5 (Hair et al., 2010), and the SMC value were between 0.324 and 0.797, which are above the benchmark of 0.2 (Bentler and Wu, 1993), and the Cronbach's α coeefficients were between 0.812 to 0.859, which are above the benchmark of 0.7 (Nunnally, 1978). Hence, the achieved results suggest a high interna consistency, thus confirming reliability of each contruct. The AVE values were all above 0.5, indicating high convergent validity of the measurement indicators (Hair et al., 2010). This study also followed the ideas of Gaski and Nevin (1985) which are the coefficient between two latent constructs of Cronbach's α smaller than 1 and the square root of AVE are larger by paring two latent constructs suggested by Fornell and Larcker (1981). The statistic results fit the above suggestions, supporting discriminant validity.

Table 1 Correlation of Latent Variables

| Variables | Green Operations | Green Innovation | Environmental operational performance | Environmental managerial performance | Composite reliability | AVE |
|---|---|---|---|---|---|---|
| Green Operations | .736 | | | | .904 | .542 |
| Green Innovation | .548** | .712 | | | .858 | .507 |
| Environmental operational performance | .549** | .624** | .730 | | .820 | .533 |
| Environmental managerial performance | .441** | .555** | .633** | .766 | .850 | .586 |
| Cronbach's α | .838 | .812 | .848 | .859 | | |

Note: *p＜.05;**p＜.01; ***p＜.001

# STATISTICAL RESULTS

## 1. Evaluation of Rival Models

Hair et al. (2010) suggest utilizing rival models to verify the optimal hypothesis model, and then perform individual path coefficient test to confirm hypotheses. From previous liuterature, this study designs four rival models, as shown in Figure 2. The Model 1 (i.e. the completely mediated model) explored the mediating impact of green innovation in between green operations and environmental performance. Model 2 was partially mediated model which explored the impact of

green operations on green innovation; meanwhile, the paths related to environmental operational performance and environmental managerial performance were ignored. Model 3 examined the impact of green innovation on environmental operational performance and environmental managerial performance while the path related green operations were ignored. Model 4 presented the direct impact of green operations on environmental operational performance and environmental managerial performance whereas all indirect impact on path was ignored. Hypothetical model was a partially mediated model containing the impact of green operations on environmental operational performance and environmental managerial performance through the mediators of green innovation and the direct impact of green operations on environmental operational performance and environmental managerial performance. Table 2 shows the fit statics of rival model comparison. After the comparison between the path analyses of models 1-4, the hypothetical model was found to fit well with the data, indicating that green innovation should be added in between green operations and environmental operational performance and environmental managetial performance.

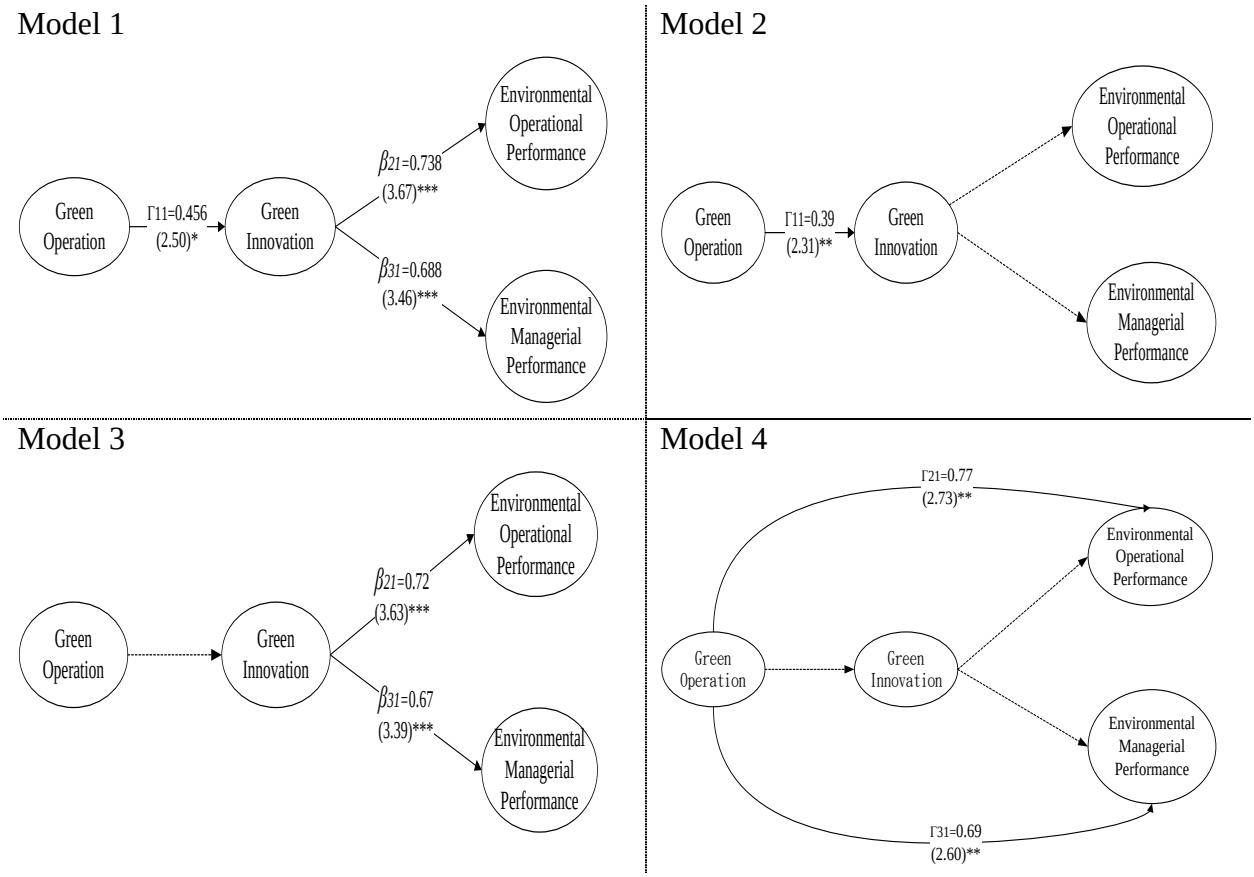



Figure 2 Rival Models

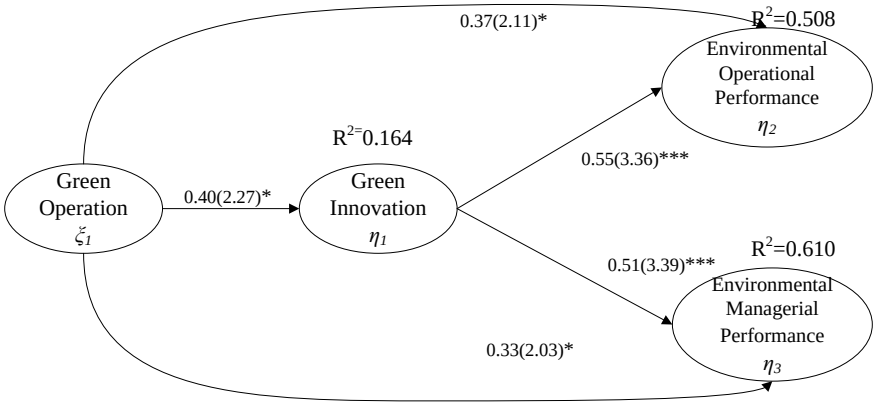
## 2. Overall Model Fit

This study adopted the idea of Hair et al. (2010) to choose absolute fit measures, incremental fit measures, and parsimonious fit measures to test the model fit. Absolute fit measures were to

measure overall goodness-of-fit for both the structural and measurement models collectively. Table 2 showed the achieved values for absolute fit measures respectively were $x^2$/df=1.24, GFI=0.865, AGFI=0.833, RMR=0.020, and RMSEA=0.042, indicating goodness-of-fit results. Incremental fit measures refered to measure goodness-of-fit that compares the current model to a specified independence nmodel to determine the degree of improvement over the null model. In Table 2, the obtained values for incremental fit measures respectively were NFI=0.702, IFI=0.924, TLI=0.910, and CFI=0.920. NFI was lower than the standardize value 0.9. Parsimonious fit measures refered to measure goodness fit representing the degree of model fit per estimated coefficient. The statistcs results of parsimonious fit measures were PNFI=0.620 and PGFI=0.698 , indicating the overall good model fit.

Table 2 Rival Model Comparison

| Fit indicators | Model 1 | Model 2 | Model 3 | Model 4 | Hypothetical model | Limiting value | Fit result |
|---|---|---|---|---|---|---|---|
| Absolute Fit Measures | | | | | | | |
| $x^2$/df | 1.25 | 1.69 | 1.317 | 1.565 | 1.24 | 1-5 | Yes |
| GFI | .863 | .816 | .858 | .836 | .865 | >.8 | Yes |
| AGFI | .832 | .776 | .827 | .799 | .833 | >.8 | Yes |
| RMR | .029 | .043 | .032 | .040 | .020 | <.05 | Yes |
| RMSEA | .042 | .071 | .048 | .64 | .042 | <.05 | Yes |
| Incremental Fit Measures | | | | | | | |
| NFI | .672 | .550 | .652 | .587 | .702 | >.9 | No |
| IFI | .911 | .748 | .886 | .797 | .924 | >.9 | Yes |
| TLI（NNFI） | .896 | .708 | .868 | .764 | .910 | >.9 | Yes |
| CFI | .907 | .737 | .881 | .789 | .920 | >.9 | Yes |
| Parsimonious Fit Measures | | | | | | | |
| PNFI | .599 | .495 | .585 | .526 | .620 | >.5 | Yes |
| PGFI | .703 | .761 | .702 | .684 | .698 | >.5 | Yes |




Note: * $p$<.05, **$p$<.01, ***$p$<.001

Figure 3 Hypothetical Structural Model

## 3. Empirical Result of Hypothetical Structural Model

The SEM approach was applied to test the causal relationship between lantent variables. Figure 3 shows the path analysis of hypothesized structural model. The statistics results show that green operations have positively impact on green innovation ($\gamma 11$= 0.40, t = 2.27, p<0.05), green innovation has positively impact on environmental operational performance ($\beta_{21}$=0.55, $t$ = 3.36, $p$<0.001), green innovation has positively influence on environmental managerial performance ($\beta 31$=0.51, $t$= 3.39, $p$<0.001), green operations have positively impact on environmental operational performance ($\gamma 21$=0.37, $t$= 2.11, $p$<0.05), and green operations have positively influence on environmental managerial performance ($\gamma 31$ =0.33, $t$ = 2.03, $p$<0.05).

Previous literature mainly explores the impact of green operations on environmental performance and the corelations among green innovation, environmental operational performance, and environmental managerial performance. However, there has been a lack of inverstigations on the mediating influence among the dimensions, which is the interest of this paper. The statistical results of all structural paths strongly supported proposed hypotheses, as shown in Table 3.

First, the hypothesis H1 is strongly supported, stating that green operations have a positive impact on green innovation. Hence, it can be confirmed that the more practice on green operations, the more high-tech firms can accelerate green innovation, which in turn helps acheive energy-saving goals, improve productive technology, enhance waste product reuse, and obtain more comtetitive advantages.

This study support hypotheses H2 and H3 that green innovation has positivily impact on environmental performance (i.e operational management, manegerial performance). Hence, through deeply considering product designs for easy recycle and reuse, emission disposal, and adjusting devision of authority, the high-tech industry can not only better save water and engry but also improve internal administration and information delivery as well as ensure industrial substantial safety.

The finding support H4 and H5 that green operations have positivily impact on environmental performance (i.e. operational management, menegerial performance). Through designing new products to reduce product life cycle impact, supervisors and employees implement emvironmental issues in daily operational and manufacturing activities to use adjusted environmental products to establish waste and material categorization systems and to practice long-term green philosophy. Simultaneously, the manufa tured green products can substantially assist firms in reducing air pollution, ing greenhouse gap emission, diminishing cost, and increasing production output.

Finally, this study aims to explore the mediating effect of green innovation on green operations and environmental performance. The empirical results show that green operations implementation can effectiveily improve environmental operational performance and environmental managerial performance through green innovation strengthening. Hence, it is suggested that green design through using improved environmental products and reusing waste

materials, green processes through effectively minimizing toxic emission and reducing waste, and green administration through falicitating internal information delivery and supporting the adoption of new environmental policies have all effectively benefit environmental performance by reducing environmental pollution, industrial safety accidents, and scarced water and engry consumption.

Table 3 Path Coeffieient and Hypothesis Testing

| Hypotheses | Path coefficient | *T* value | Results |
|---|---|---|---|
| $H_1$ Green operations→ Green innovation | .40 | 2.27* | Supported |
| $H_2$ Green innovation→ Environmental operational performance | .55 | 3.36*** | Supported |
| $H_3$ Green innovation→Environmental managerial performance | .51 | 3.39*** | Supported |
| $H_4$ Green operations→ Environmental operational performance | .37 | 2.11* | Supported |
| $H_5$ Green operations→ Environmental managerial performance | .33 | 2.03* | Supported |

Note：* $p$<.05；**$p$<.01；***$p$<.001

## CONCLUSION AND IMPLICATION

The current study mainly explores the whether the application of green operation model in high-tech industry would affect organizational environmental performance through green innovation. Through verifying the hypothetical models, this empirical study have successfully clarified the relationship between all variables and in turn addressed all research questions. The results show that the import of green operation model positively affects green innovation. In other words, the more practicable green operational model will definitely lead to the more promotional green innovation. This finding strongly supports previous studies that green operational model has a positive impact on green innovation (Winn and Roome, 1993; Ottman, 1999; Marcus, 2007). Second, this study confirms that the strengthening of green innovation will positivily affect environmtnal operational performance, hence implying that manufacturers should emphatically stimulate green innovation in order to obtain better environmental operational performance. This finding is consistent with previous research that green innovation positivily affects environmental operational performance (Geffen and Rothenberg, 2000; Rosa and Pierpaolo, 2010). Third, the achieved results suggest that the enhancement of green innovation will positivily affect environmental managerial performance, which support the extant literature (Shrivastava, 1995). Forth, better green operations are proposed to positivily affect environmtnal operational performance, which is in line with previous studies (Theyel, 2001; Chien and Shih, 2007). Finally, this study finds that better implementation of green operations can effectively improve environmental managerial performance, confirming the results obtained in previous research (Chien and Shih, 2007; Chen, 2008).

With achieved relationships among green operations, green innovation, environmental operational performance, and environmental managerial performance, this study provided several useful contributions and academic implications. Firstly, in the context that green issues are currently the novel theme for research and have attracted increasing attention from managers but there remains the lack of empirical studies among green operations, green innovation, and

environmental performance, this study has contributed to the extant literature with the model combining these aspects. Second, by putting forward that the integrating of green operations and green innovation affects organizational environmental performance more positively than the sole impact of green operations on organizational environmental performance, this study has suggested manufacturers should pay more attention to develop related strategies to better cope with customer demand, thus acehive better customer satisfaction and sutainable operation. As such, the research findings have provided helpful academic references and managerial guidelines for firms in gaining competitive environmental performance.

It is noted that nurmous industries currently set their goals on benefits regardless environmental protection, which in turn causes serious demange on environment. This study finds that green operations have a direct and positive impact on green innovation. In other words, once importing green operation model, high-tech industries will gain more benefits in propoting green innovation. Green innovation capability enhancement, in turn, facilitates the industries in skipping over the competition of Red Ocean, creating their own competitiveness, reducing environmental demange, and obtaining more benefits as well as the win-win situation between industry and environment. Moreover, this study also finds that green operations have a direct and positive impact on environmental performance through green innovation, implying that green innovation is a critical factor of promoting environmental performance in high-tech industry. Therefore, in the context that public is currently paying more attention to environmental issues in industries, once firms attempt to improve green innovation, they would definitely achive greater benefits on eco-environment and more positive industry image, thus result in better organizational operational performance and organizational managerial performance, indicating a triple-win aspects among industry, publics, and environment.

Despite the above contributions, this study remains several limitations. Due to sample restriction, future studies are encouraged to expand the sampling subjects to different industries (e.g. food industry, logistics). Since many questionnaire items regarding green operations, green innovation, and organizational performance possibly cause respondents to lose patience, further assessment for items is recommended. It is also suggested that data should be collected using vertical section and time-series methods and to explore the interations among variables in different time situation for deeply observing variations and seeking more valid results. Finally, in addition to understand the impact of different factors and results, comparative analyses may be effective to seek for reliable empirical study.

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