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Abstract

Environmental management has been researching extensively in the last two decades. Pressure from environmental regulations or policies plays an important role to boost environmental management practices. Nevertheless, the relationship between such pressure and the ultimate firm performance is not very obvious. Although green product innovation has been recognized as a predictor to improve environment performance, there is a lack of discussion in the literature to examine the mediating effect of green product innovation between the aforementioned pressure and firm performance. Additionally, most previous studies adopted a static view which ignores the implications on external dynamic factors in many empirical studies. In this connection, this study contributes to the field of knowledge by filling these two gaps. More specifically, this study: (i) examines the effect of green product innovation on the relationship between pressure of environmental regulations (or policies) and firm performance; and (ii) evaluates the moderating effect of environmental dynamism on the relationship between green production innovation and firm performance. A questionnaire survey is conducted in an emerging country, China, to verify the hypotheses.

Keywords: Environmental dynamism, Green product innovation, Environmental regulations, Environmental management, Performance.

1. Introduction

Undoubtedly, various managerial practices are used to improve the performance of firms, such as that by better allocating their resources (e.g. Tse et al., 2012; Wu et al., 2013). This ultimately helps firms to generate profits and gain competitive advantage in the market. Specifically to the operations management domain, companies widely implement quality management strategies, like total quality management, to enhance customer satisfaction that in turn would contribute to the business performance (Jayaram, et al. 2010). Environmental management is one recent concern that has received massive attention from both researchers and practitioners. Environmental management is now a widely adopted operations strategy (Gupta, 1995; Klassen and Whybark, 1999). Although with an explicit focus on addressing environmental concerns into implementing supply chain, surprisingly, only a handful of studies can provide evidences that organizations may generate business opportunities to outperform their competitors (e.g. Vachon and Klassen, 2008; Zhu et al., 2008). Even cost efficiency, which is the traditional focus of operations management, has not been studied well in this regard (Porter and van der Linde, 1995).

One main driver to the development of environmental management is the corresponding pressure from environmental regulations (Zhu et al., 2011; Tseng et al., 2013). Existing research mainly focuses on retailers' perspective to understand environmental issues by considering consumers' perception as the independent variable of environmental issues (Lee et al., 2012). One possible drawback of this approach is that the perception of consumers is somehow so subjective and difficult to measure exactly. In practice,

environmental issues are usually affected by various factors, for instance, packaging and labels (Hyllegard et al., 2012). Thus, we advocate taking the perspective of suppliers to investigate environmental issues. Stated clearly, we argue that awareness to environmental related regulations or policies takes a crucial role to affect the integration of environmental issues into supply chains in companies. This is because one important, underlying driver of environmental management in organizations is the pressure from external regulations (Zhu et al., 2011). However, it is believed that such pressure cannot lead to good performance directly. This is explained below.

Researchers generally recognize that the success of integrating environmental issues into organization cannot be achieved easily if the concern of green innovation is not clearly addressed when developing business process for companies (Chen et al., 2006; Chen, 2008; Ziegler and Nogareda, 2009). Whether or not firms can boost their performance through environmental management would be a combination of many factors. Among them, the ability to provide green product innovation and the awareness of, hence pressure generated from, environmental regulations cannot be separated. However, this relationship has not been investigated. Therefore, it is worth studying the effect of green product innovation on the relationship between the aforementioned pressure and firm performance, which is the first research question of this work.

That being said, strictly static regulation and market may not necessarily result in technical efficiency (van der Vlist et al., 2007). As a matter of fact, the assumption that "external environmental is very stable" can hardly be justifiable on majority of, if not all,

occasions. Like many operations management variables, environmental regulations and technology are always subject to change. In this connection, it is worth investigating the aforementioned relationship between the pressure of environmental regulations, green product innovation, and firm performance when the external environment is uncertain. Above can be explained through the lens of contingency theory because static theories or best practices for operations strategy are no longer effective (Sousa and Voss, 2008; Chavez et al., 2015). Environmental dynamism can be regarded as external uncertainty and can be defined as the rate of change or unpredictability prevalent in a firms' environment (Eroglu and Hofer, 2014). It is a possible moderating variable by taking the contingency view. This will be further explained in Section 2. In this connection, environmental dynamism is expected to have different degrees of moderating effect on the association between green innovations and firm performance. This is the second research question to be answered in this work.

To address the above-mentioned questions, this paper proposes a research framework that sets out to investigate the following research objectives:

- To examine the relationship among the pressure of environmental regulations, green product innovation, and firm performance;
- To investigate the moderating effect of environmental dynamism on the relationship between green product innovation and firm performance.

This paper therefore contributes to the environmental management research by understanding the relationship of the pressure of environmental policies and firm

performance via green product innovation, and to study the moderating effect of environmental dynamism on the relationship between green product innovation and firm performance. The rest of the paper is organized as follows: Section 2 reviews existing studies, and then formulates the hypotheses accordingly. This is followed by Section 3 which outlines the research method and data collection. Section 4 presents the results. Finally, Section 5 discusses the findings and concludes this paper.

2. Literature Review and Hypotheses Development

2.1 Pressure of environmental regulations / policies

Regulatory pressure is probably the key driver to push firms towards sustainable development, especially if the target markets include the member states of the European Union (De Brito et al., 2008). The REACH Directive (European Union, 2003) is a typical example that firms need to follow in order to control chemical substances being used in a product. Aligning firms' activities to the regulations would be a necessity. However, whether or not such alignment will eventually affect the firms performance is unclear. Firm performance is always a key concern of companies. However, to date, there is limited research investigating the relation between the pressures from the environmental regulations and business outcome. Empirical findings demonstrate that environmental regulations lead to improved environmental performance (Kagan et al., 2003). But conversion of such environmental performance to firm profitability, for example, may not be linear. For example, King and Lenox (2001) also find that there is a relationship between the environmental performance and financial gain, but which one is the cause or effect was unclear.

In China, environmental issues are notorious and hence the country also started imposing environmental regulation since 1980s, initially set by the State Environmental Protection Agency (SEPA), which is now rebranded as the Ministry of Environmental Protection (MEP) (McGuire, 2014; Bai et al., 2015). This is a reflection of the determination of the Chinese Government to tackle environmental issues. For example, MEP published the Chinese version of Waste Electrical and Electronic Equipment (WEEE) regulation in 2009 for the implementation in 2011 (Zhu et al., 2013). Such regulations definitely have exposed Chinese firms to great pressures, let alone the external pressures from other countries which require the exported products to comply with the respective regulations. In this connection, Bai et al. (2015) review the state-of-the-art in corporate sustainability development in China and the associated development of the regulatory pressures, which support the views of the authors of this article.

Therefore, we argue that the pressure of environmental regulations or policies may not directly lead to better firm performance. Hence, it is urged to gain more understanding on whether or not firms can convert the environmental performance achieved through the pressure of environmental regulations to firm performance. For instance, Rao and Holt (2005) provide empirical evidence that implementing green operations can enhance a company's competitiveness and economic performance. Moreover, there is a clear relationship between improvements in environmental performance and compliance with environmental regulations on a company's competitiveness (Bacallan, 2000). More recently, Shu et al. (2014) claimed that government support strongly mediates the effect

on radical green product innovation than its effect on incremental product innovation. Therefore, the pressure of such environmental regulations, which will definitely affect the implementation of environmental practices, should also positively relate to the firm's performance. The next question is of course, what other factor(s) may be able to facilitate such process. In the next section, we will explore one such possible factor, which is green product innovation.

2.2 Green Product Innovation and Firm Performance

Green product innovation takes the environmental factors (e.g. material usage, energy consumption, etc.) into product design considerations for both new and (modification of) existing products, with the prime objective to reduce the negative environmental impacts over the products' life-cycle (Dangelico and Pujari, 2010, Chang, 2011). Guoyou et al. (2013) consider green innovation as "an instrument to improve firms' environmental management process", and is related to any changes, either technologically, organizationally, societally, or institutionally, that result in a reduction of environmental burdens. More specifically, green product innovation has an impact on firms' competitive advantage and theirs image (Chen et al., 2006; Chen, 2008; Wong, 2012). Lin et al. (2013) also showed that green product innovation had a positive effect on firm performance via an empirical study in the automobile industry.

The ultimate objective of any business is to earn profit and survive in the marketplace. This can be accomplished by adding value to the customers through the core business processes. Incorporating environmental concerns into corporate operations can be one of

many ways to accomplish the objective (Hansman and Claudia, 2001). This can also improve firms overall efficiency as the traditional way to define efficiency does not take bad outputs into consider, and, as a consequence, can include increasing environmental performance and reduce cost (Rao, 2005). Vachon and Klassen (2008) verified such relationship for North American organizations through an empirical study. This in line with Porter and van der Linde (1995)'s assertion that environmental management practices can help firms to introduce innovations in order to offset the cost of implementing the practices. Consequently, forms can be more competitive in the market via the environmental management practices.

Curwen et al. (2013) offer a potential solution approach to relief consumers' environmental concern by claiming that "examination of the connections between design process and the supply chain is imperative for advancing sustainable practices in the apparel and textile industry". Grounded in their claim, we propose a research model which links green product innovation to firm performance in terms of operations efficiency and firm profitability. Green product innovation plays an important role to influence consumer behavior and hence firms performance (Lee et al., 2012; Lin et al., 2013). Chen and Burns (2006) presented a relevant case study to support this assertion. They advocated that "solutions cannot be achieved without action by the government, industry, and the consumers". This brings out another issue which is the pressure of environmental regulations or policies in our proposed model. Green product innovation should link to the pressure of environmental regulations or policies directly. Such pressure is inevitable (otherwise they are not called regulations or policies) so green

product innovation is a direct consequence of it. The pressure itself cannot lead to good environmental performance, but green product innovation is a proper medium to convert such pressures to improve environmental performance and hence possibly firm performance. This can also be explained by the contingency theory and further discussion can be found at the end of next sub-section.

A recent empirical study in China revealed that customer and regulatory pressures could promote organization responses which then could improve green innovation, albeit unspecific to green product innovation (Huang et al., 2015). This finding coupled with the above discussion in Section 2.1 and Section 2.2, we first hypothesize that pressure of environmental regulations / policies would affect green product innovation, which then affect firm performance. This is represented by the first two hypotheses:

H1: Pressure of environmental regulations / policies is positively associated with green product innovation.

H2: Green product innovation is positively associated with (a) cost efficiency and (b) firm profitability.

2.3 Environmental dynamism

Environmental problems of many manufacturing supply chains, which typically include a number of early manufacturing activities outsourced to emerging counties like China, are also difficult to tackle due to its complexity, let alone the dynamics of a real business (Chan et al., 2012). Nevertheless, the effects cannot be underestimated (Jørgensen et al., 2010). To better capture the dynamics of the business, contextual factors, such as market

dynamism, play a significant role in environment management and business performance. A lack of such factors is believed to be a key success to explain why environmental policies have not achieved their objectives successfully (Revell and Rutherfoord, 2003). Market dynamism exerts an external impact on firms due to various changes induced by different sources, such as technology innovation, customer expectation, and product demand.

The impact of the external environment on innovation and performance has been examined extensively (e.g., Matusik and Hill, 2006; Jansen et al., 2006). Environmental dynamism is concerned with the extent to which external environment are characterized by "change in technologies, variations in customer preferences, and fluctuations in product demand or supply of materials" (Jansten et al., 2006). It refers to the rate of change and the degree of instability of environment (Dess and Beard, 1984; Azadegan et al., 2013; Eroglu and Hofer, 2014). Under a dynamic environment with frequent and rapid changes induced by technology, customers, and suppliers, existing products and processes are easy to become obsolete. As such, the dynamic environment provides a drive for the improvement of the existing and processes or the development of new products and processes. An empirical study concluded that environmental dynamism is a driver in China that affects competitive advantage significantly (Li and Liu, 2014). Accordingly, firms pursuing green product innovation are more likely to capture changing circumstances by improving the existing and processes or developing new products and processes. Hence, we expect that environmental dynamism would have a moderating effect on green product innovation and firm performance.

Above assumption can be explained through the lens of contingency theory. The theory involves three types of variables (Sousa and Voss, 2008): Contextual variables, response variables, and performance variables. Contextual variables refer to the exogenous situational characteristics which can influence the organizations of concern. Environmental dynamism is an example of such contextual variables, and a classic example is uncertainty in market demand (Eroglu and Hofer, 2014). For example, if market demand has a positive relationship with environmental performance (e.g. Lin et al., 2013), fluctuations of demand would definitely influence the performance and hence the effectiveness of green product innovation. Therefore, it is unreasonable to assume that the external environment is static. For instance, Azadegan et al. (2013) studied the moderation effect of environmental dynamism on lean operations practice performance. However, this is the first study to examine the moderation effect of environmental dynamism on the relationship between green product innovation and firm performance. In this study, not only the environmental dynamism is modeled as a contextual factors, the pressures of environmental regulations / policies is in fact another type of contextual factor which is subject to change over time, and is primarily an exogenous factor.

In addition to the contextual factors, green product innovation is the response variable in the contingency theory paradigm, which is the actions taken by the organizations in response to the contextual factors (i.e. the pressure of environmental regulations / policies and environmental dynamism in this study). The last piece of the puzzle is the performance variables which are the independent variables that measure the effectiveness

of the response variables (i.e. the actions) subject to the contextual variables. They are represented by firm profitability and cost efficiency in the proposed research model in this study. Therefore, environmental dynamism is expected to moderate the relationship between green product innovation and firm performance, i.e. H2a an H2b mentioned in previous section. Therefore, the last hypothesis is as follows:

H3: Environmental dynamism moderates the effect of green product innovation on (a) cost efficiency and (b) firm profitability.

To conclude, the proposed research model is depicted in Figure 1. Next section will present the details of the research design and research instrument to verify above hypotheses.

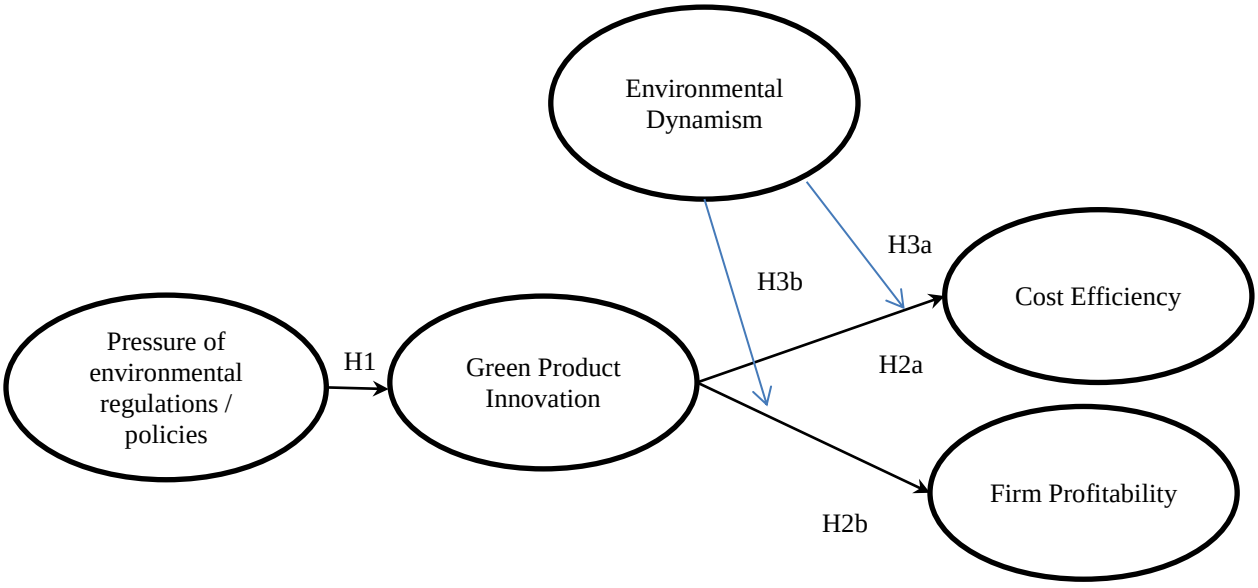

Figure 1: Conceptual Model

3. Research Methodology

3.1 Survey Development and Measurements

A self-administrated questionnaire was developed as the research instrument to examine the hypotheses. As depicted in Appendix A, all questionnaire items were based on a 7-point Likert scales, from 1 (strongly disagress) to 7 (strongly agree). All measures in our study were adapted from the extant literature as shown in Appendix A. Adaptation is required mainly because the questionnaire survey was conducted with Chinese respondents. Therefore, some words and even sentence structures are changed to improve understanding. In addition, back-translation was employed between English and Chinese by bilingual Chinese researchers to ensure conceptual equivalence (Cai et al., 2010). The questionnaire was then reviewed by three academics in this field and further adjustment in use of words was implemented. The revised questionnaire was pilot-tested with a small group of post-doctoral researchers to ensure that the indicators were understandable and relevant to practices in China (Hensley, 1999). The wordings in some of the questions are further adjusted based on the feedback from the pilot test.

3.2 Data Collection and Sample

Due to the nature of this research, the target frame of the survey is operations managers or equivalent from the industry operating in China. Samples cover a variety of industries (such as automotive industry, electrical and electronic industry, chemical industry, manufacturing industry, textile industry, and toys industry, etc.) in order to improve the generalizability of this work and the proposed model. In short, the units of analysis were set as individual firms whereas the units of data collection were managers. The survey

was conducted online and took place from April 24 to May 8, 2015 (i.e. 2 weeks). In total, there are 250 responses returned from the online survey.

4. Analysis and Results

We now examine the reliability and validity of our constructs. We adopted the two-step approach prosed by Gerbing and Anderson's (1988). The first step is to examine the measurement model, which includes convergent validity and discriminant validity. The objective is to assure that the measures used in the analysis are reliable and valid. This is followed by the structural model to analyze the data. Table 1 presents descriptive statistics on each variable and the correlations among constructs.

Table 1: **Descriptive statistics and correlations matrix**

	Mean	Std.	1	2	3	4	5
1. Pressure of environmental regulations / policies	4.28	1.28	1				
2. Green Product Innovation	4.50	1.27	.542**	1			
3.Operations Cost Reduction	4.51	1.19	.397**	.575**	1		
4.Firm Profitability	4.75	1.21	.439**	.597*	.690**	1	
5. Environmental Dynamism	4.34	1.19	.542**	.613**	.711**	.697**	1

** significant at the 0.01 level

4.1 Measurement Instrument Validation

Convergent validity exists if a group of indicators are measuring one common factor. Composite reliability and average variance extracted were calculated using the

procedures suggested by Fornell and Larcker (1981). Composite reliability (CR) for each construct is at least 0.813, and average variance extracted is at least 0.524. Cronbach's alpha values of all factors are well above 0.70. Table 2 provides all of these values and suggests sufficient convergent validity.

Table 2: Convergent validity and reliability

Construct	Label	Standardized Loading	Cronbach's Alpha	Composite Reliability
1. Pressure of environmental regulations / policies	EP1	.746	.927	.929
	EP2	.865		
	EP3	.904		
	EP4	.870		
	EP5	.846		
	EP6	.727		
2. Green Product Innovation	GPI1	.732	.808	.813
	GPI2	.818		
	GPI3	.618		
	GPI4	.713		
3. Cost Efficiency	CE1	.813	.891	.891
	CE2	.840		
	CE3	.802		
	CE4	.823		
4.Firm Profitability	FP1	.819	.917	.919
	FP2	.882		
	FP3	.894		
	FP4	.842		
5. Environmental Dynamism	ED1	.796	.906	.907
	ED2	.811		
	ED3	.846		
	ED4	.746		
	ED5	.763		
	ED6	.758		

Discriminant validity among the constructs can be tested by comparing the average variance extracted (AVE) of each construct with the square of the correlation between all possible pairs of constructs (Hair et al., 2010). Table 3 shows that all the AVE values (in bold) fulfil this as they are all greater than the square of the correlation between all

possible pairs of constructs.

Table 3: Discriminant validity test

	1	2	3	4	5
1. Pressure of environmental regulations / policies	**.687**	.294	.158	.193	.294
2. Green Product Innovation	.542	**.524**	.331	.356	.376
3. Cost Efficiency	.397	.575	**.672**	.476	.506
4. Firm Profitability	.439	.597	.690	**.739**	.486
5. Environmental Dynamism	.542	.613	.711	.697	**.620**

Note: Diagonal entries (in bold) are average variances extracted, entries below the diagonal are correlations, and the entries above the diagonal represent the squared correlations.

Additionally, the overall measurement model provides a good fit to the data ($\chi 2$=473.029, Dof=242, p=0.00, CFI=0.948, TLI=0.941, and RMSEA=0.062). Overall, the results offer support for discriminant validity among the constructs.

4.2 Common Method Bias

We performed Harman's single factor test ($\chi 2$=1734.213, Df=252, p=0.00, CFI=0.665, TLI=0.634 and RMSEA=0.153). Our Harmon's single factor test results are considerably worse than those of the measurement model ($\chi 2$=473.029, Dof=242, p=0.00, CFI=0.948, TLI=0.941, and RMSEA=0.062). As suggested by Lindell & Whitney (2001), we also employ the lowest bi-variate correlation among the manifest variables as the marker variable to check for the impact of method variance. The adjusted correlation matrix was computed and was tested with the significance of the adjusted correlations. It was found that after adjustment, all correlations remain significant. Based on the above reliability

and validity tests, we are confident to conclude that common method bias does not exist in this study.

4.3 Hypothesis Testing

4.3.1 Main effects results

We first established a structural equation model to test each hypothesis, namely, H1, and H2a, and H2b. According to the results summarized in Table 4, the overall fit of this structural model is acceptable, with the CFI and TLI well above the recommended threshold of 0.90 (Hu and Bentler, 1999), and the SRMR less than 0.08 (Hu and Bentler, 1999). Also those hypotheses H1, H2a and H2b are all supported.

Table 4 Structural model testing

Structural paths	Standardized estimates	R square
H1 Pressure of Environmental regulation/policy →Green Product Innovation	.580***	.337
H2a Green Product Innovation → Cost Efficiency	.692***	.478
H2b Green Product Innovation →Firm Profitability	.697***	.485
Model fit: $\chi 2$= 249.897, Dof=131, p=0.00, CFI=0.963, TLI=0.957, and RMSEA=0.060		

*** significant at the 0.001 level

4.3.2 Moderation effects of environmental dynamism

A number of steps were followed to investigate the moderating role of the environmental dynamism in the GPI–CE relationship. First, we examined the interaction between GPI and environmental dynamism. In order to reduce the threat of multi-collinearity, the two variables were first centered (Aiken and West, 1991). Next, CE was regressed on dynamism, GPI and GPI × dynamism. The interaction term was significant (β = .119, p = .007) and multi-colinearity (VIF = 1.061) was not a problem, so environmental

dynamism moderates the relationship between green product innovation and cost efficiency. As such, Hypothesis 3a was confirmed. Results indicate that the positive relationship between green product innovation and cost efficiency is stronger in environments characterized by high dynamism.

A similar procedure was employed to examine the moderating role of the environmental dynamism in the GPI–FP relationship. First, we investigated the interaction between GPI and environmental dynamism. FP was regressed on dynamism, GPI and GPI × dynamism. The interaction term was marginally significant ($\beta = .076$, $p = .092$), providing marginal support for Hypothesis 3b.

5. Discussions

Our main effects (hypotheses H1, H2 (a), & (b)) results provide the empirical evidence to support Porter and van der Linde (1995a)'s proposition that environmental pressure enables firms to develop green innovations and that the benefits derived from these innovations may offset the cost of implementing environmental management and enable the firm to act more competitively (hypotheses H1, H2(a) and H2(b)). Moreover, in our study, we distinguished two measurements of firm performance – cost efficiency and profitability. These two measurements can represent different major focuses of organizations, some firms are cost-oriented, and others are pursuing premium prices. Our study suggest that green product innovation could bring firms not only cost efficiency but also profitability, thus for firms with either orientation, green product innovation development is a key capability for competiveness.

While green product innovation is generally recognized as the key to environmental development, the empirical findings mainly show that green product innovation is a predictor for environmental performance (e.g., Rao, 2005; Vachon and Klassen, 2008). However, this research clearly demonstrates that green product innovation is a mediator after pressure of environmental regulations is introduced. Speaking clearly, pressure of environmental regulations impacts positively green product innovation that in turn affects cost efficiency and firm profitability. This reveals that aligning firm's activities to cope with the pressure of the environmental regulations is necessary. In doing so, a firm's ability of developing green product innovation and firm's business performance will be increased. This research extends this body of literature on environmental management by empirically showing that the mediating effect of green product innovation on the relationship between pressure of environmental regulations and operational performance or business performance.

That being said, it is the Government who initiates and controls those environment regulations or policies. In other words, the pressures generated by such regulations or policies were actually originated from the policy makers. The presence of the mediating factor (the green product innovation) between such pressures and firm performance clearly implies that policy makers should take the capability of the industry in terms of green product innovation into consideration. For example, limiting carbon emissions by setting up a regulation and cap it at any level is easy, whether or not the industry can respond to this regulation and then achieve good technical efficiency is another issue. The

traditional way of calculating efficiency does not take bad outputs (i.e. carbon emissions in the example) into consideration. Therefore, once these bad outputs become part of the equation, the overall efficiency is definitely reduced as more resources are expected to put in place to lower the bad outputs while maintaining the same level of good outputs. In other words, the inputs would need to be increased which lower the efficiency of the system from traditional definition. That's also the reason why green product innovation is the mediating factor because such innovation can bring the level of bad outputs lower with less extra input resources. At least the reduction in efficiency could be controlled at a lower level. Therefore, the results of this research are also beneficial to policy makers and the advice to them is that setting up environmental regulations without considering the practical implications would only blindly shift the responsibility to the manufacturers and in a long run, many companies who are unable to innovate in this aspect will not be able to survive. This in fact will affect the economy of the whole country in a long run.

This study also contributes to the literature on environmental management by investigating moderating effects. The findings of this study indicate that environmental dynamism moderates the relationship between green product innovation and cost efficiency and between green product innovation and firm profitability (i.e. hypotheses 3(a) and 3(b)); the former is stronger. So far, there is limited research examining moderating factors in the environmental context. Perhaps, this may be due to the complexity of environmental problems (Chan et al., 2012). But, it is still suggested that the impact of environmental problems cannot be underestimated (Jørgensen et al., 2010). In this study, we provide empirical evidence to support environment dynamism is an

important contingency factor for the relationship between green innovation and firm performance. Firms pursuing green product innovation can better improve their performance in terms of cost efficiency and firm profitability under a dynamic circumstance. To describe the performance improvement in more detail, the improvement is found to be more for cost efficiency than for firm profitability. This empirical finding suggests that under high dynamic business environment, firms could more likely to achieve cost efficiency rather than profitability. Although it might be because cost efficiency is easier to measure a firm's operations while a firm's profitability is often affected by many factors, it still suggests managers could put more efforts on the cost-saving-oriented environment activities under higher environment dynamism.

If we look at this from another angle, the moderating effect implies that the effect of green innovation is more sensitive to dynamic environment, which directly related to the introduction of new technology or materials (i.e. more frequently changing of the modes of production or the rate of innovation). From this perspective, the Government may consider spending resources on the technological improvement in the country rather than spending resources on sorely setting up regulations and studying the impact of environmental issues. Take carbon emissions again, we all know that we should limit the level of emissions, but spending effort only to define the limit will not be constructive to efficiency. Resource should also be spent on the technological improvement and to promote green product innovation (in fact they are directly related to each other). In this case, all companies can be beneficial from it and the carbon emissions will be reduced accordingly to a level that is governed by the technological capability. Just to clarify that

it is not the intention of the authors to suggest lifting the regulations or policies completely, which is still an important driver to green product innovation. Please see below.

The results on the impact of pressure of environmental regulations on green product innovation imply that understand environmental issues is necessary and important. In practice, manufacturing companies with a goal of providing green innovative products are suggested to align their firms' activities to the environmental regulations. Further, the findings of the moderating effect of environmental dynamism on the relationship among green product innovation and cost efficiency or firm profitability imply that under a dynamic environment that is characterized by frequent and rapid changes induced by technology, customers, and suppliers, manufacturing companies may consider such kind of changes when designing and/or manufacturing green innovative product for the reason that such changes can enhance a firm's ability to achieve higher cost efficiency and firm profitability.

6. Conclusion

The objectives of this research are: (1) to examine the relationship among the pressure of environmental regulations, green product innovation, and firm performance and (2) to investigate the moderating effect of environmental dynamism on the relationship between green product innovation and firm performance. In accordance with these objectives, a research model was developed to test the relationship among pressure of environmental regulations, green product innovation, cost efficiency and firm performance and the

moderating effect of environmental dynamism on the hypothesized relationships. The model was tested using the collected samples from 250 companies in the Mainland China and employing structural equation modeling. The test results of this study show that pressure of environmental regulations has a positive impact on green product innovation, which in turn influences cost efficiency and firm profitability. The findings of this research also show that environmental dynamism has a relatively strong moderation effect on the relationship among green product innovation and cost efficiency and moderates marginally the relationship among green product innovation and firm profitability. The results provide useful insights to research and practice for environment management.

There are two key limitations in this research. First, this research considers pressure of environmental regulations as the predictor of green product innovation in sampled manufacturing companies. There are other possible predictors that may affect green product innovation. For instance, institutional pressures may have influence on green product innovation. Therefore, future research may identify various kinds of institutional or external pressure and investigate their influence on green innovation. Second, this research only considers environmental dynamism as the moderator for investigation. Further research may identify other moderators relevant to the studied context, like top management championship for environmental management, and examine their moderating effects on the relationship among innovation and performance. Based on the above, future research is, drawing upon organizational value and institutional theory, to investigate how institutional pressures (such as Coercive Pressures) motivate companies

to adopt proactive environmental management strategy and how such effects are moderated by organizational value (such as Organizational Culture, Organizational Learning).

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References

Azadegan, A., Patel, P. C., Zangoueinezhad, A., Linderman, K. 2013. The effect of environmental complexity and environmental dynamism on lean practices. *Journal of Operations Management* 31(4), 193-212.

Aiken, L. S., West, S. G. 1991. *Multiple regression*. Beverly Hills: Sage Publishing.

Bacallan, J. J. 2000. Greening the supply chain, *Business & Environment* 6(5), 11-12.

Bai, C., Sarkis, J., Dou, Y., 2015. Corporate sustainability development in China: review and analysis. *Industrial Management & Data Systems*, 115(1), 5-40.

Cai, S., Jun, M., Yang, Z. 2010. Implementing supply chain information integration in China: The role of institutional forces and trust. *Journal of Operations Management* 28(3), 257-268.

Chan, R. Y., He, H., Chan, H. K., Wang, W. Y. 2012. Environmental orientation and corporate performance: the mediation mechanism of green supply chain management

and moderating effect of competitive intensity. *Industrial Marketing Management* 41(4), 621-630.

Chang, C. H. 2011. The influence of corporate environmental ethics on competitive advantage, the mediation role of green innovation. *Journal of Business Ethics* 104(3), 361-370.

Chavez, R., Yu, W., Jacobs, M., Fynes, B., Wiengarten, F., Lecuna, A. 2015. Internal lean practices and performance: The role of technological turbulence. *International Journal of Production Economics* 160, 157-171.

Chen, H. L., Burns, L. D. 2006. Environmental analysis of textile products. *Clothing and Textiles Research Journal* 24(3), 248-261.

Chen, Y. S. 2008. The driver of green innovation and green image – green core competence. *Journal of Business Ethics* 81(3), 531-543.

Chen, Y. S., Lai, S. B., Wen, C. T. 2006. The influence of green innovation performance on corporate advantage in Taiwan. *Journal of Business Ethics* 67(4), 331-339.

Chiou, T. Y., Chan, H. K., Lettice, F., Chung, S. H. 2011. Influence of greening the suppliers and green innovation on environmental performance and competitive advantage. *Transportation Research Part E: Logistics and Transportation Review* 47(6), 822-836.

Curwen, L. G., Park, J., Sarkar, A. K. 2013. Challenges and solutions of sustainable apparel product development a case study of Eileen Fisher. *Clothing and Textiles Research Journal* 31(1), 32-47.

Dangelico, R. M., Pujari, D. 2010. Mainstreaming green product innovation: why and how companies integrate environmental sustainability. *Journal of Business Ethics* 95(3), 471-486.

De Brito, M. P., Carbone, V., Blanquart, C. M. 2008. Towards a sustainable fashion retail supply chain in Europe: organization and performance. *International Journal of Production Economics* 114(2), 534-553.

Dess, G. G., Beard, D. W. 1984. Dimensions of organizational task environments. *Administrative Science Quarterly* 29(1), 52-73.

Eroglu, C., Hofer, C. 2014. The effect of environmental dynamism on returns to inventory leanness. *Journal of Operations Management* 32(6), 347-356.

European Union, 2003. Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment. *Official Journal of the European Union* 13, L37.

Fornell, C., Larcker, D. F. 1981. Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research* 18(1), 39–50.

Gerbing, D. W., Anderson, J. C. 1988. An updated paradigm for scale development incorporating unidimensionality and its assessment. *Journal of Marketing Research* 25 (2), 186-192.

Gligor, D. M., Esmark, C. L., Holcomb, M. C. 2015. Performance outcomes of supply chain agility: When should you be agile? *Journal of Operations Management* 33, 71-82.

Guoyou, Q., Saixing, Z., Chiming, T., Haitao, Y., Hailiang, Z. 2013. Stakeholders' influences on corporate green innovation strategy: a case study of manufacturing firms in China. *Corporate Social Responsibility and Environmental Management* 20(1), 1-14.

Gupta, M. C. 1995. Environmental management and its impact on the operations function. *International Journal of Operations & Production Management* 15(8), 34-51.

Hansmann, K.W., Claudia, K. 2001. Environmental management policies in Sarkis, J. (Ed.), *Green manufacturing and operations: from design to delivery and back.* Greenleaf Publishing, Sheffield: 192-204.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E. 2010. *Multivariate data analysis* (7th ed.). Upper Saddle River, NJ: Prentice Hall.

Hensley, R. L. 1999. A review of operations management studies using scale development techniques. *Journal of Operations Management* 17(3), 343-358.

Hu, L., Bentler, P. M. 1999. Cutoff criteria for fit indexes in covariance structure analysis: Coventional criteria versus new alternatives. *Structural Equation Modeling* 6(1), 1-55.

Huang, X. -X., Hu, Z. -P., Liu, C. -S., Yu, D. -J., Yu, L., -F. 2015. The relationships between regulatory and customer pressure, green organizational responses, and green innovation performance. *Journal of Cleaner Production*, in press.

Hyllegard, K. H., Yan, R. N., Ogle, J. P., Lee, K. H. 2012. Socially responsible labeling the impact of hang tags on consumers' attitudes and patronage intentions toward an apparel brand. *Clothing and Textiles Research Journal* 30(1), 51-66.

Jansen, J. J. P., Van Den Bosch, F. A. J., Volberda, H. W. 2006. Exploratory innovation, exploitative innovation, and performance: effects of organizational antecedents and environmental moderators. *Management Science* 52 (11), 1661-1674.

Jayaram, J., Ahire, S. L., Dreyfus, P. 2010. Contingency relationships of firm size, TQM duration, unionization, and industry context on TQM implementation—A focus on total effects. *Journal of operations Management* 28(4), 345-356.

Jørgensen, M. S., Jørgensen, U., Hendriksen, K., Hirsbak, S., Thomsen, H. H., Thorsen, N. 2010. Environmental management in Danish transnational textile product chains. *Management Research Review* 33(4), 357-379.

Kagan, R. A., Gunningham, N., Thornton, D. 2003. Explaining corporate environmental performance: how does regulation matter. *Law and Society Review* 37(1), 51-90.

Kaynak, H., Hartley, J. L. 2008. A replication and extension of quality management into the supply chain. *Journal of Operations Management* 26(4), 468-489.

King, A. A., Lenox, M. J. 2001. Does it really pay to be green? An empirical study of firm environmental and financial performance: an empirical study of firm environmental and financial performance. *Journal of Industrial Ecology* 5(1), 105-116.

Klassen, R. D., Whybark, D. C. 1999. Environmental Management in Operations: The Selection of Environmental Technologies. *Decision Sciences* 30(3), 601-631.

Lee, N., Choi, Y. J., Youn, C., Lee, Y. 2012. Does green fashion retailing make consumers more eco-friendly? The influence of green fashion products and campaigns on green consciousness and behavior. *Clothing and Textiles Research Journal* 30(1), 67-82.

Li, D.-Y., Liu, J., 2014. Dynamic capabilities, environmental dynamism, and competitive advantage: Evidence from China. *Journal of Business Research*, 67(1), 2793-2799.

Lin, R. -J., Tan, K. -H., Geng, Y. 2013. Market demand, green product innovation, and firm performance: evidence from Vietnam motorcycle industry. *Journal of Cleaner Production* 40, 101-107.

Matusik, S. F., Hill, C. W. L. 1998. The utilization of contingent work, knowledge creation, and competitive advantage. *Academy of Management Review* 23(4), 680-697.

McGuire, W. 2014. The effect of ISO 14001 on environmental regulatory compliance in China. *Ecological Economics*, 105, 254-264.

Porter, M. E., van der Linde., C. 1995. Green and competitive: ending the stalemate. *Harvard Business Review* 73(5), 120-134.

Rao, P. 2002. Greening the supply chain: a new initiative in South East Asia. *International Journal of Operation and Production Management* 22(6), 632-655.

Rao, P., Holt, D. 2005. Do green supply chains lead to competitiveness and economic performance. *International Journal of Operation & Production Management* 25(9), 898-916.

Revell, A., Rutherfoord, R. 2003. UK environmental policy and the small firm: broadening the focus. *Business Strategy and the Environment* 12(1), 26-35.

Shu, C., Zhou, K. Z., Xiao, Y., Gao, S. 2014. How green management influences product innovation in China: The role of institutional benefits. *Journal of Business Ethics*, in press.

Sousa, R., Voss, C. A. 2008. Contingency research in operations management practices. *Journal of Operations Management* 26(6), 697-713.

Staw, B. M., Epstein, L. D. 2000. What bandwagons bring: effects of popular management techniques on corporate performance, reputation, and CEO pay. *Administrative Science Quarterly* 45(3), 523-559.

Tse, Y. K., Tan, K. H., Ting, S. L., Choy, K. L., Ho, G. T. S., Chung, S. H. 2012. Improving postponement operation in warehouse: an intelligent pick-and-pack decision-support system. *International Journal of Production Research* 50(24), 7181-7197.

Tseng, M. -L., Chiu, A. S. F., Tan, R. R., Siriban-Manalang, A. B. 2013. Sustainable consumption and production for Asia: sustainability through green design and practice. *Journal of Cleaner Production* 40, 1-5.

van der Vlist, A. J., Withagen, C., Folmer, H. 2007, Technical efficiency under alternative environmental regulatory regimes: The case of Dutch horticulture. *Ecological Economics* 63(1), 165-173.

Vachon, S., Klassen, R. D. 2008. Environmental management and manufacturing performance: the role of collaboration in the supply chain. *International Journal of Production Economics* 111(2), 299-315.

Wong, C. Y., Boon-itt, S., Wong, C. W. Y. 2011. The contingency effects of environmental uncertainty on the relationship between supply chain integration and operational performance. *Journal of Operations Management* 29(6), 604-615.

Wong, S. K. S. 2012. The influence of green product competitiveness on the success of green product innovation: Empirical evidence from the Chinese electrical and electronics industry. *European Journal of Innovation Management* 15(4), 468-490.

Wu, J., Zhang, W. Y., Zhang, S., Liu, Y. N., Meng, X. H. 2013. A matrix-based Bayesian approach for manufacturing resource allocation planning in supply chain management. *International Journal of Production Research* 51(5), 1451-1463.

Zhu, Q., Cordeiro, J., Sarkis, J., 2013. Institutional pressures, dynamic capabilities and environmental management systems: Investigating the ISO 9000 – Environmental management system implementation linkage. *Journal of Environmental Management*, 114, 232-242,

Zhu, Q., Geng, Y., Sarkis, J., Lai, K. H. 2011. Evaluating green supply chain management among Chinese manufacturers from the ecological modernization perspective. *Transportation Research Part E: Logistics and Transportation Review* 47(6), 808-821.

Zhu, Q., Sarkis, J., Lai, K. H. 2008. Green supply chain management implications for "closing the loop". *Transportation Research Part E: Logistics and Transportation Review* 44(1), 1-18.

Ziegler, A., Nogareda, J. S. 2009. Environmental management systems and technological environmental innovations: exploring the causal relationship. *Research Policy* 38(5), 885-893.

APPENDIX A: CONSTRUCT ITEMS

Construct	Label	**Items**	**Sources**
Pressure of environmental regulations / policies	EP1	National environmental regulations (such as waste emission and cleaner production)	Zhu et al. (2011)
	EP2	National resource saving and conservation regulations	
	EP3	Regional environmental regulations (such as waste emissions and cleaner production)	
	EP4	Regional resource saving and conservation regulations	
	EP5	Developed countries' environmental regulations	
	EP6	Products potentially conflict with laws (such as circular economy, EPR, and EHS)	
Green Product Innovation	GPI1	Using less or non-polluting/toxic materials. (Using environmentally friendly material).	Chen et al. (2006); Chen (2008); Chiou et al. (2011).
	GPI2	Improving and designing environmentally friendly packaging (e.g.: less paper and plastic material used) for existing and new products.	
	GPI3	Recovery of company's end-of-life products and recycling.	
	GPI4	Using eco-labeling.	
Cost Efficiency	CE1	Produce products with low costs	Wong et al. (2011); Gligor et al.(2015)
	CE2	Produce products with low inventory costs	
	CE3	Produce products with low overhead costs	
	CE4	Offer price as low or lower than competitors	
Firm Profitability	FP1	Profit / Loss	Staw and Epstein, (2000); Kaynak and Hartley (2008).
	FP2	Return of assets	
	FP3	Profit margin	
	FP4	Return on equity	
Environmental Dynamism	ED1	Major changes in the modes of production and/or service provision	Azadegan et al. (2013)
	ED2	A high rate of innovation	
	ED3	Major changes in consumer demographics	
	ED4	Frequent and major changes in government regulations	
	ED5	An increasing amount of spending on research and development	
	ED6	Frequent and major changes in the number of competitors	