Supply chain integration capabilities, green design strategy and performance

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Abstract

Purpose – This paper examines how supply chain integration capabilities inform green design strategy adoption and whether green design strategy can lead to higher levels of environmental and economic performance.

Design/methodology/approach – A survey-based approach was used to empirically test the study hypotheses. Based on 216 usable responses collected from automakers around the globe, we compared the results from two different data groups (i.e., Chinese firms vs. Western firms) using the structural equation modeling approach.

Findings – In the Chinese context, both internal and external supply chain integration capabilities are significantly related to the successful adoption of a green design strategy. However, the relationships are not significant in Western context. Green design is found to positively impact environmental performance in both contexts; however, no significant relationship is revealed between green design and economic performance in either context. Finally, environmental performance was found to have a significant and positive impact on economic performance in both contexts.

Research limitations/implications – The cross-sectional survey design that was focused only on the auto industry may affect the inferences of causality and generalizability of this study.

Practical implications – Managers should understand their specific organizational context first, and then strategically develop their external and internal supply chain integration capabilities in order to maximize their green design efforts for improved environmental performance. Companies can be certain that the more gains made in environmental management, the more economic returns can be expected.

Originality/value – This research contributes to the existing resource-based view literature by linking supply chain integration capabilities to green design strategy adoption in different organizational contexts. It also sheds a light on the association between green design and different performance dimensions, and adds value to the current debate on the association between environmental performance and economic performance.

Keywords Sustainability, Green design, Supply chain integration capability, Environmental performance, Resource-based view, Structural equation modeling, Automotive

Paper type Research paper

1. Introduction

To target environmental issues, many organizations have started adopting the so-called 'eco-design' or 'green design' strategy, which is associated with investing in various green design programs. Green design is defined as the systematic consideration of design performance with respect to environmental, health, safety, and sustainability objectives over the full product and process life cycle (Glantschnig, 1994; D'Agostini et al., 2017). Examples include Panasonic's eco-value creation initiatives (Paulraj et al., 2014), Mazda's effort for reducing hazardous materials in its product design (Mazda, 2016), and Nissan's zero-emission vehicles, such as electric cars and fuel cell vehicles (Nissan, 2018). The successful adoption of a green design strategy within an organization may depend upon various factors such as company size, structure, and the nature of the products manufactured (Glantschnig, 1994; Liu et al., 2016). Previous studies have shown that to successfully adopt green strategies, firms are required either to develop and possess specific organizational capabilities (e.g., Lee and Klassen, 2008; Wu and Pagell, 2011; Liu et al., 2016), or to access external resources and capabilities through strategic business partnerships (Blome et al., 2014). For example, Ford has spent huge efforts into developing strong relationships with its suppliers to foster shared commitment and supplier capability in order to achieve its sustainability objectives in product development (Ford, 2014). BYD, China's leading maker of electric cars, has strengthened its partnership with Daimler AG to bring new models to the largest markets seeking to phase out traditional combustion engine vehicles (Bloomberg News, 2017). Likewise, ABB, the leading power and automation technology group, has deepened a strategic collaboration with BYD to jointly develop new solutions for energy storage, building on their complementary strengths (ABB, 2014).

Drawing on the resource-based view (RBV) and its extensions (Barney, 1991; Cao and Zhang,

2011), some prior research has claimed that supply chain integration (SCI) is a strategic organizational capability, with which a focal firm can expect to combine external and internal resources to achieve and sustain competitive advantage. Numerous studies have been conducted to explore the link between SCI and firm performance, but the findings are largely inconsistent (Leuschner et al., 2013; Mackelprang et al., 2014). More importantly, to the best of our knowledge, most research has focused on the capability – performance linkage, neglecting the association between capability and strategy (Armstrong and Shimizu, 2007; Newbert, 2007). Therefore, the original contribution of this study is to seek to understand the specific role of SCI capability in the successful adoption of a green design strategy. We select the auto sector for our study because it has rather complex supply networks, and is often at the forefront of environmental management (Zhu et al., 2007). Today, many automakers have entered into the race of developing greener models, including well-known and well-established automobile giants such as General Motors (GM) (Lienert and White, 2018) and emerging, super-ambitious auto firms such as the Chinese manufacturer BYD. Not every firm is succeeding in this new endeavor, however. We argue that the auto firms with stronger SCI capability are more easily able to capitalize on both their internal and external resources and capabilities, and thus are more likely to successfully adopt a green design strategy.

Further, we argue that a firm's efforts to adopt a green design strategy will eventually pay off, in terms of both improved environmental and economic performance. Existing research has produced contrasting findings on this association (cf., Li et al., 2016; Zhu and Sarkis, 2004; Zhu et al., 2007; Figge and Hahn, 2012). For instance, Zhu and Sarkis' (2004) seminal work was based on a sample of 186 data points from a mix of industries and found a positive eco-design to economic performance (ECP) and environmental performance (ENP) link. However, the later

study by Zhu et al. (2007) found no significant relationship between eco-design and environmental and economic performance in the Chinese auto industry. They argued that one of the reasons for this finding was that most of these Chinese automakers were at the early stages of adopting green design strategies, and that consequently those strategies had not led to significant changes in ECP and ENP. They concluded that as time progressed the relationships would become clearer. A decade later, the studied relationships may become more evident, and they thus deserve a more updated view. Concerning the contrasting findings with regard to the green design – performance link in the existing literature, it is thus worthwhile to conduct further research in this area.

Moreover, there are conflicting results in the extant literature on the relationship between an organization's ENP and ECP (Horváthová, 2010; Ortas et al., 2014; Petljak et al., 2018). Accordingly, this study also aims to add value to the current debate by examining the ENP – ECP relationship in a specific industry context. Unlike previous single-context studies (e.g., Yu et al., 2014; Zhu et al., 2007) of green design and supply chain management in the auto industry, our research also focuses on comparing the hypothesized relationships within an international context, using data from Chinese and Western auto firms. We believe that this particular industry focus with a comparative dimension could offer interesting insights into our research objectives.

This article includes six sections. After the introduction, section 2 discusses the theoretical foundations and the development of our hypotheses. In section 3, we introduce our research methodology for data collection and data analysis. The research results are presented in section 4. In section 5, we then discuss the research findings and their implications for theory and management practice. Finally, in section 6, we draw several conclusions, discuss the limitations of the study, and offer directions for future research.

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2. Literature review and hypotheses

There has been an extensive body of research on supply chain integration (SCI) in recent years, despite different foci being placed on topics such as supply chain partnerships and supply chain collaboration (Soosay et al., 2008; Flynn et al., 2010; Cao and Zhang, 2011; Vanpoucke et al., 2014; Huo, 2012; Kamal and Irani, 2014). According to Mackelprang et al. (2014), SCI is a very complex and multifaceted phenomenon. Whilst prior research has conceptualized SCI in various ways and studied many of its critical elements, SCI can be defined as "the degree to which a manufacturer strategically collaborates with its supply chain partners and collaboratively manages intra- and inter-organization processes" (Flynn et al., 2010, p.59).

There are also a number of researchers who regard SCI as a strategic capability enjoyed by some firms (e.g., Zacharia et al., 2011; Cao and Zhang, 2011; Vanpoucke et al., 2014; Liu et al., 2016). In light of the resource-based view (RBV) and its extensions (Barney, 1991; Cao and Zhang, 2011), it is argued that a SCI capability is a relation-specific asset. As it is embedded in a network of business partnerships, a SCI capability is particularly socially complex, causally ambiguous, and thus more difficult to imitate (Cousins and Menguc, 2006; Cao and Zhang, 2011; Huo, 2012). By possessing a SCI capability, a focal firm is able to combine external and internal resources to achieve and sustain competitive advantage.

Considering the dimensionality of a SCI capability, some studies have regarded it as a unidimensional construct (e.g., Cousins and Menguc, 2006; Huang et al., 2014), while others have differentiated it into internal and external integration capabilities (e.g., Stank et al., 2001; Petersen et al., 2005; Huo, 2012), although recognizing that there is a great deal of overlap between these two dimensions. Consistent with several seminal studies on the topic (e.g., Flynn

et al., 2010; Wong et al., 2011; Zhao et al., 2011; Schoenherr and Swink, 2012), we argue that a SCI capability ultimately includes internal integration and external integration. Internal and external integration capabilities play dissimilar roles, however, in the context of supply chain management. While the former focuses on cross-functional collaboration within a firm, the latter recognizes the importance of establishing close ties and partnerships with suppliers and customers. Both perspectives are critical to successful supply chain management (Flynn et al., 2010).

2.1 Internal integration capability

In particular, an internal integration capability is defined as the ability of a firm to establish liaison between its logistics/supply chain department and other functions to work together in a cooperative manner to arrive at mutually acceptable outcomes (Liu et al., 2016). An internal integration capability recognizes that different departments within an organization should break down functional barriers and operate as part of an integrated process (Flynn et al., 2010). When a customer's order arrives, all involved activities and functions within a firm should work together in order to fulfill the customer's expectations. As Ellinger (2000) puts it, collaboration between departments can ensure delivery of high quality services to customers, which involves the ability to work seamlessly across the silos that have characterized organizational structures. However, achieving a strong internal integration is not as easy as it sounds. It often involves such issues as interpersonal interactions, company culture, and trust (Holland et al., 2000), and it seldom results from mere memberships on teams (Jassawalla and Sashittal, 1999). According to the existing research (e.g., Flynn et al., 2010; Narayanan et al., 2011), once an organization possesses a strong internal integration capability, superior performance can be expected.

2.2 External integration capability

An external integration capability focuses on external collaboration with supply chain partners, including suppliers in the upstream and customers in the downstream of the supply chain (Flynn et al., 2010; Leuschner et al., 2013; Seo et al., 2014). It is considered as the ability of a focal firm to establish collaborative partnerships with its supply chain members. Such partnerships are best described as an inter-organizational relationship type in which the involved parties agree to co-invest resources, mutually achieve goals, and share information, rewards and responsibilities (Liu et al., 2016). In addition, a long-term collaborative relationship can foster trust between a firm and its network partners, which is another valuable inter-firm resource (Blome et al., 2014; Handfield and Bechtel, 2002). As Gold et al. (2010) put it, the trust-based, long-term strategic partnership requires time and effort, it cannot be traded on the marketplace and it is very difficult for competitor firms to replicate. Empirical evidence suggest that by achieving a high level of external integration in its supply chains, a firm is more likely to improve its business performance (e.g., Cao and Zhang, 2011; Vanpoucke et al., 2014; Zacharia et al., 2011).

2.3 Supply chain integration capability and green design

Green design, design for environment (DfE) or eco-design is defined as the systematic consideration of design performance with respect to environmental, health, safety, and sustainability objectives over the full product and process life cycle (D'Agostini et al., 2017; Gmelin and Seuring, 2014). It is a concept that has been widely used for product and process design with certain environmental considerations. Studies have shown that 80% of the environmental burden and cost of a product is fixed during the design phase (Tseng et al., 2013). Therefore, adopting a green design strategy can offer a great potential to reduce negative

environmental impact at an early stage. The scope of green design encompasses many disciplines, including environmental risk management, product safety, pollution prevention, ecology, material conservation, accident prevention, and waste management (Hwang et al., 2013). Although it is complex, topics covered in green design all have similar goals of minimizing the use of non-renewable resources, effectively managing renewable resources, and minimizing toxic releases to the environment (Zhu and Sarkis, 2004).

By studying the issues and challenges surrounding green design from the perspective of an individual company, Glantschnig (1994) pointed out that implementing a green design strategy will entail different challenges for different companies, depending on factors such as company size, structure, and the nature of the products manufactured. However, to realize effective green design, a first step that can be taken is to improve internal coordination between functions and to create synergies with common corporate environmental goals and certain dedicated resources, efficient information management, and training (Gmelin and Seuring, 2014). Similarly, Handfield et al. (2001) explored that the primary obstacle to the integration of environmental issues into product design was a lack of coordination between functions. The adoption of a green design strategy is ultimately a cross-functional undertaking because it affects all the functional areas of a business enterprise.

Following the rationale of RBV, the adoption of strategies requires firms to possess appropriate resources and capabilities (Barney, 1991). In particular, some researchers have argued that when choosing green strategies, firms should select practices that 'fit' with their existing resources and capabilities (Christmann, 2000; Liu et al., 2016; Liu et al., 2017). Theoretically, we argue that the gained supply chain integration is a set of capabilities that can be used in successful green

design adoption (Vachon and Klassen, 2008). A strong internal integration capability may help a firm to form strategic alignment between functions, a climate supportive of teamwork and team-based accountability (Holland et al., 2000), and thus contribute positively to the successful adoption of its green design strategy. For instance, finding the right suppliers for green products and components can be tricky and complex, and touches on the concerns and activities of many different functions within the firm. These include the functions with some input into product design choices and the specification of requirements (marketing and sales, R&D, design, engineering, and production), and the functions responsible for managing the supply-side consequences of those choices (purchasing and logistics). We argue that a strong internal integration capability will enable these various functions to work together effectively, helping to smooth the procurement process and thereby facilitating the successful adoption of green design strategy. Thus, we hypothesize,

H1: Firms with higher levels of supply chain internal integration have better green design adoption.

Externally, an organization's interactions with a larger industrial system such as with suppliers and customers, and with external forces such as product standards and regulations, have an impact on what is doable in terms of green design (Glantschnig, 1994). Sihvonen and Partanen (2017) further noted that green design is typically a multi-disciplinary and multi-levelled undertaking; to achieve the technically, economically, and environmentally best product in the least time, communication between the various levels of product realization is a must. By studying the auto industry, Bras (1997) pointed out that close working relationships and critical design information sharing with network players could facilitate green design adoption. Based on

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the RBV, we bring forward a similar theoretical argumentation and propose that the successful adoption of a green design strategy may require a firm to possess a strong external integration capability. It is believed that strong partnerships and integration with supply chain members may facilitate knowledge sharing and cooperative activities, wherein suppliers' technology and innovation capabilities can be brought into the design process to enhance green design performance. Thus, we hypothesize,

H2: Firms with higher levels of supply chain external integration have better green design adoption.

2.4 Green design and performance

As green design aims at the integration of environmental considerations into product design practices such as pollution prevention, resource conservation, and waste management (Gmelin and Seuring, 2014), it is highly likely to improve a firm's overall environmental performance at an early stage. As Zhu and Sarkis (2004) noted, materials selection at the design stage of a product has the most impact on its environmental performance over the product life cycle. In other words, green design can improve an organization's environmental performance by addressing product functionality while simultaneously minimizing life-cycle environmental impacts. Pursuing eco-efficiency in green design, firms can produce the same amount with fewer resources than traditional methods (Chen et al., 2012). In addition, green design focuses on the reduction or complete elimination of hazardous substances in products that could potentially cause safety concerns and environmental accidents. Further, reduced energy consumption to use the product, increased economies through possible refills or restoration, a longer lifespan or the elimination of pollution might further improve environmental performance (Tseng et al., 2013). Theoretically, following the logic of RBV (Barney, 1991), green design constitutes a strategy

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that can be implemented to earn rents as the firm has created unique and valuable environmental competitive advantages. As spelled out earlier, green design adoption is a complex undertaking that requires unique capabilities so as to achieve competitive benefits for the firm. Therefore, we hypothesize that,

H3: Firms with higher levels of green design adoption achieve better environmental performance.

Achieving better economic performance can be the main objective and motivation for most firms to pursue a green design strategy (Zhu and Sarkis, 2004). Introducing sustainable products may provide firms with new opportunities to be competitive and add value to their core businesses. For example, Yi-Chan and Tsai (2007) studied green design in the high-tech industry and found that firms with a higher degree of adoption of green design strategies have better new product performance in terms of time to market, market share, quality, and cost.

In addition, the adoption of a green design strategy may on one hand may help an organization to improve the safety of its products, thereby minimizing the costs of potential environmental accidents; on the other hand, green design could enhance the organization's reputation and green image, thereby winning more customers (Jacobs et al., 2010). Furthermore, use of sustainable materials in product design can improve operational efficiency and productivity, as well as mitigating the environmental impact. For example, appropriate material selection during the design process to enable easier chemical separation can be beneficial to the recycling process and waste reduction (Chen et al., 2012). Taken together, we believe that green design can help firms to reduce costs and improve profits. Thus, we hypothesize,

H4: Firms with higher levels of green design adoption achieve better economic performance.

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2.5 Environmental performance and economic performance

Drawing on the RBV, Russo and Fouts (1997) conducted an early empirical study on the relation between corporate environmental performance (ENP) and economic performance (ECP). They posited that ENP and ECP are positively related based on an analysis of 243 firms over two years. Their assertion is further supported by Rao and Holt (2005), who argued that a firm's greater effort into greening its supply chains for environmental improvement leads to competitiveness and economic performance. There are also a few studies conducted in various national or regional contexts to examine the ENP – ECP link, for example Wagner and Schaltegger's (2004) empirical study of EU manufacturing, and Fujii et al.'s (2013) study of Japanese firms. Despite these efforts in the past three decades, the results still seem to be different and even conflicting (Horváthová, 2010). The main reasons for obtaining differences in the sign of the ENP – ECP link are due to the different theoretical lenses being adopted, the different methodologies used to measure these two constructs, and the varying time periods and geographic areas considered (Moneva and Ortas, 2010). For example, the advocates of an inverse U-shaped relationship predict a positive relationship between ENP and ECP up to the point where economic benefits are maximized (Schaltegger and Synnestvedt, 2002; Wagner and Schaltegger, 2004).

Nevertheless, the shortcoming of this U-shaped view is that it lacks a dynamic and long-term perspective in the analysis (Horváthová, 2010; Moneva and Ortas, 2010). In practice, no organizations are 'silly' enough to invest in or to spend additional money on projects that no longer bring any benefits to them. If a firm wants to survive, it has to constantly improve its competitive position in the market by, for example, continuously introducing new products and adopting new technologies in its operations for cost reduction and quality enhancement. Consistent with Jacobs et al.'s (2010) view, we believe that an overall and continued

improvement in the environmental performance of a firm could facilitate revenue gains by means of enhanced brand reputation and access to new markets, and cost reductions by effective environmental management in production, distribution, and risk mitigation. Thus the overall financial performance of the firm would be improved. Bearing these issues in mind, we hypothesize that,

H5: Firms with higher levels of environmental performance achieve better economic performance.

Figure 1 below shows our conceptual model for the proposed study.

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3. Methodology

3.1 Questionnaire and measures design

The questionnaire was developed with a four-step approach. First, we conducted preliminary interviews (using unstructured, open-ended questions) with academics and industrial managers in the areas of supply chain, logistics, and environmental management. This step provided us with a basic understanding of supply chain integration and current industry practices in green design. Then, we developed a draft questionnaire with a pool of measurement items by consolidating the findings from the interviews and the literature review. Third, the draft questionnaire was pre-tested with five academics and six managers in relevant fields to evaluate clarity, utility, and relevancy. We combined or rephrased several measurement items and dropped irrelevant ones according to the feedback. Fourth, we conducted a pilot test with 20 supply chain/logistics managers in the auto industry. The questionnaire was further refined according to the comments

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received. The questionnaire was in both English and Chinese. Translation was done and crosschecked by our research colleagues who are bilingual in English and Chinese to ensure consistency and invariance.

The measurement items were developed following the procedures suggested by Gerbing and Anderson (1988). When possible, previously validated measures were relied upon to improve the reliability and validity of the items. Three items were used to measure our first independent variable, supply chain internal integration capability (INTER). These items were based on prior work by Flynn et al. (2010) and Schoenherr and Swink (2012). For assessing supply chain external integration capability (EXTER), we adapted previously validated measures from Das et al. (2006), Cao and Zhang (2011), and Zhao et al. (2011). A five-point scale was used to capture the competency level of SCI capabilities in each respondent firm (see Appendix).

Turning to green design strategy (GD), the items were adopted from Zhu and Sarkis (2004) and Zhu et al. (2007). As suggested by the pilot test, we included an additional item to measure product longevity and durability in product design. To measure GD, we modified the 5-point scale used by Zhu and Sarkis (2004) by placing more emphasis on adoption. Measures of the environmental performance (ENP) and economic performance (ECP) constructs were consistent with those used by Zhu and Sarkis (2004). A five-point scale was used to measure the constructs (see Appendix).

3.2 Data collection

We collected our data from the auto sector, as this sector has rather complex supply networks and is often at the forefront of sustainability initiatives (Zhu et al., 2007). This specific context makes it interesting to explore whether the level of success in green design adoption depends

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upon supply chain integration. A random sample of 1,000 Chinese and Western automakers was

drawn from available nationwide databases that comprise approximately 40,000 entries in total

(suppliers and OEMs). Our initial interviews suggested that the appropriate candidates for the

survey would be at least mid-level managers with sound overall knowledge of supply chain

integration and environmental management. We thus made an initial attempt to contact logistics

or SCM department managers (firms use different terms) as they appear to have suitable

knowledge due to their significant boundary spanning activities. The contact information was

gained through sector-based professional groups. Anonymity was guaranteed and additional

incentives were offered to candidates to increase the response rate. The survey was administered

via an online form following the suggestions given by Schaefer and Dillman (1998). Reminder

emails were sent to non-respondents two weeks after the first emailing, and another fortnight

later we sent final-round emails as well as making follow-up telephone calls when possible. A

total of 246 responses were received, of which 216 were usable, resulting in an overall effective

response rate of 21.6%. The final dataset contains responses from 102 Chinese-owned firms and

114 Western-owned firms that are mainly located in North America and Europe. Table 1 reveals

the descriptive statistics of the final sample.

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3.3 Non-response bias and common method bias

Comparing respondents with non-respondents in terms of firm size (number of employees),

supply chain position (main products) and their annual sales yielded no significant differences,

indicating that these responses were representative of the original sample. We also compared the

early responses to the late responses along the main variables in our survey (Armstrong and

Overton, 1977). The underlying assumption is that non-respondents tend to be more similar to

late respondents, who would have fallen into the former category had no follow-up steps been taken (Fowler, 2009). The results of a t-test reveal that the respondents do not differ significantly ($p > .05$), leading us to conclude that non-response bias was not a major concern in this study.

Given that we obtained data from a single respondent for each firm using a self-reported questionnaire, common method bias might be a concern. To mitigate this concern, we applied several procedures proposed by Podsakoff et al. (2003). To test the existence of common method variance, we first performed Harman's single-factor test (Podsakoff and Organ, 1986). The factor analysis of all items revealed five factors with eigenvalues greater than 1.0 that accounted for 73% of the total variance. The first factor only accounted for 32% of the variance, which is not a majority of the total variance. Second, a single-common-method-factor approach was conducted (Podskoff et al., 2003). The results indicated that the method factor did not significantly improve the model fit indices (NNFI by .002 and CFI by 0.004). Besides, the item loadings for the factors were still significant despite the inclusion of a method factor. These results indicate that common method bias was not a significant problem in this study.

3.4 Preliminary test

We conducted confirmatory factor analysis (CFA) for the whole dataset using IBM AMOS 22. Items that exhibited significant low item-to-scale total correlations, weak loadings or cross loadings to the appropriate constructs were removed (see Appendix). All standardized parameter loadings were significant (p < .001) and ranged from .675 to .913, providing strong support for convergent validity. The composite reliabilities (CR) of all constructs exceeded the .70 cutoff, and the average variance extracted (AVE) indices were greater than the .50 benchmark (see Table 2). These results and a good overall model fit ($\chi^2_{(157)} = 209.176$, IFI = .978, NNFI = .974,

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CFI = .978, and RMSEA = .039) demonstrate the adequate convergent validity and unidimensionality of these scales (Hair et al., 2010).

To assess the discriminant validity of the measures, we compared the AVE for the individual constructs to the shared variance between all possible pairs of constructs. The results reveal that, for each construct, the AVE was much higher than its maximum shared variance (MSV) with other constructs, thus supporting discriminant validity (see Table 2).

Internal scale reliability was assessed with Cronbach's alpha. The Cronbach's alpha values for all of the constructs exceeded the recommended threshold of .70 (Nunnally, 1978). Exploratory factor analysis (EFA) also produced a five-factor structure with all items loading clearly on their intended factors.

Although our hypotheses will be tested using the separate Chinese and Western datasets, measurement invariance is essential before conducting any further analysis (Steenkamp and Baumgartner, 1998). We performed a two-group invariance test with multi-group CFA in AMOS 22. First, we performed a configural invariance test consisting of the baseline models of the Chinese and Western samples without imposing any equality constraints. As shown in Table 2, the model exhibits good fit: $\chi^2_{(315)} = 418.707$, $p < .001$; CFI = .959; and RMSEA = .039 – thus supporting configural invariance. Second, we tested metric invariance by constraining all free factor loadings to be equal across the two data groups. The goodness-of-fit results show that the model exhibits good fit to the data: $\chi^2_{(332)} = 435.025$, $p < .001$; CFI = .958; RMSEA = .038. Also, no significant change was found between the configural invariance model and the metric invariance model ($\Delta\chi^2 = 16.318$, $p > .05$), which supports metric invariance. A third level of invariance (scalar) is necessary to allow mean comparison of the underlying constructs across the

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two groups. To test scalar invariance, we constrained all factor loadings and all observed variable

intercepts. The full scalar invariance test reveals reasonable fit: $\chi^2_{(347)} = 512.066$, $p < .001$; CFI

= .933; RMSEA = .047. There is, however, a significant change between the restricted model

and the baseline model ($\Delta\chi^2 = 93.359$, $p < .001$). Therefore, we refined our models by relaxing 4

items and achieved partial scalar invariance (see Table 2). Overall, the results of the invariance

tests were satisfactory for the aim of our study (Steenkamp and Baumgartner, 1998).

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3.5 Data Analysis

We followed Gerbing and Anderson's (1988) two-step approach (first measurement model and

then structural model) to analyze the data. Specifically, to test the study hypotheses 1 – 5, we

used structural equation modeling (SEM) with two separate data groups, Chinese (Group 1) and

Western (group 2). We compared these two groups to see whether they have different path

coefficients of the structural model (Byrne, 2016). To enhance the robustness of our test and

further compare the differences in two data groups, we conducted a multi-group SEM analysis in

AMOS 22.

4. Results

Table 3 reports the SEM results, including standardized path coefficients, significance levels,

model fit indices, and χ^2 difference test results from the multi-group SEM analysis.

First, for the Chinese group, the fit indices are all found to be within a good range (CFI = .982,

NNFI = .979, IFI = .983, RMSEA = .033), suggesting a good fit between the model-implied

covariance matrix and the data. In contrast, for the Western group, the fit indices are found to be

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not as good as those of the Chinese group, but they are still within an acceptable range (CFI = .920, NNFI = .907, IFI = .922, RMSEA = .080).

Second, the causal paths INTER → GD and EXTER → GD are statistically significant for the Chinese group, thus supporting H1 and H2. However, these paths are not significant for the Western group. The results also suggest that the causal path GD → ENP is statistically significant for both groups, supporting H3. Meanwhile, the GD → ECP path is not statistically significant for either group. Therefore, H4 is not supported. Finally, the structural path ENP → ECP is statistically significant for both groups, thus supporting H5.

In the multi-group analysis, we first compared a fully constrained model, where the paths are constrained to be equal across two groups, to an unconstrained model. The results of the χ^2 difference test revealed that the two groups vary at the model level ($\Delta\chi^2 = 13.683$, $p < .05$), indicating that differences exist in the path relationships between China and Western contexts. We then constrained each path individually in order to test the statistical differences path by path. The results indicated that INTER has a relatively greater influence on GD in the Chinese group than in the Western group, despite the difference being marginal ($\Delta\chi^2 = 3.049$, $p < .10$). Next, although there is no statistically significant difference between the two groups, it seems that in the Chinese context EXTER makes a greater contribution to GD than in Western context ($\beta = .333^{**}$ vs $\beta = .196$). Meanwhile, the effect of GD on ENP is also significantly different between the two groups ($\Delta\chi^2 = 4.648$, $p < .05$). The results suggest that the Chinese group appears to benefit more from adopting GD than the Western group regarding environmental performance ($\beta = .478^{***}$ vs $\beta = .360^{***}$).

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5. Discussion

5.1 Supply chain integration and green design

In our hypotheses, we expected that both supply chain internal and external integration capabilities would positively relate to the adoption of a green design strategy. The empirical results suggest a different story, however. In the Chinese context, both internal and external integration capabilities are more significantly positively related to green design than in the Western group. Coinciding with previous studies, this finding may be explained by the notion that Chinese firms are more in favor of a collective work ethic, and they perform best when part of in-groups rather than alone or in an out-group (Earley, 1993; Sivakumar and Nakata, 2003). In addition, as another study shows, Chinese automakers lack their own product development and R&D capabilities compared to the Western counterparts (Lockström et al., 2010). Therefore, when they adopt green design initiatives, these Chinese auto firms may be more reliant on collaborative efforts and joint-problem solving, thus revealing a stronger integration to green design linkage.

Lockström et al. (2010) also noted that the business relationships in China are very different from the way they are built in the West, as indicated by the different negotiating style and value of contacts, and a more personalized approach. *Guanxi*, which is an important cultural and social element in China, is an intrinsic part of Chinese business (Park and Luo, 2001). Chinese managers focus on networking and connections, and strive to foster a strong guanxi with business partners, customers, and the government to seek opportunities and create competitive advantage (Cai et al., 2010). Strong guanxi can also foster trust among business partners, thereby offering the Chinese firms access to strategic external resources and capabilities which they lack. Consistent with previous research (Li and Atuahene-Gima, 2001), the relationship-based strategy

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and strategic alliances with partners are key for successful product development in the Chinese context. It is thus no surprise to see that in their pursuit of green design strategy and product innovations, the Chinese companies are more reliant on joint efforts and collaborations both internally and externally.

Contrary to our expectation, however, internal and external integration capabilities did not show a significant positive relationship with green design in the Western group. This finding might be explained by the possibility that Western firms have relatively stronger product development capabilities and their product innovation lies more typically in the hands of dedicated specialist R&D teams. Western auto firms often invest significantly in their R&D capacity and thus possess an adequate level of knowledge, skills, and capabilities to come up with new technologies on their own (Lockström et al., 2010). Therefore, they may not rely too much on internal and external collaboration when pursuing their green design strategies. This finding may also reinforce previous research on Western organizations (Earley, 1989; Sivakumar and Nakata, 2003), which revealed that Western managers are more apt to engage in social loafing and they perform best when working individually as compared to their Chinese counterparts. As explored by Vereecke and Muylle, (2006), Western firms' supply chain collaboration efforts are too modest and un-orchestrated in many companies, many of which may not have reached a minimum threshold level to show substantial improvements. These various arguments may explain why there is a weaker integration to green design linkage in the Western context in our study.

5.2 Green design strategy and performance

We hypothesized that green design strategy adoption would positively contribute to the

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environmental performance of a firm. This prediction is supported by both data groups. Therefore, no matter where a firm is located, actively engaging in green design initiatives and taking environmental considerations into account in new product development can help improve environmental performance. This finding is consistent with previous research (e.g., Zhu and Sarkis, 2004), which posits that green design is a useful tool to improve an organization's environmental performance. This finding is also consistent with developments by some firms in the auto sector. For example, Toyota's effort to incorporate easy-to-dismantle design for effective resource recycling has not only reduced its consumption of non-renewable resources, but also improved its production efficiency and energy consumption (Toyota, 2016).

However, this finding contradicts that of Zhu et al. (2007), who did an early study on the Chinese automotive industry and found no significant relationship between green design and environmental performance. A possible explanation, as noted by Zhu et al. (2007), is that most of these Chinese firms were at an early adoption stage in implementing green design practices when their study was conducted. Consequently, the impact of green design on environmental performance improvement had not yet become obvious. A decade later, efforts in the adoption of green design initiatives have finally paid off in the Chinese auto industry and thus a closer relation is revealed in our research. They have now benefited more from adopting the green design strategy (GD $_{mean}$ = 3.65) toward their improved environmental performance, compared to their Western counterpart (GD $_{mean}$ = 3.47).

Conversely, our prediction of a positive association between green design strategy adoption and economic performance was not supported in either of the two data groups. A possible explanation might be that although green design may bring many environmental benefits, its direct impact on a firm's economic performance could be marginal due to current technological

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constraints, low sales volumes of green products and customer preferences, as is shown in the GM or Tesla cases (Lienert and Carey, 2017). It may require further technological breakthroughs and innovations, and may take decades before customers embrace the green economy fully. For instance, automakers today have invested significant efforts into the development of clean-energy and zero-emission vehicles. These new types of vehicles can lead to better environmental performance, but may suffer from, for example, relatively poor battery performance and lack of charging facilities. It is certain that these practical obstacles will be overcome by emerging technologies and the market share of these vehicles will grow gradually. However, it will be some time before consumers fully accept and adopt these products as part of their daily lives.

5.3 Environmental performance and economic performance

In our final hypothesis, we proposed that a firm's environmental performance (ENP) is positively associated with its economic performance (ECP). This hypothesis is supported by both data groups. Improvements in a firm's environmental performance may be a result of combined efforts in environmental management and green supply chain management (Zhu and Sarkis, 2004). Regardless of its root cause, however, as long as a firm achieves improvement in its overall environmental performance, a better economic performance can be expected. This finding corroborates the findings of a previous study (Moneva and Ortas, 2010) which claims that enterprises with a higher degree of environmental performance will show better financial performance levels in the future. Moneva and Ortas's (2010) study was specifically focused on European companies, however. Our findings provide additional support for their study from a broader Chinese and Western context.

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5.4 Theoretical implications

In light of the RBV, we argue that the successful adoption of a green design strategy can be facilitated by a firm's supply chain internal and external integration capabilities. Our study suggests that the strength of this proposed capability – strategy link varies in different organizational contexts. For instance, where there is a strong team working atmosphere or a collectivist work ethic, a firm's internal and external integration capabilities can contribute more significantly to effective green design strategy adoption. Our findings may thus provide further support to prior research (e.g., Mackelprang et al., 2014) which has employed contingency theory in exploring the effects of supply chain integration.

Our findings regarding the positive GD – ENP relationship provide additional evidence to support the extant literature, which claims that the adoption of green design delivers a clear advantage in terms of improved environmental performance (e.g., Green et al., 2012; Li et al., 2016; Yi-Chan and Tsai, 2007). Whilst this finding contradicts Zhu et al.'s (2007) early study in the Chinese automotive industry, we suggest that this is because it has taken time for the environmental performance impacts of green design strategy to be fully revealed.

However, the expected positive GD – ECP link is not supported by our study. This finding may suggest that, although green design innovation can help firms to cut costs and win customers, due to current technological constraints and customer preferences, its impact on economic performance may take some time to become significant. This finding may also suggest that amongst a firm's various environmental management efforts, green design on its own cannot deliver a significant improvement in a firm's overall economic performance, at least not in the auto firms that we studied.

Our findings on the ENP – ECP link add more insights into the debate on this important relationship. Consistent with the extant literature, this study further confirms that once a firm achieves greater improvement in its environmental performance, a better economic performance can be expected (Horváthová, 2010; Moneva and Ortas, 2010; Petljak et al., 2018). Although it is not formally hypothesized in our study, our findings may also reveal a mediation effect of ENP on the GD – ECP link, which may suggest that firms adopting a green design strategy can only realize economic gains if their green design strategy leads to an improved environmental performance.

5.5 Managerial implications

Our findings suggest that managers should first clearly understand their organizational context; for example, the specific local and regional contexts in which the firm is situated, the work ethics within their teams, and how to best develop close relationships with other firms in their supply chain. Managers should then develop an appropriate supply chain integration capability based on this understanding of context, by for example building embedded ties with suppliers, rationalizing the supply base, and selecting very capable suppliers. This integration capability may eventually lead to enhanced product development capabilities (Koufteros et al., 2007), thus maximizing the firm's green design efforts. Companies should also proactively embrace the green agenda in their product development as it will eventually pay off in terms of environmental performance improvement. Despite the unclear association between green design and economic performance, organizations should endeavor to achieve an overall improved environmental performance, because the more gains are made in environmental management, the more economic returns can be expected.

6. Conclusion

In this study, we have explored the specific role of supply chain integration capabilities in the successful adoption of a green design strategy, as well as the links between green design and associated performance dimensions. We tested our hypotheses in two different groups of respondents, which returned some dissimilar results. These empirical findings confirm that internal and external integration capabilities have strong links with successful green design strategy adoption in the Chinese context where there is a strong collectivist work ethic, whereas in the Western context the relationship seems weakened where team-based atmosphere or collectivism may be relatively lacking. Our findings also suggest that green design strategy can lead to improved environmental performance, but its impact on economic performance is as yet inconclusive. Finally, the study confirms that firms with higher levels of environmental performance have higher levels of economic performance irrespective of the regional context, thus shedding new light on the debate about the relationship between these two performance dimensions.

Our study has several limitations. First, the study was only conducted in the auto industry, which may affect the generalizability of our findings beyond this sector. Second, the cross-sectional design of the empirical study may affect the inference of causality. Third, data were gathered from only one respondent for each firm in our survey, which poses a potential problem of common method bias. Future research should strive to address these limitations in order to produce more compelling and generalizable results. Interested researchers could also conduct the analysis in different industries and collect more data in various regions, and compare any differences that arise.

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References

ABB. (2014), "ABB and China's BYD form global alliance in energy storage solutions for a better world", available at: http://www.abb.co.uk/cawp/seitp202/dce7492807e5fdffc1257d49 006fd f00. aspx (accessed 10 January 2018)

Armstrong, C.E. and Shimizu, K. (2007), "A Review of Approaches to Empirical Research on the Resource-Based View of the Firm", *Journal of Management*, Vol. 33 No. 6, pp. 959–986.

Armstrong, J. and Overton, T. (1977), "Estimating nonresponse bias in mail surveys", Journal of Marketing Research, Vol. 14 No. 3, pp. 396–402.

Barney, J. (1991), "Firm resources and sustained competitive advantage", *Journal of Management*, Vol. 17 No. 1, pp. 99–120.

Blome, C., Paulraj, A. and Schuetz, K. (2014), "Supply chain collaboration and sustainability: A profile deviation analysis", *International Journal of Operations and Production Management*, Vol. 34 No. 5, pp. 639-663.

Bloomberg News. (2017), "BYD Plans to Expand Daimler Partnership With New EVs for China", available at: https://www.bloomberg.com/news/articles/2017-09-21/byd-plans-to-expand-daimler-partnership-with-new-evs-for-china (accessed 10 January 2018)

Bras, B. (1997), "Incorporating environmental issues in product design and realization", *Industry and Environment*, Vol. 20 No. 1, pp. 7–13.

Byrne, B.M. (2016), *Structural Equation Modeling With AMOS: Basic Concepts, Applications, and Programming, Third Edition*, Routledge.

Cao, M. and Zhang, Q. (2011), "Supply chain collaboration: impact on collaborative advantage and firm performance", *Journal of Operations Management*, Vol. 29 No. 3, pp. 163–180.

Cai, S., Jun, M. and Yang, Z. (2010), "Implementing supply chain information integration in China: The role of institutional forces and trust", *Journal of Operations Management*, Vol. 28 No. 3, pp. 257–268.

Chen, C., Zhu, J., Yu, J.-Y. and Noori, H. (2012), "A new methodology for evaluating sustainable product design performance with two-stage network data envelopment analysis", *European Journal of Operational Research*, Vol. 221 No. 2, pp. 348–359.

Christmann, P. (2000), "Effects of 'best practices' of environmental management on cost advantage: The role of complementary assets", *Academy of Management Journal*, Vol. 43 No. 4, pp. 663–680.

Cousins, P.D. and Menguc, B. (2006), "The implications of socialization and integration in supply chain management", *Journal of Operations Management*, Vol. 24 No. 5, pp. 604–620.

D'Agostini, M., Tondolo, V.A.G., Camargo, M.E., Dullius, A.I. dos S., Tondolo, V.A.G., Russo, S.L., Tondolo, V.A.G., et al. (2017), "Relationship between sustainable operations practices and performance: a meta-analysis", *International Journal of Productivity and Performance Management*, Vol. 66 No. 8, pp. 1020–1042.

Devanathan, S., Ramanujan, D., Bernstein, W.Z., Zhao, F. and Ramani, K. (2010), "Integration of Sustainability into Early Design through the Function Impact Matrix", *Journal of Mechanical Design*, Vol. 132, pp. 081004-1.

Earley, P.C. (1989), "Social Loafing and Collectivism: A Comparison of the United States and the People's Republic of China", *Administrative Science Quarterly*, Vol. 34 No. 4, pp. 565–581.

Earley, P.C. (1993), "East Meets West Meets Mideast: Further Explorations Of Collectivistic and Individualistic Work Groups", *Academy of Management Journal*, Vol. 36 No. 2, pp. 319–348.

Ellinger, A.E. (2000), "Improving marketing/logistics cross-functional collaboration in the supply chain", *Industrial Marketing Management*, Vol. 29 No. 1, pp. 85–96.

Figge, F. and Hahn, T. (2012), "Is green and profitable sustainable? Assessing the trade-off between economic and environmental aspects", International Journal of Production Economics, Vol. 140 No. 1, pp. 92–102.

Flynn, B.B., Huo, B. and Zhao, X. (2010), "The impact of supply chain integration on performance: A contingency and configuration approach", *Journal of Operations Management*, Vol. 28 No. 1, pp. 58–71.

Ford. (2014), "Creating a Sustainable Supply Chain: Ford's Overall Approach", available at: http://corporate.ford.com/microsites/sustainability-report-2013-14/supply-creating.html (accessed 05 November 2017).

Fowler, F.J. (2009), *Survey Research Methods*, 4th ed., Vol. 1, Sage.

Fujii, H., Iwata, K., Kaneko, S. and Managi, S. (2013), "Corporate Environmental and Economic Performance of Japanese Manufacturing Firms: Empirical Study for Sustainable Development", *Business Strategy and the Environment*, Vol. 22 No. 3, pp. 187–201.

Gerbing, D.W. and Anderson, J.C. (1988), "An updated paradigm for scale development incorporating unidimensionality and its assessment", *Journal of Marketing Research*, Vol. 25 No. 2, pp. 186–192.

Glantschnig, W.J. (1994), "Green design: an introduction to issues and challenges", *IEEE Transactions on Components, Packaging, and Manufacturing Technology-Part A*, Vol. 17 No. 4, pp. 508–513.

Gmelin, H. and Seuring, S. (2014), "Determinants of a sustainable new product development", *Journal of Cleaner Production*, Vol. 69, pp. 1–9.

Gold, S., Seuring, S. and Beske, P. (2010), "Sustainable supply chain management and inter organizational resources: a literature review", *Corporate Social Responsibility and Environmental Management*, Vol. 17 No. 4, pp. 230–245.

Green, K.W., Zelbst, P.J., Meacham, J. and Bhadauria, V.S. (2012), "Green supply chain management practices: impact on performance", *Supply Chain Management: An International Journal*, Vol. 17 No. 3, pp. 290–305.

Hair, J.F., Black, W.C., Babin, B.J. and Anderson, R.E. (2010), *Multivariate Data Analysis A Global Perspective*, 7th ed., Pearson Education, New Jersey.

Handfield, R.B. and Bechtel, C. (2002), "The role of trust and relationship structure in improving supply chain responsiveness", *Industrial Marketing Management*, Vol. 31 No. 4, pp. 367–382.

Handfield, R.B., Melnyk, S.A., Calantone, R.J. and Curkovic, S. (2001), "Integrating environmental concerns into the design process: the gap between theory and practice", *Engineering Management, IEEE Transactions on*, Vol. 48 No. 2, pp. 189–208.

Holland, S., Gaston, K. and Gomes, J. (2000), "Critical success factors for cross-functional teamwork in new product development", *International Journal of Management Reviews*, Vol. 2 No. 3, pp. 231–259.

Horváthová, E. (2010), "Does environmental performance affect financial performance? A meta-analysis", *Ecological Economics*, Vol. 70 No. 1, pp. 52–59.

Huang, M.-C., Liu, T.-C. and Yen, G.-F. (2014), "Reexamining supply chain integration and the

supplier's performance relationships under uncertainty", *Supply Chain Management: An International Journal*, Vol. 19 No. 1, pp. 64–78.

Huo, B. (2012), "The impact of supply chain integration on company performance: an organizational capability perspective", *Supply Chain Management: An International Journal*, Vol. 17 No. 6, pp. 596–610.

Hwang, S.-N., Chen, C., Chen, Y., Lee, H.-S. and Shen, P.-D. (2013), "Sustainable design performance evaluation with applications in the automobile industry: Focusing on inefficiency by undesirable factors", *Omega*, Vol. 41 No. 3, pp. 553–558.

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.

Jassawalla, A.R. and Sashittal, H.C. (1999), "Building collaborative cross-functional new product teams", *The Academy of Management Executive (1993-2005)*, Vol. 13 No. 3, pp. 50–63.

Kamal, M.M. and Irani, Z. (2014), "Analysing supply chain integration through a systematic literature review: a normative perspective", *Supply Chain Management: An International Journal*, Vol. 19 No. 5/6, pp. 523–557.

Koufteros, X.A., Edwin Cheng, T.C. and Lai, K.-H. (2007), "'Black-box' and 'gray-box' supplier integration in product development: Antecedents, consequences and the moderating role of firm size", *Journal of Operations Management*, Vol. 25 No. 4, pp. 847–870.

Lee, S.-Y. and Klassen, R.D. (2008), "Drivers and Enablers That Foster Environmental Management Capabilities in Small-and Medium-Sized Suppliers in Supply Chains", *Production and Operations Management*, Vol. 17 No. 6, pp. 573–586.

Leuschner, R., Rogers, D.S. and Charvet, F.F. (2013), "A meta-analysis of supply chain integration and firm performance", *Journal of Supply Chain Management*, Vol. 49 No. 2, pp. 34–57.

Li, H. and Atuahene-Gima, K. (2001), "Product Innovation Strategy and the Performance of New Technology Ventures in China", *Academy of Management Journal*, Vol. 44 No. 6, pp. 1123–1134.

Li, S., Jayaraman, V., Paulraj, A. and Shang, K. (2016), "Proactive environmental strategies and corporate performance: role of green product design and green supply chain processes in the Chinese high-tech industry", *International Journal of Production Research*, Vol. 54 No. 7, pp. 2136-2151.

Lienert, P. and Carey, N. (2017), "GM challenges Tesla with promise of profitable electric cars", available at: https://uk.reuters.com/article/us-gm-ceo/gm-challenges-tesla-with-promise-of-profitable-electric-cars-idUKKBN1DF272 (accessed 10 Feb 2018).

Lienert, P. and White, J. (2018), "GM races to build a formula for profitable electric cars", available at: https://www.reuters.com/article/us-gm-electric-insight/gm-races-to-build-a-formula-for-profitable-electric-cars-idUSKBN1EY0GG (accessed 08 February 2018).

Liu, Y., Zhu, Q. and Seuring, S. (2017), "Linking capabilities to green operations strategies: the moderating role of corporate environmental proactivity", *International Journal of Production Economics*, Vol. 187, pp. 182-195.

Liu, Y., Srai, J.S. and Evans, S. (2016), "Environmental management: the role of supply chain capabilities in the auto sector", *Supply Chain Management: An International Journal*, Vol. 21 No. 1, pp. 1–19.

Lockström, M., Schadel, J., Harrison, N., Moser, R. and Malhotra, M.K. (2010), "Antecedents to

supplier integration in the automotive industry: A multiple-case study of foreign subsidiaries in China", *Journal of Operations Management*, Vol. 28 No. 3, pp. 240–256.

Mackelprang, A.W., Robinson, J.L., Bernardes, E. and Webb, G.S. (2014), "The Relationship Between Strategic Supply Chain Integration and Performance: A Meta-Analytic Evaluation and Implications for Supply Chain Management Research", *Journal of Business Logistics*, Vol. 35 No. 1, pp. 71–96.

Mazda. (2016), "Sustainability report 2016", available at: http://www2.mazda.com/en/publicity/release/2016/201608/160831a.html?link_id=csrn1609022 (accessed 05 November 2017)

Moneva, J.M. and Ortas, E. (2010), "Corporate environmental and financial performance: a multivariate approach", *Industrial Management & Data Systems*, Vol. 110 No. 2, pp. 193–210.

Narayanan, S., Jayaraman, V., Luo, Y. and Swaminathan, J.M. (2011), "The Antecedents of Business Process Integration in Business Process Outsourcing and Its Effect on Firm Performance", *Journal of Operations Management*, Vol. 29 No. 1–2, pp. 3–16.

Newbert, S.L. (2007), "Empirical research on the resource-based view of the firm: an assessment and suggestions for future research", *Strategic Management Journal*, Vol. 28 No. 2, pp. 121–146.

Nissan. (2018), "ZERO EMISSION", available at https://www.nissan-global.com/EN/ZEROEMISSION/ (accessed 08 June, 2018)

Nunnally, J. (1978), *Psychometric Theory*, New York: McGraw-Hill.

Ortas, E., M. Moneva, J. and Álvarez, I. (2014), "Sustainable supply chain and company performance: A global examination", edited by Stefan Schaltegger, Prof Roger Burr, D. *Supply Chain Management: An International Journal*, Vol. 19 No. 3, pp. 332–350.

Park, S.H. and Luo, Y. (2001), "Guanxi and Organizational Dynamics: Organizational Networking in Chinese Firms", *Strategic Management Journal*, Vol. 22 No. 5, pp. 455–477.

Paulraj, A., Jayaraman, V. and Blome, C. (2014), "Complementarity effect of governance mechanisms on environmental collaboration: does it exist?", *International Journal of Production Research*, Vol. 52 No. 23, pp. 6989–7006.

Petersen, K.J., Handfield, R.B. and Ragatz, G.L. (2005), "Supplier integration into new product development: coordinating product, process and supply chain design", *Journal of Operations Management*, Vol. 23 No. 3, pp. 371–388.

Petljak, K., Zulauf, K., Štulec, I., Seuring, S. and Wagner, R. (2018), "Green supply chain management in food retailing: survey-based evidence in Croatia", *Supply Chain Management: An International Journal*, Vol. 23 No. 1, pp. 1–15.

Podsakoff, P.M., MacKenzie, S.B., Lee, J.-Y. and Podsakoff, N.P. (2003), "Common method biases in behavioral research: a critical review of the literature and recommended remedies.", *Journal of Applied Psychology*, Vol. 88 No. 5, pp. 879–903.

Podsakoff, P.M. and Organ, D.W. (1986), "Self-reports in organizational research: Problems and prospects", *Journal of Management*, Vol. 12 No. 4, pp. 531–544.

Rao, P. and Holt, D. (2005), "Do green supply chains lead to competitiveness and economic performance?", *International Journal of Operations & Production Management*, Vol. 25 No. 9, pp. 898–916.

Russo, M.V. and Fouts, P.A. (1997), "A Resource-Based Perspective on Corporate Environmental Performance and Profitability", *Academy of Management Journal*, Vol. 40 No. 3, pp. 534–559.

Schaefer, D.R. and Dillman, D.A. (1998), "Development of a standard e-mail methodology:

Results of an experiment", *Public Opinion Quarterly*, Vol. 62 No. 3, pp. 378–397.

Schaltegger, S. and Synnestvedt, T. (2002), "The link between 'green' and economic success: environmental management as the crucial trigger between environmental and economic performance", *Journal of Environmental Management*, Vol. 65 No. 4, pp. 339–346.

Schoenherr, T. and Swink, M. (2012), "Revisiting the arcs of integration: Cross-validations and extensions", *Journal of Operations Management*, Vol. 30 No. 1, pp. 99–115.

Seo, Y.-J., Dinwoodie, J. and Kwak, D.-W. (2014), "The impact of innovativeness on supply chain performance: is supply chain integration a missing link?", *Supply Chain Management: An International Journal*, Vol. 19 No. 5/6, pp. 733–746.

Sihvonen, S. and Partanen, J. (2017), "Eco-design practices with a focus on quantitative environmental targets: An exploratory content analysis within ICT sector", *Journal of Cleaner Production*, Vol. 143, pp. 769–783.

Sivakumar, K. and Nakata, C. (2003), "Designing global new product teams: Optimizing the effects of national culture on new product development", *International Marketing Review*, Vol. 20 No. 4, pp. 397–445.

Soosay, C.A., Hyland, P.W. and Ferrer, M. (2008), "Supply chain collaboration: capabilities for continuous innovation", *Supply Chain Management: An International Journal*, Vol. 13 No. 2, pp. 160–169.

Steenkamp, J.-B.E. and Baumgartner, H. (1998), "Assessing measurement invariance in cross-national consumer research", *Journal of Consumer Research*, Vol. 25 No. 1, pp. 78–107.

Toyota. (2016), "Sustainability Report 2016", available at: http://www.toyota-global.com/sustainability/report/sr/ (accessed 05 January 2018).

Tseng, M.-L., Chiu, (Anthony) Shun Fung, Tan, R.R. and Siriban-Manalang, A.B. (2013), "Sustainable consumption and production for Asia: sustainability through green design and practice", *Journal of Cleaner Production*, Vol. 40, pp. 1–5.

Vachon, S. and Klassen, R.D. (2008), "Environmental management and manufacturing performance: The role of collaboration in the supply chain", *International Journal of Production Economics*, Vol. 111 No. 2, pp. 299–315.

Vanpoucke, E., Vereecke, A. and Wetzels, M. (2014), "Developing supplier integration capabilities for sustainable competitive advantage: A dynamic capabilities approach", *Journal of Operations Management*, Vol. 32 No. 7, pp. 446–461.

Vereecke, A. and Muylle, S. (2006), "Performance improvement through supply chain collaboration in Europe", *International Journal of Operations & Production Management*, Vol. 26 No. 11, pp. 1176–1198.

Wagner, M. and Schaltegger, S. (2004), "The Effect of Corporate Environmental Strategy Choice and Environmental Performance on Competitiveness and Economic Performance", *European Management Journal*, Vol. 22 No. 5, pp. 557–572.

Wong, C.Y., Boon-itt, S. and 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*, Vol. 29 No. 6, pp. 604–615.

Wu, Z. and Pagell, M. (2011), "Balancing priorities: Decision-making in sustainable supply chain management", *Journal of Operations Management*, Vol. 29 No. 6, pp. 577–590.

Yi-Chan, C. and Tsai, C.-H. (2007), "The effect of green design activities on new product strategies and performance: An empirical study among high-tech companies", *International Journal of Management*, Vol. 24 No. 2, p. 276.

Yu, W., Chavez, R., Feng, M. and Wiengarten, F. (2014), "Integrated green supply chain

management and operational performance", *Supply Chain Management: An International Journal*, Vol. 19 No. 5/6, pp. 683–696.

Zacharia, Z.G., Nix, N.W. and Lusch, R.F. (2011), "Capabilities that enhance outcomes of an episodic supply chain collaboration", *Journal of Operations Management*, Vol. 29 No. 6, pp. 591–603.

Zhao, X., Huo, B., Selen, W. and Yeung, J.H.Y. (2011), "The impact of internal integration and relationship commitment on external integration", *Journal of Operations Management*, Vol. 29 No. 1, pp. 17–32.

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 No. 3, pp. 265–289.

Zhu, Q., Sarkis, J. and Lai, K. (2007), "Green supply chain management: pressures, practices and performance within the Chinese automobile industry", *Journal of Cleaner Production*, Vol. 15 No. 11–12, pp. 1041–1052.

Appendix: Measurement items

| Measurement items	*Loading*
Internal integration (Scale: 1 = 'not at all competent' to 5 = 'very competent')	
C1Q1 We can form close collaboration between supply chain/logistics department and other functions for business tasks.	.786
C1Q2 We have effective and efficient cross-functional teams with the involvement of SC/Logistics department.	.800
C1Q3 Among business functions, we have well-established common agenda, share concerns, and are committed to building trust.	.772
External integration (Scale: 1 = 'not at all competent' to 5 = 'very competent')	
C3Q1 We have built long-term strategic partnership with our suppliers/customers in the supply chain on a large scale.	.711
C3Q2 With supply chain partners, we share our knowledge and critical information; provide training and collaborative learning on a regular basis.	.781
C3Q3 With supply chain partners, we have joint-effort on problem solving, share rewards and risks.	.893
C3Q4 We have established trust, commitment, shared values and a common vision with our supply chain partners.	.858
Green design (Scale: 1 = not considering it; 2 = considering it currently; 3 = planning adoption; 4 = implementing; 5 = successfully implemented).	
GD1 Design of products for reduced consumption of material/energy	.721
GD2 Design of products for reuse, recycle, recovery of material, component parts	.731
GD3 Design of products to avoid or reduce use of hazardous of products and/or their manufacturing process	.843
GD4 Design of products for longevity and durability	.769
Environmental performance (Scale: 1 = not at all; to 5 = very significant)	
P1E1 Reduction of air emission	.729
P1E2 Reduction of waste water	.830
P1E3 Reduction of solid waste	.837
P1E4 Decrease of consumption of hazardous/harmful/toxic materials	.762
P1E5[□] Decrease of frequency for environmental accidents	n/a
P1E6 Improve a company's environmental image	756
Positive economic performance (Scale: 1 = not at all; to 5 = very significant)	
P2E1 Decrease of cost for materials/components purchasing	.675
P2E2 Decrease of cost for energy consumption	.702
P2E3 Decrease of cost for waste treatment	.913
P2E4 Decrease of cost for waste discharge	.884
P2E5[□] Decrease of fine for environmental accidents	n/a
P2E6[□] Increased profit of selling greener products	n/a

[□] Item was dropped in CFA
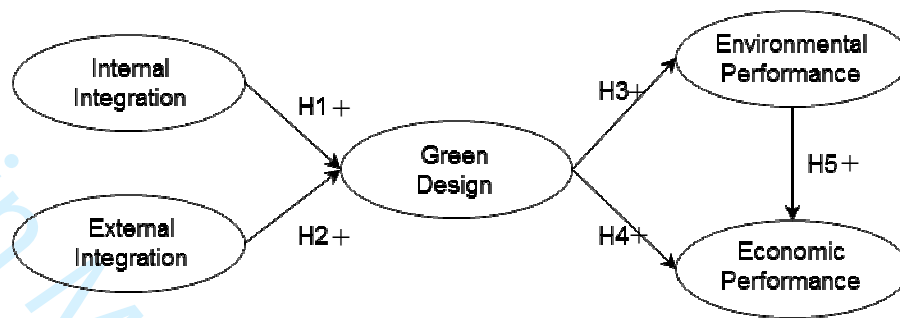
Figure 1 Conceptual model

Table 1 Descriptive statistics and correlation matrix (n = 216)

	Mean	Std.	α	CR	AVE	MSV	INTER	EXTER	GD	ENP	ECP
INTER	4.154	.606	.828	.829	.618	.241	1				
EXTER	3.913	.702	.880	.886	.662	.241	.448**	1			
GD	3.929	.826	.848	.851	.589	.159	.180**	.237**	1		
ENP	4.043	.732	.886	.888	.614	.418	.249**	.296**	.346**	1	
ECP	3.821	.736	.879	.875	.641	.418	.169*	.171*	.290**	.587**	1

Notes: * $p < 0.05$; ** $p < 0.01$

Table 2 Measurement invariance test

	χ² value	df	p-value	χ²/df	CFI	NNFI	RMSEA	PCLOSE	Δχ² test
Configural invariance	418.707	315	.000	1.321	.959	.951	.039	.974	-
Metric invariance	435.025	332	.000	1.310	.958	.952	.038	.982	Δχ² = 16.318; p = .361
Scalar invariance	512.066	347	.000	1.476	.933	.927	.047	.701	Δχ² = 93.359; p < .001
Partial scalar invariance	453.990	343	.000	1.324	.955	.950	.039	.977	Δχ² = 35.283; p = .106

Table 3 Structural model results

Structural Path (from-to)	Group 1: China (n = 102)		Group 2: Western (n = 114)		Multi-group analysis
	Standardized coefficients	t-value	Standardized coefficients	t-value	Δχ² test (df = 1)
INTER → GD (Hypothesis 1)	.457***	3.479	.023	.170	3.102$^+$
EXTER → GD (Hypothesis 2)	.333**	2.910	.196	1.462	.170
GD → ENP (Hypothesis 3)	.478***	3.763	.360***	3.258	4.963*
GD → ECP (Hypothesis 4)	.042	.414	-.010	-.099	.005
ENP → ECP (Hypothesis 5)	.740***	5.231	.550***	4.366	1.362
Model fit indices:					
χ²	179.650		278.925		
df	162		162		
χ²/df	1.109		1.722		
NNFI	.979		.907		
CFI	.982		.920		
IFI	.983		.922		
RMSEA	.033		.080		

Notes: Significant at:$^+$ $p \le .1$ * $p \le .05$ ** $p \le .01$; *** $p \le .001$