Environmental management: the role of supply chain capabilities in the auto sector

Abstract

Purpose – This paper explores the specific role of supply chain capabilities in the implementation of particular green strategies, and the extent to which this relationship is contingent upon firm size.

Design/methodology/approach – A survey-based approach was used to empirically test the study hypotheses. Data that was collected from 225 senior logistics/supply chain managers across the automotive OEM and supplier base (predominantly from China, North America and Europe) was analyzed using moderated regression analyses.

Findings – Supply chain capabilities contribute to effective green strategy implementation and their magnitude varies significantly with respect to green design, green purchasing, and green manufacturing. Firm size has positive moderating effects on *supply chain flexibility* in both green design and green purchasing, and on *supplier appraisal capability* in both green purchasing and green manufacturing. However, unexpectedly, firm size negatively moderates not only *SCM skills/knowledge* in both green design and green purchasing but also *IT/IS support* in green manufacturing.

Research limitations/implications – This study adopted a cross-sectional survey design and was only conducted in the automotive industry which may affect the inferences of causality and generalizability beyond this sector.

Practical implications – Managers should consider whether the green strategies that they want to follow 'fit' with their existing resources/capabilities and firm-level conditions, and accordingly develop and deploy appropriate supply chain capabilities for successful implementation.

Originality/value – The research contributes to the existing resource-based view literature by studying the capability – strategy link with its specific application to environmental management.

Keywords Sustainability, Environmental management, Capabilities, Resource-based view, Surveys, Regression analysis

Paper type Research paper

1. Introduction

Environmental management concerns the integration of principles related to environmental protection and sustainability into the organizational decision-making process in order to convert resources into usable products (Angell and Klassen, 1999). Research on this subject has extended to the field of operations management, especially supply chain management (SCM) (Lee and Klassen, 2008; Carter and Easton, 2011; Cucchiella and Koh, 2012), leading to strategies such as green design, green purchasing, and green manufacturing. To target environmental problems with their suppliers, a number of well-known companies are actively pursuing these green strategies. Examples include Panasonic's ECO-Value Creation initiative in 2010, Boeing's close collaboration with their suppliers on environmental stewardship, and P&G's supplier scorecard system for environmental collaboration (Paulraj et al., 2014).

A number of studies have shown that the integration of environmental management with operations management can improve business performance and provide a competitive advantage (e.g., Zhu and Sarkis, 2004; Yang et al., 2011; Green Jr et al., 2012). However, the implementation of environmentally and competitively sound strategies is often extremely difficult for companies (Klassen and Whybark, 1999), especially in the automotive industry where the level of complexity is extremely high in supply networks (Thun and Müller, 2010).

According to the resource-based view (RBV) (Wernerfelt, 1984), the conception and implementation of strategies employs bundles of firm-specific resources and capabilities (Barney, 1991). Morash (2001) stated that the choice of a supply chain strategy should be supported by specific organizational capabilities in order to achieve the intended performance. 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; Mahoney, 1995). Similarly, if sustainable development, especially environmental management, provides firms with a competitive advantage, the implementation of green strategies may require firms to possess and deploy specific logistics/SCM-related resources and capabilities.

Despite the need to address the potential relation between firms' specific logistics/SCM capabilities and green strategies, according to recent reviews of the empirical research on the RBV of the firm, most existing studies have focused on the association of firms' resources/capabilities with their competitive advantages and/or performance (Armstrong and Shimizu, 2007; Newbert, 2007; Ray et al., 2004); by contrast, the resources/capabilities – strategy link and the strategic 'fit' between them have been largely overlooked (Lynch et al., 2000). Moreover, prior research has reported contrasting findings in this regard. For example, Bowen et al. (2001) found no significant relation between supply management capabilities and "greening the supply process", where the internal "liaison between Purchasing and other functions" and "partnership approach with suppliers" were considered the key dimensions of the supply management capability construct. This finding directly contradicts the findings of Carter and Carter (1998) and Carter et al. (2000) who found significant positive effects of both internal collaboration particularly between purchasing and other functions and increased coordination with suppliers on green purchasing.

In this research, we therefore aim to address this research gap by studying the link between capabilities and strategy. More specifically, we attempt to understand the specific role of supply chain capabilities (SCCs) in the successful implementation of green design, green purchasing, and green manufacturing strategies in the auto sector. Based on Newbert's (2007) organizing approach, we further argue that these associations may be contingent on certain firm-level conditions. Hence, we introduce firm size as a moderator in our research model. Following an extensive review of the literature on the potential logistics/SCM-related capabilities that may support green initiatives, we conduct an empirical analysis across the global automotive industry.

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

2. Theoretical background and hypotheses

2.1. The RBV and capabilities

The RBV has at its core the notion that firms with *valuable, rare*, imperfectly *imitable,* and *nonsubstitutable* resources and capabilities can gain *sustained* competitive advantages (Barney, 1991; Dierickx and Cool, 1989; Peteraf, 1993). A firm's resources can be defined as the (tangible and intangible) assets semi-permanently tied to the firm that enable the firm to conceive of and implement strategies (Wernerfelt, 1984; Barney, 1991). Capabilities, in contrast, "refer to a firm's capacity to deploy *Resources,* usually in combination, using organizational processes, to effect a desired end" (Amit and Schoemaker, 1993, p.35). Capabilities have two idiosyncratic characteristics. First, they are firm-specific and cannot be easily transferred from one organization to another. Second, the primary purpose of capabilities is to enrich the productivity of a firm's resources to provide a competitive advantage (Makadok, 2001). Any differences in firms' resources and capabilities may affect their strategy adoption and thus their competitive advantages and disadvantages (Teece and Pisano, 1994). A firm can build and develop strategic capabilities that provide competitive advantages. However, capabilities are path dependent, causally ambiguous, and socially complex (Barney, 1991), which render the development of new capabilities extremely difficult. An important extension of the RBV is the relational view, which argues that a firm's critical resources may extend beyond a firm's boundaries and may be embedded in inter-organizational routines and processes (Dyer and Singh, 1998). Unique competitive advantages may thus be achieved as a result of the synergistic combinations of complementary resources and capabilities across firm boundaries (Madhok and Tallman, 1998).

Although recent research has debated the limitations of the RBV (e.g., Priem and Butler, 2001a, 2001b; Makadok and Coff, 2002; Priem, 2001; Barney, 2001), it does not diminish its value as a useful perspective for understanding firm strategies and competitive advantages. Specifically, although the RBV is not a prescriptive theory (Priem and Butler, 2001a, 2001b), it is powerful for explaining how a firm may gain and sustain a competitive advantage by possessing, acquiring, and exploiting the 'right' resources and capabilities (Lockett et al., 2009; Kraaijenbrink et al., 2010).

2.2. Supply chain capabilities

The RBV is no stranger to logistics/SCM literature (Olavarrieta and Ellinger, 1997; Closs et al., 1997; Morash et al., 1996; Morash, 2001; Rungtusanatham et al., 2003; Tracey et al., 2005; Wu et al., 2006; Barney, 2012). In today's highly competitive environment, the increasing reliance on supply network relationships, shifting channel power and globalization necessitate the use of logistics/SCM for enhanced competitiveness. As Fawcett et al. (1997) noted, the importance of on-time delivery, unique service offerings, and cost efficiency in complex and dynamic networks all point to logistics/SCM processes that could, if properly managed, perform as critical capabilities/core competences.

According to Olavarrieta and Ellinger (1997, p.572), SCCs may "…involve a complex combination of physical assets, organizational routines, people skills and knowledge, which are not obvious and which require time to develop and integrate". Previous research has also taken a divergent view on the conceptualization of SCCs because of their complexity. For instance, studies such as Morash et al. (1996) have focused on business behavior and processes, and distinguished SCCs into *demand-oriented* and *supply-oriented* capabilities. Likewise, the model shown in Lynch et al. (2000) emphasizes on operational excellence and thus identifies *process* capabilities and *value-added service* capabilities as key logistics capabilities. These studies direct particular attention to routine/process-based activities and their conceptualizations are mainly based on an intra-organizational perspective.

Other research has claimed that SCCs may not only reside in firms but also span organizations because of the great boundary spanning activities and the management of highly complex supply networks (e.g., Srai and Gregory, 2008). These capabilities resulting from particular network configurations combined with specific organizational routines may more fully meet the definitions encompassed in the RBV because they are rather complex, valuable and difficult to imitate. This broader supply network perspective emphasizes that both intra- and inter- firm processes and routines are critical to an effective SCM. Our definition of SCCs thus takes a broader network perspective:

> *Bundles of SCM skills, knowledge, routines and competencies that are developed over time through complex interactions, both within a firm and with its network partners with which the firm can coordinate SCM activities and deploy resources (internal and external) towards a desired end.*

By conducting a review of the literature on logistics capabilities, Esper et al. (2007) synthesized the most frequently discussed SCCs into five major categories: *customer focus capability*, *supply management capability*, *integration capability*, *measurement capability*, and *information exchange capability*. Following Esper et al., Gligor and Holcomb (2012) further contended that SCCs have both internal and external dimensions. Through effective coordination and cooperation, lower-level capabilities could lead to integrated SCCs (i.e., higher-order/distinctive capabilities). Similarly, through an analysis of existing research, Defee and Fugate (2010) speculated that logistics/SCM capabilities can be classified into core/higher-order capabilities and lower-level functional capabilities.

Consequently, empirical research on SCCs can be differentiated into two major streams in terms of the level of analysis. The first stream has primarily focused on examining and exploring the direct relation between firms' high-order/distinctive SCCs and their competitive advantage/performance (e.g., Wu et al., 2006). The second stream has emphasized on exploring more interesting aspects of single/specific (lower-order) SCCs, with regard to either their interrelations/contributions to higher-order capabilities (e.g., Kim, 2006; Daugherty et al., 2009) or their direct effects on firms' competitive advantage and/or performance (e.g., Richey et al., 2007; Rungtusanatham et al., 2003).

The RBV literature has noted that the implementation of strategies requires firms to possess appropriate resources and capabilities (Wernerfelt, 1984; Barney, 1991). SCCs are believed to support the implementation of supply chain strategies (e.g., lean and agile strategies), and once these strategies are successfully implemented, they can help firms to achieve supply chainrelated competitive advantages (Morash, 2001). Moreover, through the implementation of supply chain strategies, organizations may be able to develop higher-level/distinctive SCCs (e.g., agile SCCs), which are more valuable, rare, and difficult to imitate and substitute (Day, 1994; Gligor and Holcomb, 2012). Consequently, a *sustained* supply chain-related competitive advantage can be expected.

Along a similar line, we believe that SCCs can also facilitate the implementation of green strategies. For instance, if a firm decides to adopt a green design strategy to offer environmentally friendly products on the market, it may require the firm to work closely with its suppliers who can support new design initiatives. The firm may also need to deploy its SCM skills and knowledge to adapt to the new challenges inherent in sourcing and finding new, competent suppliers. Once a green design strategy is successfully adopted, the firm may be able to gain an environmentally competitive advantage by offering greener products on the market. In addition, by adopting a green design strategy, the firm may be able to gain a distinctive higherorder green design capability, which can offer the firm a sustained environmentally competitive advantage in the long run, as such a capability is rather difficult to acquire and imitate and thus more valuable and rare (Shang et al., 2010).

According to a systematic literature review, the frequently cited fundamental logistics/SCM capabilities were selected as key SCCs for this research (see Table I). These SCCs are considered lower-order functional capabilities. Although these capabilities can be developed in isolation, they are more likely to be mutually supportive (Kristal et al., 2010; Daugherty et al., 2009; Shang and Marlow, 2005). Additionally, as Ralston et al. (2013) noted, although higher-order, unique logistics capabilities have the potential to improve a firm's logistics performance, each lowerlevel capability must be analyzed on its own merits.

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2.3. Environmental management in the auto sector

The auto sector has traditionally received considerable attention in the context of greening because of its pollution effects (van Hoek, 2001; Zhu et al., 2007). Customers and communities have expressed great expectations for the auto industry with regard to environmental performance, as its products are by nature resource-burning products (Thun and Müller, 2010).

In fact, each phase of an automobile's life cycle affects the natural environment (Koplin et al., 2007). Therefore, many automakers have begun to implement various green strategies to address the negative environmental impacts of automobile production. Examples include Toyota's ecodesign initiatives, Volkswagen's green purchasing programs, and GM's green manufacturing (Nunes and Bennett, 2010), among others. However, owing to the level of complexity and worldwide expansion of its supply networks, the auto industry is also confronted with significant barriers and challenges to its environmental management (Thun and Müller, 2010; Xia and Tang, 2011). As noted by Thun and Müller (2010), these challenges may arise from a lack of internal environmental commitment and cross-functional integration and externally from a lack of ecooriented partnerships with supply chain partners. In addition, the limited resources and capabilities of suppliers (e.g., process and design capabilities) may frequently hamper an effective response to the environmental pressures in the auto industry (Lee and Klassen, 2008; Oh and Rhee, 2010).

Although recent research has focused on exploring the drivers of successful environmental management (e.g., Walker and Jones, 2012), few studies have specifically examined the auto sector. Even less research has considered the important role of SCCs in the adoption of green strategies in the auto industry. For example, by studying the Australian automotive industry, Simpson et al. (2007) noted that buyer-supplier relationship-specific investment could have a significant impact on the green supply commitment of suppliers. Such an assertion has also been supported by Zhu et al. (2010), who conducted a comparative analysis on environmental management between Japanese and Chinese automakers. These researchers have argued that encouraging win-win relationships with suppliers and customers can help large companies to realize sustainable development for entire supply chains. Similarly, Thun and Müller's (2010) study in the German automotive industry further noted the need for both inter- and intra- firm resources for effective environmental management. Therefore, based on the extant literature and the practical examples, we propose that SCCs can play an important role in the successful implementation of green strategies in the auto sector.

2.4. Hypothesis development

Figure I represents the conceptual model for this study.

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2.4.1. SCCs and green design

Green design is rather complex and challenging given its multi-disciplinary and multi-level nature (Bras, 1997; Braungart et al., 2007). Adopting this strategy to reduce negative environmental impacts and to improve a firm's overall environmental performance may require the firm to have appropriate SCCs. For example, the active involvement of the logistics/SCM department in the green design process may help the auto firm to choose qualified suppliers for the new design initiatives that are supported by a well-developed supplier selection and evaluation mechanism. Similarly, external integration with supply chain members may facilitate knowledge sharing and cooperative activities, where suppliers' technology and innovation capabilities can be brought into the design process to enhance green design performance. Additionally, these knowledge and information sharing activities may be facilitated by effective and reliable SCM IT systems. For example, Volkswagen provides an online platform for all suppliers, where they can share critical environmental knowledge (Koplin et al., 2007).

Often, green designers are required to assess different alternatives and to evaluate various tradeoffs for better design outcomes (Handfield et al., 2001). The logistics staffs' skills and knowledge can also provide useful input into these assessments, such as on the availability of alternative materials and supplies. Finally, the adoption of a green design strategy may require a firm to be able to sense market trends and to quickly launch greener products on the market. Thus, a more flexible supply chain may be able to cope with these demands and changes, which may enable the firm to rapidly and cost-effectively introduce greener products on the market.

Taken together, we hypothesize:

H1. Supply chain capabilities are positively associated with green design implementation.

2.4.2. SCCs and green purchasing

The strategy of incorporating 'green' considerations into purchasing activities to improve a firm's environmental performance is more complicated, as it must consider not only traditional factors such as a supplier's cost, quality, lead time and flexibility but also environmental responsibility (Lee et al., 2009). SCCs are thus proposed to enable the implementation of a green purchasing strategy. For example, on the basis of four case studies, Green et al. (1996) found that firms that are good at formal approaches to selecting and assessing suppliers may find it easier to incorporate green factors into their purchasing strategies. In addition, Carter and Carter (1998) suggested that the increased coordination with suppliers and downstream members of the supply chain, as well as within firms, facilitates green purchasing initiatives.

Furthermore, green purchasing may require extensive supplier coaching, education, and mentoring (Holt, 2004), such as the ISO 14000 series certifications. The efficiency and effectiveness of such training and education programs may largely depend on the level of skills/knowledge of the focal firms' purchasing teams. SCM IT/IS support may also play a significant role in the adoption of a green purchasing strategy if it enables effective knowledge sharing and data exchange for environmental monitoring. For example, enabled by its IT system, Volkswagen can provide effective and timely support to its suppliers concerning environmental management (Koplin et al., 2007). Finally, it is expected that greater supply flexibility occurs as the number of environmentally qualified suppliers increases, which makes it easier for the buying firms to choose the right competent suppliers to realize their green purchasing strategy.
Thus, taken together, we hypothesize:

H2. Supply chain capabilities are positively associated with green purchasing implementation.

2.4.3. SCCs and green manufacturing

The successful adoption of a green manufacturing strategy may become extremely challenging because it involves complex techniques and systems (Miller et al., 2010), requiring the possession and deployment of appropriate firm resources and capabilities (Klassen and Whybark, 1999; Wong et al., 2012). Thus, green manufacturing may be facilitated by the appropriate SCCs. For instance, Klassen (1993) argued that to successfully adopt a green manufacturing strategy, the manufacturing group must foster internal collaboration with other functional areas within a firm. Likewise, Klassen and Vachon (2003) found that external integration with supply chain members could significantly affect both the level and the form of investment in environmental technologies in Canadian manufacturing plants.

Furthermore, the successful implementation of a green manufacturing strategy may require the support of specific logistics/SCM skills and knowledge. For instance, the effective production scheduling and material planning for productivity improvement and waste reduction can be facilitated by SCM personnel who are proficient in JIT/lean logistics management skills. An effective supplier appraisal system may ensure that a firm can find competent suppliers who can satisfy the requirements and changes that derive from the adoption of a green manufacturing strategy. In addition, supply chain flexibility could facilitate green manufacturing implementation - e.g., by quickly adapting to new production process technologies and various pollution prevention techniques, and by cost-effectively manufacturing any new high quality and green products. Finally, effective and reliable SCM IT/IS support may enable firms to effectively monitor environmental performance and identify potential environmental problems in production (Melville, 2010). Thus, taken together, we hypothesize:

H3. Supply chain capabilities are positively associated with green manufacturing implementation.

2.4.4. Firm size as a moderator

Newbert (2007) conducted a systematic review of the empirical research in the RBV literature and identified four RBV approaches (i.e., the *resource-heterogeneity approach*, *organizing approach*, *conceptual-level approach*, *and dynamic capabilities approach*). In the organizing approach, certain firm-level conditions are argued to enable the effective exploitation of resources and capabilities. In this study, we use the organizing approach to argue that *firm size* is an important firm-level condition (Lin and Ho, 2011) that may affect the effective exploitation of the SCCs for green strategy implementation.

Large firms may be more exposed to various environmental pressures either from the government or from other stakeholders (Lin and Ho, 2011). Therefore, large firms may be more likely to deploy their resources and capabilities toward the adoption of green strategies to improve their environmental performance and enhance their green image. This assertion is consistent with the organization theorists who contend that the visibility of an organization can bear increased institutional pressure to pursue green strategies (Blome et al., 2014; Tate et al., 2010).

In addition, large organizations may fully realize the benefits of green strategies for creating and maintaining competitive advantages; therefore, they may more proactively exploit their resources and capabilities for green strategy implementation. Conversely, although small firms may possess a certain level of functional capabilities such as basic SCM skills and knowledge, they may be less likely to use these capabilities to implement environmental strategies, since they are either less exposed or less reactive to environmental management.

Therefore, the relationship between capabilities and the three noted green strategies may become stronger in larger firms than in smaller firms. Overall, firm size is expected to positively moderate the relationship between SCCs and green strategy implementation; accordingly, we propose the following hypotheses:

H4a. The bigger the size of a firm, the stronger the association between supply chain capabilities and green design implementation

H4b. The bigger the size of a firm, the stronger the association between supply chain capabilities and green purchasing implementation

H4c. The bigger the size of a firm, the stronger the association between supply chain capabilities and green manufacturing implementation

3. Methodology

3.1. Questionnaire development

Following Creswell (2009) and Sudman and Bradburn (1982), the questionnaire was developed with a four-step approach. First, we conducted preliminary interviews (using unstructured, openended 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 logistics/SCM-related capabilities and current industry practices in environmental management. 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 pretested with five academics and six managers in relevant fields to evaluate clarity, utility and relevancy. We combined or rephrased scale items and dropped irrelevant ones according to the feedback. Fourth, we conducted a pilot test with 20 supply chain/logistics managers in the automotive industry. The questionnaire was further refined according to the comments received. The questionnaire was in both English and Chinese. Translation was made and crosschecked by our research colleagues who are bilingual in English and Chinese to ensure consistency and invariance.

3.2. Data collection

We collected our data from the auto sector, as the automotive industry has rather complex supply networks and is often at the forefront of sustainability (Koplin et al., 2007; Thun and Müller, 2010). This specific context makes it interesting to explore whether the level of success in environmental management depends upon each unique auto firm's SCCs. A random sample of 1,000 automotive manufacturers around the world was drawn from available nationwide databases that comprise approx. 40,000 entries. Our initial interviews suggested that the appropriate candidates for the survey be at least mid-level managers with sound overall knowledge of SCM and environmental management. We thus made an initial attempt to contact logistics/SCM department managers in the auto sector (Sheehan and McMillan, 1999). The contact information was gained through sector-based professional groups. To increase the response rate, we assured the target candidates that all responses would remain anonymous and confidential and, as an additional incentive to participate, a copy of the final report with findings and conclusions would be available to all the participants, together with a small prize draw. The survey was administered via an online form following the suggestions given by Schaefer and Dillman (1998). Two weeks after the first emailing, reminder emails were sent to nonrespondents. Another fortnight later, we sent final-round emails as well as follow-up calls when possible. A total of 246 responses were received, of which 225 were usable, resulting in an overall effective response rate of 22.5%. Table II reveals the distribution of respondent firms in terms of firm size, supply chain position, and region.

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We compared those early responses to those who responded after follow-up steps were taken in each 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). Results of t-tests revealed 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.

3.3. Measurement

The measurement was developed following the procedures as suggested by Gerbing and Anderson (1988). When possible, previously validated measurements were relied upon to improve the reliability and validity of the measures. Three items were used to measure our first independent variable (IV), LIASN. These scales were primarily based on prior work (e.g., Flynn et al., 2010; Schoenherr and Swink, 2012). The second IV measured the extent to which a firm was able to develop APRSL, as reflected by three items obtained from Spekman (1988), Choi and Hartley (1996), and Tracey and Tan (2001). For assessing COLLN, we adapted previously validated measures from Das et al. (2006), Cao and Zhang (2011), and Zhao et al. (2011). The scale for SKILL was obtained from Lee et al. (1995), Briscoe et al. (2001), and Byrd and Turner (2001). The construct, FLEXY, was based on previous research on supply chain flexibility (Duclos et al., 2003; Vickery et al., 1999; Stevenson and Spring, 2007). Our last IV, IT/IS, was measured with three items also derived from earlier studies (Sanders and Premus, 2005; Rai et al., 2006). A five-point scale was used to capture the competency level of SCCs in each respondent firm (i.e., 1 = not at all competent to 5 = very competent).

Turning to our dependent variables (DVs), green design items were adopted from Zhu and Sarkis (2004) and Zhu et al. (2007). As suggested by the pilot test comments, we included an additional item derived from Zhang et al. (1997) to measure product longevity and durability in product design. Measurement of the green purchasing construct was consistent with that used by Zhu et al. (2007). The items for measuring green manufacturing were taken from Zhu and Sarkis (2004). We adapted the five-point scale used in Zhu and Sarkis (2004) by placing more emphasis on implementation (i.e., 1 = not considering it; 2 = considering it currently; 3 = planning implementation; 4 = implementing; 5 = successfully implemented).

Firm size was measured by categorical data of the total number of employees (1 = less than 200; 2 = 200-500; 3 = 501-1000; 4 = 1001-2000; 5 = 2001-3000; 6 = more than 3000). Previous research suggests that the geographic location of a firm influences its decision to invest (Nachum et al., 2008), so we controlled for four arbitrary regions: China (CN), North America (NA), Europe (EU), and Other in the analysis by creating three dummy variables. We also supposed that there were differences across firms with respect to their tier positions (Choi and Hartley, 1996), so we controlled for supply chain tiers (OEM, Tier 1 and Tier 2 suppliers) with two dummy variables in the study.

To avoid/diminish common method bias, we applied several procedures proposed by Podsakoff et al. (2003). To test the existence of common method variance, Harman's single-factor test was performed (Podsakoff and Organ, 1986). The factor analysis of all items revealed nine factors with eigenvalues greater than 1.0 that accounted for 75% of the total variance. The first factor only accounted for 32% of the variance. These results indicated that common method bias was not a significant problem in this study.

Because the data came from firms across multiple countries and the data from China seems to be dominating, measurement invariance is essential before conducting any further analysis. Because of the limited number of data, we performed a two-group (Chinese compared with non-Chinese) invariance test with multi-group confirmatory factor analysis (CFA) (Steenkamp and Baumgartner, 1998) in IBM AMOS 22. First, we performed a configural invariance test consisting of the baseline models of Chinese and non-Chinese samples without imposing any equality constraints. As shown in Table III, the model exhibits good fit: $\chi^2_{(795)} = 1092$, $p < .001$; CFI = .930; and RMSEA = .041 – thus supporting configural invariance. Second, we tested metric invariance by constraining all free factor loadings to be equal across the two groups. The goodness-of-fit results show that the model exhibits good fit to the data: $\chi^2_{(817)} = 1126$, $p < .001$; CFI = .927; RMSEA = .041, and no significant increase between the configural invariance model and the metric invariance model was found ($\Delta\chi^2 = 34$, $p > .05$), in support of metric invariance. A third level of invariance is necessary to allow mean comparison of the underlying constructs across the two groups: scalar invariance. To test scalar invariance, we constrained all factor loadings and all observed variable intercepts. The full scalar invariance test did not return satisfactory results. Therefore, we refined our models by relaxing several items and achieved partial scalar invariance (see Table III). Overall, the results of the invariance tests were acceptable for the aim of our study (Steenkamp and Baumgartner, 1998).

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Internal scale reliability was assessed with Cronbach's alpha. The α values for the constructs all exceeded the recommended threshold of .70 (Nunnally, 1978). The exploratory factor analysis (EFA) also produced a nine-factor structure with all items loading clearly on their intended factors. Accordingly, we estimated a nine-factor CFA measurement model with all the measures.

After we dropped two items (GP1 and GM1), the model indicated a satisfactory fit: $\chi^2_{(426)} = 709$, $p < .001$; CFI = .935; RMSEA = .054, PCLOSE = .151. Furthermore, all factor loadings were highly significant ($p < .001$), the composite reliability (CR) of all constructs exceeded the .70 cutoff, and the average variance extracted (AVE) indices were greater than the .50 benchmark

(Hair et al., 2010), all of which demonstrate adequate convergent validity and reliability (see Appendix). 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 Appendix).

3.4. Data Analysis

To test the study hypotheses, a moderated hierarchical linear regression analysis was performed as employed in previous operations management research (e.g., Klassen and Angell, 1998; Zhu and Sarkis, 2004). Prior to creating the interaction terms, the main effects and the moderator variable were mean-centered as recommended by Aiken and West (1991).

The variance inflation factor (VIF) was used to assess the degree of collinearity that exists in the regression models. No significant VIF was found in any of the models (max.VIF = 2.79: control variable for OEM – well below the recommended threshold of 10.0) (Hair et al., 2010). Thus, multicollinearity was not a serious concern in our study.

4. Results

The descriptive statistics and Pearson correlation results are shown in Table IV. Table V reports the regression results. First, as revealed in Model 1, there were significant differences among countries. As compared with China, EU had a significant negative relationship with green purchasing, while NA revealed a significant positive relationship with green manufacturing. Second, significant differences also existed between tier positions as compared with Tier-2 suppliers. OEM and Tier-1 suppliers demonstrated significant positive associations with green design and green manufacturing. They also had positive but no significant relationships with green purchasing.

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Turning to the main effects (Model GD2), among the six SCCs, APRSL and SKILL were found to be significantly and positively related to green design, supporting H1; whilst FLEXY also demonstrated positive association with green design, the relationship was not significant (β = .115, p > .10). Overall, H1 was partially supported.

For green purchasing (Model GP2), all six SCCs demonstrated positive associations but only APRSL and SKILL were significant in the relationship. The positive association between COLLN and green purchasing became significant in Model 3 and Model 4 when new variables were entered. Hence, H2 was also partly supported.

LIASN, SKILL and FLEXY were found to have significant positive relationships with green manufacturing (Model GM2), supporting H3. APRSL was also positively related to green manufacturing, however this relationship was not significant (β = .121, p > .10). Interestingly, COLLN revealed a negative relationship with green manufacturing whilst it was not significant (β = -.136, p > .10).

Model 3 included firm size in the regression analysis. The results demonstrated that firm size revealed significant positive effects on all the DVs. As shown in Model GD4, mixed results were found for the moderating effects of firm size. First, a marginal positive moderation was detected for the association between FLEXY and green design (β = .074, p < .10), supporting H4a. Surprisingly, firm size negatively moderated the effect of SKILL on green design (β = -.197, p < .001). No significant moderating effects were detected for the other four SCCs in the test. Thus, H4a was not fully supported by the results.

Second, in Model GP4, firm size was found to positively moderate the effect of APRSL (β = .100, p < .05) on green purchasing and marginally for FLEXY (β = .080, p < .10). Again, a negative moderating effect of firm size on the relationship between SKILL and green purchasing was explored (β = -.129, p < .01). No significant moderation was found for the other tested SCCs for green purchasing. Thus, taken together, H4b was only partly supported.

Turning to green manufacturing (Model GM4), a marginal positive moderating effect was found for APRSL ($\beta = .077$, $p < .10$), providing partial support for H4c. However, firm size was found to negatively moderate the effect of IT/IS on green manufacturing ($\beta = -.088$, $p < .05$). No significant moderating effects were revealed for the other SCCs tested in the model. Taken together, H4c was not fully supported.

5. Discussion

5.1.The role of SCCs

In our hypotheses, we expected that all six key SCCs would be positively associated with the implementation of the three examined green strategies. However, the empirical results suggest a different story. To seek the possible explanations and better understand our study findings, we conducted 5 post-survey interviews with senior managers who participated in our survey. For brevity, only the relevant findings are discussed as they relate to our survey results.

Regarding green design, supplier appraisal and SCM skills/knowledge capabilities are more important than other SCCs. One possible explanation may be that suppliers currently play a much more important role in new car development (Oh and Rhee, 2010). According to our postsurvey interviews, supplier capabilities in handling product design have become a key consideration when auto firms select new suppliers. A well-developed supplier selection and evaluation mechanism can help the focal firms find competent suppliers who meet their green design requirements and specifications, thus facilitating the implementation of firms' green design strategies. In addition, green design often involves the development and application of complex technologies, processes, and new materials, which requires an adequate level of skills/ knowledge among logistics/SCM personnel who take part in the design endeavor. For example, the extensive knowledge of the logistics/SCM personnel on the available low impact environmental design materials and suppliers can enable effective sourcing for the focal firm's green design strategy adoption.

For green purchasing, all the SCCs demonstrate positive relationships but only supplier appraisal, SCM skills/knowledge, and external integration capabilities are relatively more significant in the relationship. First, consistent with Noci (1997), the successful implementation of a green purchasing strategy requires suppliers to meet certain environmental criteria and to improve their environmental performance (e.g., ISO14001 certification). A sophisticated supplier selection and evaluation system can ensure that suppliers satisfy the environmental requirements that are imposed by the buying firm. Therefore, a firm's supplier appraisal capability becomes vital in the adoption of a green purchasing strategy. Furthermore, an adequate level of skills/knowledge among logistics/SCM staff, particularly regarding environmental management, would help an auto firm develop appropriate environmental criteria and guidelines, potentially facilitating green purchasing. External integration could also facilitate the implementation of green purchasing. This finding is different from the work of Bowen et al. (2001) but is consistent with the work of Carter and Carter (1998). Collaborative partnerships with suppliers are vital because they can help auto firms to engage in effective environmental cooperation and joint efforts on problem solving in purchasing activities (Simpson et al., 2007), which will bring mutual environmental benefits through the effective integration of inter- and intra-firm know-how and technologies (Zhu et al., 2010).

Concerning green manufacturing implementation, internal integration, SCM skills/knowledge, and supply chain flexibility capabilities are more important than other SCCs. A potential reason for this finding may be that green manufacturing entails appropriate pollution-prevention techniques and environmental management systems. As previous research has stated, making the right decisions on technology choices in the first place not only requires competent skills and knowledge but also depends on a collaborative mechanism among the internal functions involved (Klassen and Whybark, 1999; Vachon and Klassen, 2008). The active involvement of logistics/SCM functions may ease the introduction of new environmental technologies and systems for green manufacturing in the auto sector. For instance, one of our interviewed auto manufacturers had successfully upgraded to a more advanced painting technique that could significantly reduce paint utilization, waste generation, and energy consumption. With the skills/knowledge and active participation of the logistics personnel, the manufacturer was able to quickly identify the qualified producers and suppliers of paint, paint booths, oven systems, and so forth.

Surprisingly, supply chain flexibility is significantly and positively related to green manufacturing. This finding may appear to be counterintuitive, as flexibility is often associated with agility and rapid response to various changes and uncertainties (Yi et al., 2011). Rapid and frequent changes in production and delivery may generate waste and higher costs, and may affect the overall supply chain efficiency, thereby resulting in negative impacts on the environment. However, this finding provides further support for Klassen and Angell (1998), who argued that manufacturing flexibility may support broader initiatives aimed at improving the scope and depth of integration for environmental issues in manufacturing. For instance, according to our interviews, the adoption of platform and modularization technologies in car making has greatly improved manufacturing flexibility, which, in turn, could enhance production efficiency, unit costs, and environmental performance. Volkswagen gains efficiencies through synergies by adopting the 'Modular Toolkit Strategy' [1] in its production, which helps the company to achieve production flexibility and significant emissions reduction. Thus, in this respect, supply chain flexibility could contribute to the successful adoption of green manufacturing strategies, especially in the automotive industry.

5.2.The role of firm size

As revealed by the results, large firms are more likely to implement green supply chain strategies. Although not formally hypothesized, this finding is different from that of Zhu et al.
(2007), who found that firm size negatively correlated with environmental management in the Chinese automotive industry.

We hypothesized that firm size would positively moderate the relationship between SCCs and the implementation of green strategies. However, the findings are very different from what we originally expected. First, firm size positively moderates the association between supply chain flexibility and green design. A possible explanation may be that large auto firms are more actively pursuing green design strategies to address increasing stakeholder pressure and changes in customer demand; therefore, greater supply chain flexibility may be required to quickly introduce

[1] "Experience D[r]iversity"- Volkswagen Group – Factbook 2011

and offer more green products on the market. As such, the relationship between supply chain flexibility and green design is stronger in larger auto firms than in smaller ones.

However, the SCM skills/knowledge capability contributes less to the adoption of green design strategies in large auto firms. This finding is somewhat surprising. According to our post-survey interviews, large auto firms normally have well-established R&D departments that are responsible for new product development. Whilst cross-functional collaboration and the involvement of the logistics/SCM function in green design may provide many benefits, as previously shown (Handfield et al., 2001), the R&D departments' skills and capabilities play a more important role in the pursuit of a green design strategy, especially in the automotive industry. This may provide a potential explanation for why the SCM skills/knowledge – green design link becomes weaker in larger firms.

Moreover, firm size positively moderates the link between supplier appraisal capability and green purchasing. As discussed by Min and Galle (2001), large firms with significant purchasing volume are more heavily involved in green purchasing because large purchasing volumes could facilitate economies of scale, which increase the attractiveness and support of a green purchasing strategy. Additionally, because larger firms normally have greater bargaining power, they may be more willing to deploy their supplier appraisal capabilities towards green purchasing through, for example, the development of more rigid supplier selection and evaluation systems to mandate their suppliers' environmental commitment. Therefore, the positive relationship between supplier appraisal and green purchasing is amplified in larger auto firms.

It has also been discovered that supply chain flexibility best facilitates the implementation of green purchasing strategies in large firms. As previously discussed, large automakers normally have significant purchasing volumes and varieties, and often a large pool of suppliers, which may create more challenges in pursuing a green purchasing strategy. Supply chain flexibility, especially supply flexibility (Duclos et al. 2003), may be more critical in green purchasing implementation on such a large scale, as it can enable large firms to find alternative sourcing partners who can meet their purchasing standards more easily. In addition, since large auto organizations usually have a coercive power over suppliers, greater supply chain flexibility may ensure that suppliers can quickly adapt to the various environmental requirements imposed by the buying firms. These conditions may provide possible explanations for the amplified supply chain flexibility – green purchasing linkage in larger organizations.

Again, SCM skills/knowledge capability contributes less to the adoption of the green purchasing strategy in large auto firms. According to our post-survey interviews, because of their significant purchasing volumes and complexity in the auto sector, large organizations usually have a specialized procurement function (either situated within the logistics/SCM department or as a separate department) to perform the purchasing and supplier appraisal activities. Therefore, although the logistics and SCM skills/knowledge may contribute to the development of sophisticated supplier appraisal systems, their direct impact on green purchasing becomes less significant as purchasing and supplier appraisal becomes more specialized in larger firms.

Next, supplier appraisal capability best enables the implementation of green manufacturing strategies in large organizations. Because large auto firms actively pursue green manufacturing strategies, many environmental management programs and systems may require the support of their suppliers. Previous research has indicated that the environmental management capabilities (EMC) of suppliers could significantly impact the successful implementation of green operations in the buying firms (Wong et al., 2012). As such, large firms that have more purchasing power may be more likely to deploy their supplier appraisal capabilities to select and evaluate their suppliers who have a high level of EMC in order to facilitate the adoption of green manufacturing strategies. Therefore, the association between supplier appraisal and green manufacturing may thus become more significant in larger auto firms.

Interestingly, the logistics/SCM-related IT/IS provide less support for the implementation of a green manufacturing strategy in large auto firms. According to our post-survey interviews, a possible explanation is that large firms often adopt specialized environmental management IT systems to provide effective support for their green manufacturing objectives. For example, Ford launched the Global Emissions Manager database (GEM) in 2007 to facilitate environmental performance tracking. This industry-leading database provides a globally consistent approach for measuring and monitoring environmental data at each plant, which helps Ford to track and improve its efforts to reduce water consumption, energy use, CO_2 emissions and the amount of waste sent to the landfill. This might provide a possible explanation for the weakened association between the logistics/SCM-related IT/IS support and green manufacturing in large firms.

5.3.Theoretical implications

The outcome of this research adds to the academic understanding of the link between capability and strategy. In particular, the research offers useful insights into the specific role of logistics/SCM-related capabilities in the adoption of green strategies. As revealed by the survey results, significant positive associations exist between SCCs and three key elements of environmental management strategies, which imply that variations in the successful implementation among firms may be explained in light of the RBV theory.

More specifically, the empirical findings suggest that specific SCCs may be required for different green strategy adoption; in other words, SCCs may play dissimilar roles in the implementation of green strategies for sustained competitive outcomes. Therefore, this study provides a deeper understanding of the ‘fit’ between capabilities and strategies. Previous research has also produced conflicting results regarding the factors that influence successful environmental management (e.g., Bowen et al., 2001; Carter and Carter 1998). The findings of this study confirm which green strategies are most affected by internal integration and external integration, namely, green manufacturing and green purchasing, respectively.

In addition, the empirical research indicates that the strength of the relationships between specific SCCs and the implementation of green strategies is moderated by firm size. Large firms usually have more complex supply networks than smaller firms, and they also possess more specialized and distinctive capabilities. When large firms pursue green strategies, the associations between specific SCCs and different green strategies may be contingent upon their unique firm-level conditions. Consistent with the organizing approach (Newbert, 2007) in the RBV literature, the positive and negative moderating effects of firm size further confirm the important role of firm-level conditions (Lin and Ho, 2011) in the effective exploitation of resources/capabilities for competitive advantages.

This study's hypotheses, results and implications are summarized in Table VI below.

--Insert TABLE VI Approximately Here--

6. Conclusion

This study explores the specific role of SCCs in the implementation of green design, green purchasing and green manufacturing in the auto sector, and the extent to which this relationship is contingent upon firm size. The findings of the study may add to the academic understanding of the link between capability and strategy, and provide useful insights regarding the successful factors of environmental management related to the auto industry. In addition, this study further reveals the important role of firm-level conditions in the effective exploitation of capabilities for competitive advantages.

The findings also reveal that significant regional differences exist in the adoption of green strategies among automakers. This result might be because of the special industrial context, regulations, and national capability differences, which deserve further exploration since the regional differences are beyond the scope of this study. The differences were also significant between tier positions in the automotive supply chain, which may be because the OEM and Tier1 suppliers are closer to the end customers and the market, thus making them more aware of and responsible for their environmental impacts.

The findings of the study provide practical insights into understanding how auto companies can successfully adopt green strategies for better environmental performance and competitive advantages. The decision making in environmental management and adoption of green strategies is often a complex and challenging task (Alexander et al., 2014). All too often, firms make the mistake of focusing exclusively on the adoption of "best practices" without carefully considering whether they possess the relevant resources/capabilities for their successful adoption. For example, firms blindly pursue green purchasing without adequate supplier appraisal capability for effective coordination (e.g., weak communication infrastructure and lack of standards and monitoring mechanisms). Managers should consider whether the green strategies that they want to follow 'fit' with their existing resources/capabilities and develop and deploy appropriate SCCs for specific green strategy implementation.

In addition, because of the moderating effects of firm size identified in this research, in larger auto firms, more attention to the development of specific supply chain flexibility and supplier appraisal capabilities are suggested, as these two capabilities demonstrated stronger correlations with the implementation of green design, green purchasing and green manufacturing.

Our study has several limitations. First, the study was only conducted in the automotive industry, which may affect its generalizability beyond this sector. Second, firm size was only measured with the total number of employees, which could create a biased reflection of its effects on green strategy implementation. Last but not least, the cross-sectional design of the empirical study may affect the inference of causality. Future research should strive to address these limitations in order to derive more compelling and generalizable results. Interested researchers could also conduct the analysis in different industries and compare any differences that arise. Besides, further study might be conducted to explore the geographical and tier-positioned differences in green strategy implementation.

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Appendix: Measurement items, reliability, and validity test

Measurement items (Independent variables)		*Loading*
Liaison between SCM and other functions (α =.828, CR =.830, AVE=.619, MSV=.274)		
C1Q1	We can form close collaboration between supply chain/logistics department and other functions for business tasks.	.792
C1Q2	We have effective and efficient cross-functional teams with the involvement of SC/Logistics department.	.801
C1Q3	Among business functions, we have well-established common agenda, share concerns, and are committed to building trust.	.767
Sophisticated supplier appraisal mechanism (α =.865, CR =.866, AVE=.684, MSV=.399)		
C2Q1	We have well developed supplier selection and evaluation systems that enable us to find good suppliers.	.858
C2Q2	Our supplier selection and evaluation mechanism helps us to build long-term and strategic relationships with our suppliers.	.848
C2Q3	Our supplier auditing and assessment system ensures our suppliers meet our performance requirements.	.771
Collaboration and partnership with supply chain members (α =.879, CR =.886, AVE=.662, MSV=.399)		
C3Q1	We have built long-term strategic partnership with our suppliers/customers in the supply chain on a large scale.	.730
C3Q2	With supply chain partners, we share our knowledge and critical information; provide training and collaborative learning on a regular basis.	.785
C3Q3	With supply chain partners, we have joint-effort on problem solving, share rewards and risks.	.888
C3Q4	We have established trust, commitment, shared values and a common vision with our supply chain partners.	.842
Skills/knowledge of SCM personnel (α =.848, CR =.849, AVE=.585, MSV=.341)		
C4Q1	Our SCM staff demonstrates high level of 'technology management skills/knowledge ' in terms of abilities to learn new technologies/knowledge, focus on technology as a means not an end, and understand new technological trends, etc.	.745
C4Q2	Our SCM staff demonstrates high level of 'business functional skills/knowledge' in terms of abilities to perform SCM tasks, interpret business problems & develop appropriate solutions.	.785
C4Q3	Our SCM staff demonstrates high level of 'interpersonal skills/knowledge' in terms of abilities to form good work relationships, work in a collaborative environment, work closely and maintain productive relationships with suppliers and customers, etc.	.728
C4Q4	Our SCM staff demonstrates high level of 'technical skills/knowledge' in terms of abilities to perform data management, use IT/IS, system analysis, processing and programming, etc.	.798
Supply chain flexibility (α =.832, CR =.833, AVE=.625, MSV=.341)		
C5Q1	We have the ability to efficiently and cost effectively handle emerging customer trends/demands in terms of product changes (volume, mix), customer location changes, globalization, and postponement.	.740
C5Q2	We have the ability to reconfigure our supply chain, find alternative sourcing partners in line with customer demand.	.796
C5Q3	We have the ability to align labor force skills to the needs of supply chain to meet customer service/demand requirements.	.832
Reliable and effective IT/IS Support (α =.905, CR =.905, AVE=.761, MSV=.268)		
C6Q1	Our IT/IS is well integrated with our SCM process, which can provide timely, reliable and effective support for our daily operations and satisfy customer demands.	.848
C6Q2	Our IT/IS is compatible with our supply chain partner's IT/IS, whereby information is readily, continuously and rapidly useable, accessible and shared across the entire supply chain.	.908
C6Q3	With our IT/IS support, we are able to enhance our collaborations with our supply chain partners in terms of knowledge sharing, problem solving and cooperative learning.	.860

Measurement items (Dependent variables)		
Green design (α =.859, CR =.862, AVE=.610, MSV=.375)		
GD1	Design of products for reduced consumption of material/energy	.798
GD2	Design of products for reuse, recycle, recovery of material, component parts	.735
GD3	Design of products to avoid or reduce use of hazardous of products and/or their manufacturing process	.831
GD4	Design of products for longevity and durability	.757
Green purchasing (α =.871, CR =.871, AVE=.628, MSV=.487)		
GP1¤	Providing design specification to suppliers that include environmental requirements for purchased items	

GP2	Cooperation with suppliers for environmental objectives	.856
GP3	Environmental audit for suppliers' inner management	.767
GP4	Suppliers' ISO14000 series certification	.768
GP5	Second-tier supplier environmentally friendly practice evaluation	.778
Green manufacturing (internal operations) (α =.886, CR =.879, AVE=.646, MSV=.375)		
GM1[¤]	Cross-functional cooperation for environmental improvements	
GM2	Total quality environmental management	.739
GM3	Environmental compliance and auditing programs	.898
GM4	ISO14000 series certification	.758
GM5	Environmental management systems exist	.814

[¤] Item was dropped in CFA