Title: The moderating role of learning by doing for sustainability performance

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Main subject text:

Motivation:

Recently, there are many researchers are trying to explore the relationship between sustainability collaboration and environmental performance. Meanwhile, from the industry investigation, Learn by doing (LLD) plays a quite important role in helping companies to achieve the sustainability performance. Learning by doing means employees keep on innovating in practice in order to improve the performance of firms. However, we have very limited knowledge about the moderating role of LLD in the relationship between sustainability collaboration and environmental performance. The purpose of this study is to propose a model to analyze the moderating role of LLD in the relationship between sustainability collaboration, including supplier-side sustainability collaboration (SSC) and demand-side sustainability collaboration (DSC), and environmental performance. At the same time, annual sales and employee number are considered as control variables in this relationship.

Problem:

The problem we are trying to solve is that test the moderating role of LLD in the relationship between sustainability collaboration and environmental performance. We investigated firms about supply chain management across United of America. After that, a analytical model is defined to construct a relationship between sustainability collaboration and environmental performance.

Approach:

The main method we apply is structural equation modeling. We measured reliability via Cronbach'α. In the meantime, convergent validity was tested through factor loading and average variance extracted (AVE). Then, we tested discriminant validity by comparing the inter-construct correlations and the square roots of AVEs. In order to test the moderating role of learning by doing, we applied hierarchical regression analysis by using SPSS 22.0.

Results:

First, we measured reliability via Cronbach'α. A widely suggested threshold for Cronbach'α is 0.70. We test four variables include supply-side sustainability collaboration (SSC), Demand-side sustainability collaboration (DSC), learning by doing and environmental performance. All Cronbach'α of four variables were higher than 0.70, which means that our survey data is good enough to support this research. In the meantime, convergent validity was tested through factor loading and average variance extracted (AVE). We could find that loadings ranged from 0.736 to 0.945, which were significantly higher than suggested threshold of 0.60. Besides, AVE varied from 0.593 to 0.850, naturally, they were above recommended value (0.50). As a result, we could assert that variances were caused by the indicators not measurement errors.

Last but not least, we tested discriminant validity by comparing the inter-construct correlations and the square roots of AVEs. If the square roots of AVE are higher than correlations in every factor, we believed that the discriminant validity of measurements is appropriate. All the square roots of AVEs is biggest, compared with correlations in every factor. Therefore, the discriminant validity of measurements we selected is acceptable.

In order to test the moderating role of learning by doing, we applied hierarchical regression analysis by using SPSS 22.0. At first, for the purpose of testing the interaction effect and reducing multicollinearity, we deal with variables by standardizing them. Then we test the correlation between control variables and dependent variables in model 1. Control variables (annual sales and employee number) have no effect on environmental performance at a significant level. Then we added independent variables and interactions to model 1, and interactions are also considered as independent variables in hierarchical regression analysis. Model 2 includes control variables, independent variables and dependent variables. Model 3 is a full model, which is consist of model 2 and interactions. According to the model 2 and model 3, SSC affected environmental performance was a significant level (β=0.277, $p<0.01$). At the same time, DSC also has positive effect on environmental performance (β=0.050, $p<0.01$). Simultaneously, the results in model 3 imply **LLD significantly moderated the relationship between DSC and environmental performance (β=0.231, $p<0.01$), while LLD has no moderating effect between SSC and environmental performance (p is not significant).**

Conclusions:

This research provides new knowledge among SSC, DSC, LLD and environmental performance by testing the moderating role of LLD in the model. This results empirically demonstrate the theoretical positive relationship between SSC and environmental performance as well as DSC and environmental performance. It reveals that firms especially demand-side collaboration should develop the ability of LLD in order to better to fit for future competition in sustainability collaboration with customers. Meanwhile , it shows that LLD has no moderating effect between SSC and environmental performance.

However, our study is still with limitations. At first, the data in our study collected with American firms. As we all know, the performance of firms are deeply impacted by different cultures.

Thus, the research based on America might not consistent with other cultures. In particular, the attitude on encouraging employees to innovate in practice is not same between western and eastern countries. Secondly, our study only focuses on environmental performance not overall sustainability performance of the firm. Therefore, we have limitations with respect to performance implications. But we will overcome this limitation with more objective data in future study. Though we have these limitations, we confirm that we have contributions on demonstrating the moderating role of LLD in supply chains, which will guide firms to perform better in the future.

1. Introduction

The growing demand for sustainable development in business management has prompted companies to re-examine the concept of value and profit. Primarily, two critical factors challenge industry networks: complying with social standards and achieving ecological targets or environmental performance. (Brandenburg, 2018). In 1987, the World Commission on Environment and Development proposed a general definition of sustainable development. It considers both the possibility of sustainable development for future generations and the needs of the present generation. Sustainable development requires paying attention to the decision-making process and raising awareness of issues of collective importance (Golinelli and Volpe, 2012). The vision of sustainability assigns responsibilities to businesses and integrates embedded environmental and social goals with corporate activities. Therefore, the accepted definition of sustainable development requires extensive consideration of different and frequently contradictory interests.

Early research on supply chain sustainable collaboration mainly focuses on suppliers (Sarkis, 1999), but it is necessary to extend the research to the entire supply chain (Klassen and Vachon, 2003). Therefore, the authors took demand-side (customer) and supplier-side (supplier) cooperation into account and tested the effects of the two sides on firm performance through empirical research (Bendoly and Cotteleer, 2008; Devaraj, 2007;) as well as a focus on sustainability. The growing collaborative approach in sustainable collaboration along the entire supply chain is also reflected in empirical study(Gimenez and Tachizawa, 2012).

The increasing attention on sustainable supply chain management has led to wide sustainable practice in the industry (Linton, Klassen, and Jayaraman, 2007). Firms need to tackle the increasing demand for sustainability from the upstream and downstream of the supply chain, which also leads to cooperation between firms and their suppliers and customers (Vachon and Klassen, 2006).This promotes the relationship and joint activities between firms and supply chain stakeholders thus enables firms to develop strategies to improve the efficiency of the entire supply chain, as well as to meet organizational and environmental goals. Through such improvements, firms can change customers' views and influence their market position by improving performance. Finally, improved customer perception and the consequent customer satisfaction are regarded as means to improve profitability and generate competitive advantage (Anderson, Fornell, and Lehmann, 1994).

Although industry pioneers suggest that firms must simultaneously target the sustainable development practices of demand- and supply-side to benefit from the continuous enhancement of sustainable collaboration and strategic performance, as far as we know, there is no academic research to explore the matching mechanisms of demand- and supply-side sustainable collaboration and ultimately link it to sustainability performance and environmental performance. This phenomenon is notable as companies, especially in the field of sustainability, may be strongly influenced by their surrounding networks (Chen and Paulraj, 2004). Meanwhile, from the industry investigation, learning by doing (LBD) plays an important role in helping companies to achieve sustainable performance. LBD means employees keep innovating in practice to improve the firm's performance. However, we do not have sufficient knowledge about the moderating role of LBD in the relationship between sustainability collaboration and environmental performance.

Given that, the purpose of this study is to propose a model to analyze the moderating role of LBD in the relationship between sustainability collaboration, including supplier-side sustainability collaboration (SSC), demand-side sustainability collaboration (DSC), and environmental performance. At the same time, annual sales and employee numbers are considered as control variables in this relationship.

We will ground our hypothesis in the knowledge-based view (KBV) and the relational view (RV), as firms may benefit from both sides of the supply chain through a higher and balanced level of collaboration. This results in synergistic relationships regarding sustainability performance and environmental performance. We will view sustainability performance as an improvement in resource consumption from an environmental perspective.

2. Literature review

2.1 Sustainability

People have paid more attention to sustainability in recent years. In business, sustainability is necessary for a company's long-term profitability and competitiveness (Carter and Rogers, 2008). This concept comes from internal and external pressures, such as legislative factors and the actions and pressures of various stakeholders (Winter and Konamier, 2013). Sustainability is challenging because it requires not only economic considerations but also social and environmental considerations that an organization's actions should follow. Therefore, global organizations recognize susatinability as a strategic goal (Closs et al., 2011; Siegel, 2009).

From the view of sustainable development, the relationship with stakeholder theory emerged because it is an important basis for the study of sustainable development (Ehrgott et al., 2011). According to stakeholder theory, stakeholders are those who "can affect the achievement of an organization's objectives or who is affected by the achievement of an organization's objectives" (Freeman and Reed, 1983, p. 91). There are many stakeholders in the supply chain, including customers, logistics providers, manufacturers, distributors, retailers and suppliers etc., all of them have a close relationship with internal and external departments of the organizations (Searcy, 2012). They play a fundamental role in an organization's long-term prosperity and survival. At the same time, they are required to exceed the company's financial performance (Freeman, 2010) to comply with social standards and to achieve ecological targets and environmental performance. Therefore, “organizations should not only fulfil the wants and expectations of their stakeholders, but also avoid actions that reduce the ability of the interested parties, including the future generations, to meet their needs” (Garvare and Johansson, 2010, p.741).

Sustainable development is a multidimensional structure that requires effective use of resources to realize a return on investment by adding social considerations and promoting environmental responsibility (Elkington, 1997). Given the fact that each firm is part of a broader network and is not an isolated island in today's business world (Ford et al., 2003), the need to go beyond corporate boundaries becomes important. Recently, the way to gain competitive advantage has modified the competitive structure, so competition among firms has turned into competition within supply chains (Hult et al., 2007; Christopher, 2005).Accordingly, the supply chain plays an essential role in promoting sustainability (Linton et al., 2007). In today's interconnected supply chain world, the greatest challenge for individual producers is to ensure sustainable penetration in multi-level supply chains and to develop strategies to improve environmental and social performance along the entire supply chain.

2.2 Sustainable Supply Chain Collaboration

Academic studies show that the relationship between sustainable development-oriented customers and suppliers can have profoundly effect supply chain performance (Rao and Holt, 2005). The synergies of sustainable development combine sustainable practices along both the demand- and supply-side of the supply chain (Vachon, 2007). Sustainability cooperation requires an organization’s direct involvement in planning and implementing environmental solutions with its suppliers and customers (Sarkis, 2003). This also means that firms invest their resources to commit themselves to resolving suppliers’ and customers’ sustainability goals (Paulraj, 2011). Most importantly, environmental cooperation clearly demonstrates that both sides can better understand their responsibilities and capabilities in environmental performance management (Vachon and Klassen, 2008). Therefore, environmental cooperation rarely pays attention to the short-term efficacy of environmental protection work but pays more attention to environment-friendly product design and production processes (Vachon and Klassen,2008).Past studies have investigated the impact of environmental cooperation on some outcome variables. As for the impacts on performance, research has found that environmental cooperation has a positive impact on costs, operations, manufacturing and environmental performance (Hollos et al., 2012).

To achieve excellent sustainable and environmental performance, companies must utilize the precious, rare, difficult-to-imitate, and difficult-to-replace resources that may come from joint development of sustainable products and processes in the supply chain. Especially in an increasing number of markets, customers expect companies to show excellent performance in sustainability, which requires more active rather than reactive technologies. This development is more complicated and needs cooperation along the whole supply chain. The closer an enterprise is to the ideal cooperation model, the quicker it can integrate dynamic market conditions than its competitors, and ultimately gain competitive advantage by improving sustainable and environmental performance (Smythe and Wright, 2004). Das et al. (2006) show that deviations from an ideal profile are often associated with performance degradation, indicating that higher levels of integration are desirable. Along similar lines, the impact on performance may vary depending on the relative gap between the supply chain collaboration profile and the ideal collaboration profile. This is demonstrated by the findings of Frohlich and Westbrook (2001), who showed that the greatest performance benefit is generated if the firm pursues supply chain collaborations on both the demand- and supply- side. With this belief, we expect that as deviation from the ideal profile of sustainable development increases, performance will deteriorate. This expectation is based on previous findings which strongly support the fact that high levels of sustainability cooperation will improve performance. Therefore, we assume the following:

H1a. The less similar the sustainability cooperation profile of a firm is to the ideal profile of sustainability cooperation, the lower its sustainability performance.

H1b. The less similar the supply chain cooperation profile of a firm is to the ideal profile of supply chain cooperation, the lower its environmental performance.

2.3 Inter-organizational learning along the supply chain

Knowledge plays a vital role as an intangible resource; Grant (1996) provides a suitable approach to the Knowledge-Based View (KBV). He emphasizes the importance of knowledge exchange in the process of pursuing a sustainability practice through the supply chain. The process is social, complex and differently distributed in the supply chain, therefore, the process is difficult to imitate (Vachon, 2007). Sustainability cooperation needs specific resources to ensure cooperative activities. These cooperative actions are often based on a high-level knowledge exchange to achieve sustainable products and production processes (Vachon and Klassen, 2006). Through close sustainable cooperation, firms, especially those who can share and transfer tacit knowledge are an essential factor in strengthening cooperation and creating competitive advantage (Reuter et al., 2010). In addition, companies may better understand the complementarity of their resources and combine them in a mutually beneficial way. In the context of sustainable development and environmental performance, performance effects can be expected because a company's sustainable development and environment performance are influenced by its surrounding networks (Chen and Paulraj, 2004), especially by their suppliers and customers. In particular, advanced sustainable development practices such as product management require high levels of tacit knowledge, as products and processes need to be consistent in practices that cannot easily be replicated (Vachon, 2007). These advanced practices have also proven to lead to higher levels of sustainability performance than basic sustainability practices (Klassen and Whybark, 1999). Therefore, we conclude that firms which do not use the full knowledge potential of their supply chain might not achieve higher levels of performance (Dyer and Singh, 1998).

From another angle, because cooperation is based on the trust, it can be argued that companies that do not pursue ideal partnerships may find lower investments in such relationships, thereby reducing the level of relationship-based benefit, which may lead to higher levels of sustainable and environmental performance. In fact, scholars have explained that the main benefits of supply chain collaboration come from knowledge exchange and inter-organizational learning by doing (Hult et al. 2004). Given its ability to integrate complementary resources and capabilities, the integration, transmission and creation of knowledge in the entire supply chain can create greater competitive advantages than what could be achieved by a single firm. Dyer and Singh (1998) also emphasize the importance of demand- and supply-side knowledge sharing to enhance a company's resources, to bridge the relational perspective and KBV, which recognizes the importance of knowledge complementarity. When knowledge transfer includes cooperation between multiple partners at the two ends of the supply chain, it will generate higher profits.

In the context of sustainable cooperation between the upstream and downstream of the supply chain, knowledge-sharing and other relational resources play an essential role. For example, if downstream businesses need to decompose products due to environmental regulations, they may benefit from the knowledge and expertise of materials, components and products produced in the upstream of the supply chain. Therefore, relational resources not only enhance the company's specific cooperation profile, making it achieve the ideal cooperation profile, but also enable the company to have sustainable production capacity, and ultimately improving sustainability and environmental performance, which will guide the development of our research model.

A company's KBV shows that knowledge may be the foundation of competition and is the company’s most important strategic resource (Grant, 1996). Learning is the process of accumulating knowledge and understanding the potential benefits of knowledge from individuals, groups and organizations (Nonaka, 1994). At the company level, organizational learning is a process of acquiring, disseminating, interpreting, using and storing information that can lead to new knowledge or insights that influence organizational strategy (Mohr and Sengupta, 2002). An important study of organizational learning involves inter-organizational learning along the supply chain (Spekman et al., 2002). Inter-organizational learning is an ideal extension of organizational learning; it enlarges the company's knowledge base and provides new insights and market strategies which is called “supply chain learning” (Flint et al., 2008).

Supply chain learning is the practice in which “firms look both up and down their supply chains to manage and monitor learning processes within and outside of the firm”. The content of learning can be divided into two types: information and know-how (Kogut and Zander, 1992; Grant 1996; Dyer and Singer, 1998). Information is knowledge that can be transmitted “without loss of integrity once the syntactical rules required for deciphering it are known. Information includes facts, axiomatic propositions, and symbols” (Kogut and Zander, 1992, p. 386). In comparison, the knowledge involved in know-how is tacit， complex and difficult to be defined (Kogut and Zander, 1992). The core concept in supply chain learning is to allow learners to think in cross-border ways, both functionally and organizationally. In practice, this is accomplished through three processes. First, *knowledge generation* involves recognizing innovation or market variables that can significantly affect effectiveness as well as current and future organizational business relationships. Second, *knowledge transfer* is driven by sharing the applicable innovation or market information and know-how through the entire supply chain. Third, *knowledge application* involves integrating new products, market information and know-how by changing management behaviors and processes to strengthen effectiveness (Esper et al., 2009).

The assumption behind sustainability collaboration is that customer value is created by the focal company's demand and supply areas. Information sharing is a vital organizational process within sustainability collaboration. It refers to sharing technology, marketing, production and inventory information between key suppliers and key customers (Liu et al., 2010). Supply chain learning will use this information to further develop contextual beliefs and subsequent strategic commitments (Esper et al., 2009). Communication is the heart of knowledge transfer (Mohr and Spekman, 1994), which is influenced by the frequency, depth, and content of communication (Spekman et al., 2002). Sustainability collaboration brings supply chain partners close to each other for improved communication, thus promoting frequent and in-depth cross-border communication and leading to a high-level knowledge transfer.

Supply chain learning promotes the ability to satisfy current customers (Wijk et al., 2008). In practice, it involves on-time delivery, reducing shipping errors, and reducing product losses (Manuj et al., 2013). By changing their attitudes and behaviors based on lessons learned, managers and employees from the focal companies can discover opportunities from these cross-border interactions (Flint et al., 2008) and ultimately enable the company to have sustainable production capacity and improve sustainable and environmental performance. Therefore, we assume that:

H2. Supply chain LBD moderates the relationship between supply chain collaboration (supply- and demand-side) and environmental performance.

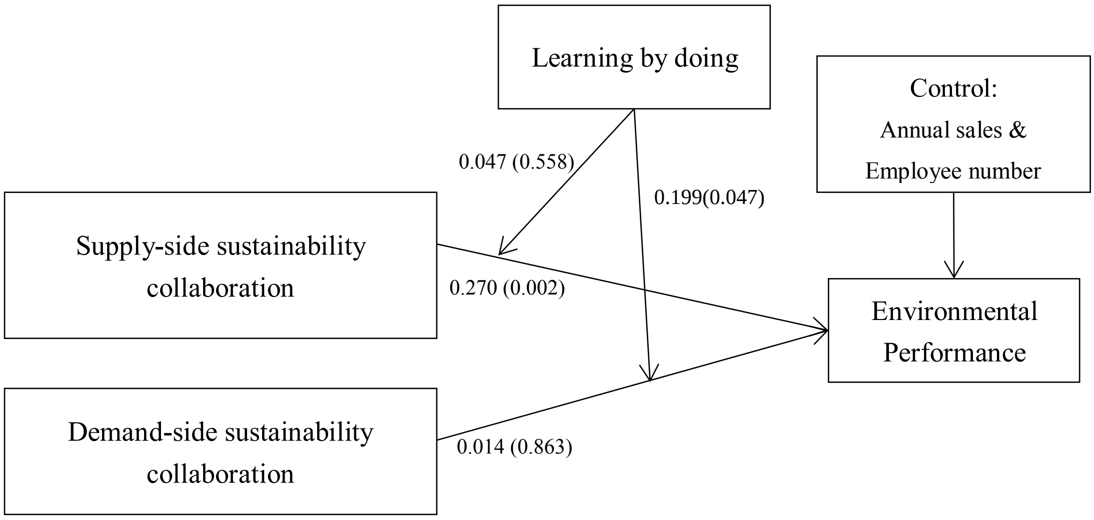

Figure 1. Research model

3. Measures

Supply-side sustainability collaboration measures the extent to which firms cooperate with suppliers to achieve environmental objectives. It also provides the supplier with materials, equipment, specifications and services to provide their suppliers with materials, equipment, specifications, and services to support their environmental goals. Demand-side sustainability collaboration reflects the extent to which firms collaborate with their customers on the collective achievements of sustainability. We used these two variables, supply-side sustainability collaboration and demand-side sustainability collaboration, as our independent variables.

LBD measures the extent to which firms encourage employees to innovate at work, cooperate with different departments, take part in decision-making that relates to them, and improve performance based on past experiences. Environmental performance is used to measure improvements in air, waste, consumption of hazardous/harmful/toxic materials, frequency of environmental accidents, energy saved and use of natural resources. LBD is a moderating factor in our research model; environmental performance is the dependent variable, and annual sales and employee number are used as control variables. Annual sales represent the firms’ location and industry. Employee numbers reflect the size of firms in a way.

Variables	Items	Factor loading	Cronbach'α	AVE	CR
Supply-side sustainability collaboration	We cooperate with our suppliers to achieve sustainability objectives.	0.899	0.960	0.834	0.968
	We provide our suppliers with sustainability-related requirements for their processes	0.930			
	We collaborate with our suppliers to provide products and services that support our sustainability goals.	0.921			
	We develop a mutual understanding of responsibilities regarding sustainability performance with our suppliers.	0.945			
	We conduct joint planning to anticipate and resolve sustainability-related problems with our suppliers.	0.870			
	We periodically provide suppliers with feedback about their sustainability performance.	0.912			
Demand-side sustainability collaboration	We cooperate with our customers to achieve sustainability objectives.	0.913	0.956	0.850	0.966
	We cooperate with our customers to improve their sustainability initiatives.	0.924			
	We collaborate with our customers to provide products and services that support our sustainability goals.	0.930			
	We develop a mutual understanding of responsibilities regarding sustainability performance with our customers.	0.934			
	We conduct joint planning to anticipate and resolve sustainability-related problems with our customers.	0.907			
Learning by doing	We encourage employees to try new methods at work.	0.763	0.779	0.593	0.853
	We encourage employees to cooperate across different departments.	0.736			
	We encourage employees to take part in decision-making that influences their personal profit.	0.828			
	We encourage employees to conduct activities repeatedly and adapt from past experiences.	0.751			
Environmental Performance	Reduction in air pollution.	0.847	0.928	0.735	0.943
	Reduction in waste (water and/or solid).	0.890			
	Decrease in consumption of hazardous/harmful/toxic materials.	0.865			
	Decrease in frequency of environmental accidents.	0.789			
	Increase in energy saved due to conservation and efficiency improvements.	0.858			

	Decrease in use of natural resources.	0.888			

Table 1. Results of confirmatory factor analysis

3.1. Measure validation

Based on past studies, we test reliability and validity at the beginning of the research. We measured reliability via Cronbach's α. A widely suggested threshold for Cronbach's α is 0.70. As Table 1 shows, we test four variables: supply-side sustainability collaboration, demand-side sustainability collaboration, learning by doing, and environmental performance. Cronbach's α for the four variables were higher than 0.70, which means our survey data is good enough to support this research. In the meantime, we tested convergent validity through factor loading and average variance extracted (AVE). We found that loadings ranged from 0.736 to 0.945, which were significantly higher than the suggested threshold of 0.60. AVE varied from 0.593 to 0.850; naturally, they were above the recommended value (0.50). As a result, we could assert that variances were caused by the indicators, not measurement errors.

Finally, we test discriminant validity by comparing the inter-construct correlations and the square roots of AVEs. If the square roots of AVEs are higher than correlations in every factor, we believe that the discriminant validity of measurements is appropriate. As can be seen from Table 2, all the square roots of AVEs are higher, compared with correlations in every factor. Therefore, the discriminant validity of measurements we selected is acceptable.

Table 2. Assessment of discriminant validity

	Mean	SD	1	2	3	4
Supplier collaboration 1	2.893	0.992	**0.913**			
Customer collaboration 2	3.347	0.915	0.627**	**0.922**		
Learning by doing 3	3.758	0.731	0.173**	0.205**	**0.770**	
Environmental performance 4	3.406	0.561	0.329**	0.247**	0.173**	**0.857**
The diagonal elements are the square roots of AVEs						

4.Results

To test the moderating role of LBD, we apply hierarchical regression analysis by using SPSS 22.0 (Muller et al., 2005). First, to test the interaction effect and reduce multicollinearity, we deal with variables by standardizing them. Then we test the correlation between control variables and dependent variables (Model 1). As can be seen in Model 1 of Table 3, control variables (annual sales and employee number) have no effect on environmental performance at a significant level. Then we add independent variables and interactions to Model 1; interactions are also considered as independent variables in hierarchical regression analysis. Model 2 includes control variables, independent variables and dependent variables. Model 3 is a full model, which consists of Model 2 and interactions. According to Model 2 and Model 3, supply-side sustainability collaboration affects environmental performance at a significant level (β=0.277, p<0.01). At the same time, demand-side sustainability collaboration has a positive effect on environmental performance (β=0.050, p<0.01). The results in Model 3 imply that LBD significantly moderates the relationship between demand-side sustainability collaboration and environmental performance (β=0.231, p<0.01), while LBD has no moderating effect between supply-side sustainability collaboration and environmental performance (p is not significant).

Table 3. Results for hierarchical regression analysis

Predictor variables	Environmental Performance		
Control variables	Model 1	Model 2	Model 3
Annual sales(sales)	0.023	-0.030	-0.041
Employee number (employee)	0.044	0.033	0.060
Main effects			
Supply-side sustainability collaboration(SSC)		0.277***	0.257***
Demand-side sustainability collaboration (DSC)		0.050***	0.020***
Learning by doing (LBD)		0.121	0.188
Interactions			
SSC×LBD			0.043
CC×LBD			0.231***
R^2	0.003	0.125	0.187
Adjusted R^2	-0.006	0.105	0.161
F change	0.323	10.343***	8.411***
***p < 0.01; **p < 0.05; *p < 0.10.			

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