Investigating Green Supply Chain Management Practices and Performance: The Moderating Roles of Supply Chain Ecocentricity and Traceability

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Abstract:

Purpose: Sustainable supply chain management has become an increasingly important driver of business performance. Understanding the contingent nature of how performance is improved in this context is, therefore, a critical task for management. We explore the moderating effects of two practices unique to sustainable supply chain - ecocentricity and supply chain traceability - on a firm's environmental and operating cost performance.

Design: Survey data were collected from 248 UK manufacturing firms and analyzed using moderated hierarchical regression.

Findings: The results suggest that green supply chain management practices (GSCM) are associated with improvements in both environmental and operating cost performance. Further, higher levels of ecocentricity and supply chain traceability are associated with stronger relationships between green supply chain management practices and cost performance. Contrary to expectations, high levels of supply chain traceability were found to negatively moderate the relationship between green supply chain management practices and environmental performance.

Limitations: Our research design was survey-based and cross-sectional. Future studies would benefit from longitudinal research designs that capture the effects of GSCM practices on performance over an extended period. Our survey data is also perceptual; using secondary data to capture environmental performance outcomes, for example, would be another opportunity for future research. Finally, the ecocentricity and supply chain traceability scales are newly developed and more work needs to be done to validate these scales.

Practical Implications: We provide additional support to findings that green supply chain management practices benefit both environmental and cost performance dimensions. In this context, we show that investments by firms in working with a broader set of eco-system partners (ecocentricity) and building supply chain traceability influences the effects of GSCM practices on performance. We encourage managers to carefully consider how they conceptualize and monitor their supply chains.

Originality: This paper offers several contributions to the research in this area. First, we develop and validate a measurement scale for ecocentricity and supply chain traceability. Second, we show how these two variables – unique to sustainable supply chains – can positively influence cost and environmental performance.

1. Introduction

Firms have increasingly adopted practices aimed at addressing environmental issues in their supply chains. The preponderance of extant literature suggests that the implementation of green supply chain management practices (GSCM) has a positive effect on both environmental performance (e.g. Geng, Mansouri and Aktas, 2017; Sadia, Kaur, Ersoz, Lotero and Gerhard-Wilhelm, 2019) and operating cost performance (e.g. Schmidt, Foerstl and Schaltenbrand, 2017). Other studies suggest managers face significant challenges to realizing fully the benefits of GSCM practices (Kirchoff, Omar and Fugate, 2016), perhaps resulting from a host of possible barriers to their implementation (Goyal and Kumar, 2017). In this vein, our research seeks to understand why performance outcomes might vary across different implementations of GSCM practices and is directly motivated by calls for research to explore the broader moderating effects on GSCM implementation (Montabon, Pagell and Wu, 2016; Pagell and Shevchenko, 2014; Touboulic and Walker, 2015) and performance outcomes. Most broadly, our research seeks to examine this central focal GSCM/performance relationship in the context of predicted moderators, which is an approach that is critically important to developing stronger and more robust GSCM theory (Fawcett and Waller, 2011; Goldsby and Autry, 2011; Maloni and Carter, 2006; Markman and Krause, 2016).

Our paper focuses on two moderators unique to a sustainable supply chain management context - namely ecocentricity and supply chain traceability – each of which has been theorized to be a key moderator that influences the effectiveness of GSCM practices (Pagell and Wu, 2009). We conceptualize ecocentricity as the firm’s proclivity to engage and learn from external stakeholders to achieve sustainability goals. Various scholars, and in particular Pagell and Wu (2009), have argued that the notion of ecocentricity is under-developed and lacks empirical measurement (Gold, Hahn and Seuring, 2013; Paulraj, 2011; Wu and Pagell, 2011). In order to address these concerns, we developed a measurement scale for ecocentricity. Supply chain traceability assesses the level of knowledge of the firm with regard to the location and processes of their products from its original source to its end customer (Dabbene, Gay and Tortia, 2014; Skilton and Robinson, 2009; Wowak, Craighead and Ketchen, 2016). Whilst widely used in practice, traceability as pointed out by Hoejmose et al. (2012), has received relatively little empirical attention. In order to address these concerns, we also develop and validate a measurement scale for supply chain traceability.

Intuitively, supply chain ecocentricity and traceability are likely to play a contingent role on the relationship between GSCM practices and a firm's cost and environmental performance. Consider that much of a firm's ability to attain its corporate sustainability standards (CSS) resides outside of its direct organizational control, often within the multiple tiers of its upstream suppliers (Grimm, Hofstetter and Sarkis, 2016). Often under-estimated however is the important role played by non-traditional supply chain actors, like industry associations and NGOs who hold valuable knowledge and expertise to address environmental performance. Similarly, the ability to track materials from the point of origin to the point of consumption underpins firm abilities to identify and address specific areas of environmental risk within its supply chains. Indeed, the reputational risks arising from a lack of supply chain traceability may be substantial (Hajmohammad and Vachon, 2015; Hartmann and Moeller, 2014; Roehrich, Grosvold and Hoejmose, 2014; Wright, 2016). In sum, an interesting question remains – *in the presence of supply chain traceability and ecocentricity, does the relationship between GSCM practices and performance (environmental and cost) improve (or worsen)?*

We conducted an empirical study that employed a survey of 248 manufacturing firms who operate in the United Kingdom. In doing so, we make several contributions to the literature. First, we develop and validate empirical scales for supply chain ecocentricity and traceability. Second, we examine how GSCM practices are associated with environmental and operating cost performance. Most importantly, we examine the GSCM practices-performance link to understand the importance supply chain traceability and ecocentricity as moderators of the relationship between GSCM practices and both cost and environmental performance.

The remainder of our paper is structured as follows. First, we review the literature to develop the foundation of our theoretical model, with a specific focus on the hypotheses among green supply chain management practices, environmental and cost performance, and the moderating roles of ecocentricity and supply chain traceability. Our research method, data analyses, and results are then overviewed. Finally, we discuss our results and conclude with both theoretical and managerial implications.

2. Literature Review and Hypotheses Development

2.1 Theoretical background: The Natural Resource-Based View (NRBV)

The Natural Resource-Based View (NRBV), proposed by Hart (1995), grew out of the earlier developments of the Resource-Based View (RBV) of the firm (Barney, 1991; Penrose, 1959). The RBV provides a theoretical framework to explain how a firm may mobilise its valuable, rare and inimitable resources to achieve sustainable competitive advantage (Barney, 1986; Wernerfelt, 1984). Indeed, it is the inimitable nature of a firm's strategic resources that protects the firm against its competition. Hart (1995: 956), however, argues that RBV theory places an over-reliance on internal resources and does not adequately consider the role of the natural environment. Firms should not only consider the resources at their disposal, but also how those resources 'fit' with the external 'natural' environment. Hart (1995) maintains that it is this 'fit' that can bridge the internal and external deficiencies within RBV theory, and thus proposes NRBV to better understand this fit between an organisation and its natural environment.

Specifically, NRBV highlights that sustainability practices are resources that competitors cannot easily imitate or acquire because of institutional or capability constraints and thus may be considered “strategic resources” from an RBV perspective (Hart and Dowell, 2011). The NRBV accordingly calls for a focus on the natural environment, arguing that firms are constrained not just by their internal resources, but also by the availability and cost of external environmental resources.

Three inter-related environmental strategies are proposed by NRBV: ‘pollution prevention’ (minimizing environmental damage and degradation such as emissions reduction, packaging reduction and so on), ‘product stewardship’ (minimizing life-cycle costs of products through, for example, product modification or redesign), and finally, ‘sustainable development’ (minimizing the environmental burden of the firm on the natural environment (the latter was relabelled as ‘clean technologies’ by Hart and Ahuja (1996)). These three ‘natural environment’ strategies, within the confines of RBV, could prove to be a source of sustainable competitive advantage. Importantly, green supply chain management practices may be considered key to carrying out these three natural environment strategies.

2.2 Green supply chain management practices and performance

Carter and Rogers (2008: 368) define GSCM as the “*strategic, transparent integration and achievement of an organisation’s social environment, and economic goals in the systematic coordination of key inter-organisational business processes for improving the long-term economic performance of the individual company and its supply chains.*” Building on this definition, we follow Tachizawa et al. (2015) who further contends that GSCM as a conceptual approach should be differentiated from the *practices* of GSCM. We focus our attention on GSCM practices specifically, which include organizational core tactics such as internal environmental management, green purchasing, supplier selection, and investment recovery.

Insert Figure 1 About Here

The positive association between GSCM practices and improved environmental (Geng, et al., 2017; Rao and Holt, 2005; Russo and Fouts, 1997; Sadia, et al., 2019; Zhu, Sarkis and Geng, 2005) and cost performance (Geng, et al., 2017; Pullman, Maloni and Carter, 2009; Zhu, et al., 2005) is well established. The principal objective in this research was thus to examine the contingencies that affect these relationships. Nonetheless, we present the GSCM practices-environmental and -cost performance links as baseline hypotheses for the purpose of statistical testing (e.g., Kim, Hur and Schoenherr (2015)), and for further empirical support of these important relationships.

These hypotheses are grounded in NRBV, which has a particular focus on achieving competitive advantage within the constraints of the natural environment (e.g., Bals and Tate, 2018) by focusing resources to develop capabilities to deploy environmental practices to achieve environmental goals. NRBV also provides support that GSCM practices lead to improved economic performance (e.g., Pullman, et al., 2009; Zhu, et al., 2005). In particular, significant cost advantages can result from GSCM practices (Carter, Kale and Grimm, 2000), such as superior waste management, use of less expensive recycled raw materials, energy consumption, environmental accidents and number of components in products (Jacobs, Singhal and Subramanian, 2010), and pollution prevention, which limits the cost of compliance with environmental regulations (Hart, 1995).

H1a: Green supply chain management practices are positively associated with environmental performance improvement.

H1b. Green supply chain management practices are positively associated with operating cost performance improvement.

2.3 The moderating role of supply chain ecocentricity

Pagell and Wu (2009, p. 50) argue that firms possessing a proclivity for environmental sustainability will "reconceptualize who is in the supply chain," such that they will leverage the expertise and skills of external environmental stakeholders. This notion of "reconceptualising" the supply chain stems from research in the area of ecocentricity (Gladwin, Kennelly and Krause, 1995; Seuring, 2004), which is defined as a characteristic of firms that consider the well-being of, and potential learning benefits gained from, their broader constituents in the environment. Ecocentricity has been discussed in the literature from a theoretical and conceptual perspective (e.g. Chavez, Yu, Feng and Wiengarten, 2016; Gold, et al., 2013), but has received limited empirical attention (Pagell and Wu, 2009). NRBV suggests that key resources must be in place to facilitate core managerial practices. Ecocentricity may be such a key resource, as it is rare and non-imitable—the notion of ecocentricity involves collaborative, relational, and cultural characteristics of the organization, each of which are noted with NRBV as being especially challenging to imitate easily by other organizations.

Firms are frequently influenced by environmentally-focused external stakeholders such as regulatory bodies, government, non-governmental organizations, and trade associations. Firms that lack supply chain ecocentricity may view these environmental external stakeholders as adversaries (Pagell and Wu, 2009), associating regulatory bodies and government as a source of coercive pressure (Zhu and Sarkis, 2007) and feeling threatened by regulators who levy legal action, penalties and fines if they do not comply with environmental regulation (Sarkis, Gonzalez-Torre and Adenso-Diaz, 2010). These firms may attempt to satisfy the institutional forces in their social context (Dacin, Oliver and Roy, 2007) to gain legitimacy with their external environmental stakeholders (Bansal and Clelland, 2004; Suchman, 1995), instead of engaging and learning to continuously improve. Thus, their practices to improve environmental performance may be out-of-date with the most current and innovative green supply chain management thinking. If ineffective, such green practices may even be viewed as superficial "greenwashing" (Laufer, 2003). Ignoring this expertise, such as recently revised standards of environmental conduct and compliance (Tate, Dooley and Ellram, 2011) from environmental external stakeholders may even result in conducting GSCM practices that damages, rather than improves, the environment.

Other business organizations, however, actively seek environmental supply chain capabilities embedded in their external stakeholders with the hope that they might drive substantive environmental improvements in their firms (Borwankar and Velamuri, 2009). These partnerships reflect an integrative arrangement where actors across sectors engage in non-hierarchical processes to achieve mutual goals (Van Huijstee and Glasbergen, 2010; Visseren-Hamakers, Arts and Glasbergen, 2011). Engaging these environmental stakeholders may well result in obtaining insights about cleaner transportation methods or the ecological packaging of materials about which the firm was previously unaware (Johnson, Dooley and Hyatt, 2018). Learning from external environmental stakeholders may facilitate more accurate definitions and measurement of standards for green product purchasing and environmental criteria for supplier selection (Tate, et al., 2011). Thus, firms with a high level of supply chain ecocentricity will proactively engage environmental stakeholders in these efforts to enhance the effectiveness of GSCM practices on the environment (Simpson, Power and Samson, 2007).

H2a. The relationship between GSCM practices and environmental performance improvement is stronger when a firm has high levels of supply chain ecocentricity, rather than low.

Similarly, engaging in and learning from environmental stakeholders should enhance the cost improvements resulting from GSCM efforts. Non-traditional supply chain members, such as NGOs, not-for-profits, and local governments can offer expertise in environmental technologies and processes that are most economical (Tate, et al., 2011). Such expertise should facilitate the planning and operational practices that have become embedded in organizational routines, improving efficiencies. By contrast, in less proactive firms they might be non-existent (Matos and Hall, 2007). Additionally, gaining access to recent environmental technologies and processes may reduce conflicts and confusion among managers who are implementing GSCM which, in turn, leads to decreased costs stemming from the improved alignment of environmental supply chain practices with relevant environmental issues (Sarkis, Zhu and Lai, 2011). Approaches that foster cooperation and environmental learning from environmental stakeholders should also result in knowledge allows the firm to mitigate risks from potential legal action, penalties, and fines associated with GSCM implementation (Roehrich, et al., 2014). Supply chain ecocentricity may even facilitate partnerships with non-traditional environmental supply chain members that assist in off-setting costs of GSCM investments (Pagell and Wu, 2009).

H2b. The relationship between GSCM practices and operating cost performance improvement is stronger when a firm has high levels of supply chain ecocentricity, rather than low.

2.4 The moderating role of supply chain traceability

The monitoring of supply chain activities has received relatively less attention in the literature (Faucheux and Nicolaï, 2011; Jenkin, McShane and Webster, 2011; Setterstrom, 2008; Wang, Yeung and Zhang, 2011). Monitoring is, however, an important risk management tool to reduce information asymmetry (Tachizawa, et al., 2015). One particular approach to monitoring is through the use of traceability (Wowak, et al., 2016). Traceability is broadly defined as the ability to identify and verify the components and chronology of events throughout the supply chain (Skilton and Robinson, 2009). It refers to tracking, which is determining the origin and characteristics of a particular product and tracing, which is collecting the history of products related to its displacement along the supply chain (Bechini, Cimino, Marcelloni and Tomasi, 2008). Traceability involves, for example, knowing the sources of raw materials, what chemicals or elements are in purchased products, tracking the environmental performance throughout the supply chain and processes involved in producing products, and tracing the origins of purchased products throughout the supply chain (Dabbene, et al., 2014). Traceability is particularly relevant under the premise of NRBV (Pullman, et al., 2009), exhibiting the NRBV criteria necessary for a natural resource to sustain advantage: it is rare and non-imitable, achieved via characteristics of causal ambiguity and complexity (Hart, 1995). Indeed, traceability it is not dependent on a single company, but relies on the complexities of a group of companies, such as intra- and inter-firm technologies and supply chain knowledge (Wowak, et al., 2016), that are challenging to copy (Skilton and Robinson, 2009).

In particular, the ability to track and trace products and activities reduces information asymmetry among supply chain members and the potential for suppliers to act opportunistically (Wowak, et al., 2016), which positively moderates the effect of organizationally focused GSCM practices on environmental performance (Plambeck, Lee and Yatsko, 2012). Traceability affords an improved level of monitoring, which has empirically been shown to increase suppliers' initial and ongoing investments in environmental initiatives (Klassen and Vachon, 2003; Lee and Klassen, 2008), enabling an increased environmental performance impact of GSCM practices. Without supply chain traceability, the efforts of firms to improve performance may be hampered, and even lead to sending of wrong signals to their (Wowak, et al., 2016). Thus, we propose:

H3a: The relationship between GSCM practices and environmental performance improvement is stronger when a firm has high levels of supply chain traceability, rather than low.

Tracking and tracing products with a complex supply network involves managerial decisions about their supply chain to reach efficiency improvements in processing organization and risk management (Rábade and Alfaro, 2006). In assessing the benefits of improving traceability, Alfaro and Rabade (2009) find that organizations realize several advantages, such as enhanced operational efficiency. They conclude that traceability amplifies the performance of existing operating procedures that are intended to lower levels of spoiled inventory, reduce stock-outs, and shorten lead-times. With respect to environmental impacts, supply chain traceability improves the quality of reporting to external stakeholders, reducing both the costs of reporting as well as the risks of potential environmentally related legal costs, penalties, and fines (Regattieri, Gamberi and Manzini, 2007). Thus, while implementing and developing GSCM practices heighten awareness by consumer and government stakeholders (i.e., it raises the bar on expectations), supply chain traceability minimizes the additional costs associated with said GSCM practices, thereby positively moderating their impact on operating cost performance (Meinlschmidt, Schleper and Foerstl, 2018). Thus, we propose:

H3b: The relationship between GSCM practices and operating cost improvement is stronger when a firm has high levels of supply chain traceability, rather than low.

3. Research Method

3.1 Survey administration and data collection

A sample of 2,000 United Kingdom manufacturing firms was randomly surveyed from a commercial database obtained from *The Manufacturer*, a UK subscription-based trade publication. Each respondent in the sample was selected based on job function, plant size (at least 50 employees), and the industry sector by SIC code. We first mailed a copy of the survey to our entire sample. Two further email rounds were sent to non-responders. Respondents were also offered the incentive of a composite summary of the research results. We received 277 responses, of which 29 were deemed not usable due to missing data. A further 34 surveys could not be delivered. The effective response rate was thus 12.6% (248/1,966).

The characteristics of the organizations in the sample are shown in Table 1, including the number of employees, industry sector and respondent title. The average number of years in the position was 9.32, and 15.2 years in the business unit, providing support that our informants were also knowledgeable about the issues under investigation. Respondents were asked to complete the survey with respect to their strategic business unit's supply chain.

Insert Table 1 About Here

The survey was pilot tested in two phases. First, the draft questionnaire was sent to five academic faculty members with expertise in this area of scholarship. These scholars were asked to comment on the content, clarity, and scaling of the survey instrument. Several changes were made as a result of this feedback. Next, the survey's web address was sent to a further nine industry members with expertise in this area of practice. Each was asked to complete the survey online, with a specific focus on the content, design, and usability of the instrument. Some minor design changes were also made at this stage of the survey instrument development process.

Tests for non-response bias were carried out by comparing early respondents (responses received within the first two weeks) and later respondents (responses received within the third week or later) (Armstrong and Overton, 1977). A *t*-test of difference was conducted on firm size (employees and sales), and mean responses to each question. We were unable to identify any statistically significant differences between earlier and later responses.

3.2 Operationalization of variables

The survey scales employed were either established scales or were developed and validated from the literature. In the latter case, for supply chain ecocentricity and environmental supply chain traceability, we followed multi-stage scale development techniques suggested by DeVellis (2003). This process included several preliminary qualitative interviews with purchasing managers, an extensive review of the extant academic and practitioner literature, pretesting, and a Q-sort with knowledgeable stakeholders. All constructs are reflective and measured using a seven-point Likert scale (see Appendix A).

Operating cost improvement - measured using a three-item scale used by Vachon and Klassen (2008). Respondents were asked to compare their organization's total product costs, production costs and labor productivity, relative to primary competitors.

Environmental performance improvement – developed by Zhu and Sarkis (2007) and used to assess the degree of improvement in environmental performance over the past 1-2 years. Respondents were asked to identify metrics relating to solid waste disposal, atmospheric emissions, raw materials usage, energy usage, wastewater reduction and recycling of product and solid waste.

Green supply chain management practices – A seven-item scale developed by Gonzalez-Benito and Gonzalez-Benito (2006), with respondents asked to consider the extent to which their firm's logistics practices, packaging, logistics-related waste recycling, sourcing strategies, and supplier selection criteria considered the natural environment.

Supply chain ecocentricity –a new scale developed for this study, based on supply chain tactics identified by Pagell and Wu (2009), as well as insights from Seuring (2004), Gold et al. (2013) and Gladwin, Kennelly, and Krause (1995). Respondents were asked about the involvement of external stakeholders in improving their supply chain environmental sustainability and included four-items assessing the degree of external feedback sought, partnerships with NGOs or NFPs, and input from regulators.

Supply chain traceability – a new scale developed for this study, based on the literature on inventory tracking and supply chain transparency (Dabbene, et al., 2014; Skilton and Robinson, 2009; Wowak, et al., 2016). Items assessed the extent to which the firm, for its complete supply chain, traces the origins of purchases, knows the source of raw materials, knows the chemicals and elements in purchased components, tracks the processes involved in producing product and tracks environmental performance.

Control variables – Three additional control variables were included in the analysis. First, a series of dummy variables were used to control for industry, reflecting the different pressures and industry models within the sample. Second, organization size could influence the extent of engagement in green supply chain management practices and the ability to influence cost and environmental performance. Including the number of employees controlled for the size of each respondent's organization. Finally, we control for a firm's previous financial performance as this dimension may influence the ability to invest in making improvements in our dependent variables, environmental and cost performance.

4. Results

Exploratory factor analysis, using principal axis factoring with oblimin rotation, was used to extract factors with eigenvalues greater than 1.0 (Tabachnick and Fidell, 2001). Following Harman's one-factor test, all items were analyzed together, and as no one factor accounted for most of the variance, common method variance was not considered to be a substantial concern (Podsakoff, MacKenzie, Lee and Podsakoff, 2003). The results of the exploratory factor analysis are presented in Table 2 and suggest a six-factor solution arising from the 32 items analyzed. All factor loadings were considerably above .40 and are therefore considered practically significant (Hair, Black, Babin, Anderson and Tatham, 2006). Table 3 provides correlations and descriptive statistics.

Insert Table 2 About Here

Insert Table 3 About Here

Ordinary least squares moderated hierarchical regression was used to test the various hypotheses. Control variables were entered in Step 1, followed by the independent variables in Step 2. Independent variables were mean centered before the multiplication of the interaction terms, which were entered in Step 3. Variance Inflation Factors (VIF) were all below 10, indicating multi-collinearity was not a substantial concern (Neter, Kutner, Nachtsheim and Wasserman, 1996).

Table 4 presents the results of the testing of our theoretical model. Hypothesis 1 was largely supported with GSCM practices positively related to environmental (β=.29, p<.001), and marginally significantly related to cost performance (β=.17, p<.10). While we did not find support for Hypothesis 2a, we did find support for Hypothesis 2b, in that supply chain ecocentricity positively moderates the relationship between GSCM practices and cost performance (β=.24, p<.001). This finding is supported by simple slope computations showing that high levels of ecocentricity were significant (t = 2.77, p <.01), while low levels of ecocentricity were non-significant (t = −-0.06, p = .95).

We also find partial support for Hypothesis 3a, in that a significant negative moderation effect of traceability exists on the relationship between GSCM practices and environmental performance (β=-.11. p<.05). This finding is supported by simple slope computations showing that low levels of traceability were significant (t = 4.54, p <.001), while high levels of traceability were nonsignificant (t = 1.50, p = .134). Additionally, we found support for Hypothesis 3b, in that a significant positive moderation effect of traceability exists on the relationship between GSCM practices and cost improvement (β=.20, p<.001). This finding is supported by simple slope computations showing that high levels of traceability were significant (t = 2.54, p <.05), while low levels of traceability were nonsignificant (t = 2.78, p = .78).

Insert Table 4 About Here

To further illustrate the effects of moderation, we plot the simple slope of the relationship between GSCM and environmental or cost performance at high and low levels of each moderator. High and low values are defined as plus and minus one standard deviation from the mean (Cohen and Cohen, 1983). Figures 2–4 illustrate these effects.

Insert Figure 2 About Here

Insert Figure 3 About Here

Insert Figure 4 About Here
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5. Discussion

Our study examined the effects on performance arising from the adoption of GSCM practices, as well as the contingent effects of ecocentricity and supply chain traceability. Results from our survey of 248 UK manufacturing organizations indicates that GSCM practices are associated with improvements in cost and environmental performance, though the effects are moderated by ecocentricity and supply chain traceability. The remainder of this section discusses the theoretical and managerial contribution of each finding in further detail.

5.1 Theoretical implications

Our research sought to examine the moderating effects of ecocentricity and traceability on GSCM practices and subsequently how it influences their impact on environmental performance and operating cost improvement. Our findings support the notion of using sustainability practices throughout the supply network (Meinlschmidt, et al., 2018), and add to the growing empirical evidence suggesting a positive relationship between GSCM practices and performance (Albertini, 2013; Carter, et al., 2000; Golicic and Smith, 2013). Consistent with prior literature, we find GSCM practices are strongly associated with improvements in environmental performance. We also find a marginally positive relationship between GSCM practices and operating cost improvement. Overall, our findings elaborate on presenting empirical evidence that sustainability simultaneously positively affects environmental and operating cost improvements.

We now turn to explore the findings around the moderation effects of ecocentricity and supply chain traceability on GSCM practice and performance. In the development of our theoretical framework, we proposed that ecocentricity through collaboration with non-traditional stakeholders and supply chain traceability as a monitoring tool may be considered 'strategic resources'. However, we find that their effects on the GSCM practices to performance link was mixed. Our first contingency considered the moderating effect of ecocentricity on GSCM practices and its environmental (H2a) and cost performance (H2b). We found no significant contingent effects of ecocentricity (at high or low levels) on environmental performance, but a significant positive effect on operating cost performance when ecocentricity was high. One explanation for these findings is that the majority of firms were primarily interested in low-level cost savings, and as such working with non-traditional partners reverts to a focus on efficiency (Hart and Dowell, 2011). It could also indicate that because this is a 'collaboration' approach it will require increased skills, flexible organizational design, stakeholder involvement and management, and more complex and long-term measurements. Ecocentricity could, therefore, be viewed as a strategic resource that facilitates a system view of the value chain, which the firm uses for broader learning from partners to drive cost minimization and potentially other value-added strategies which were not covered in our study.

Our second moderation hypothesis focused on supply chain traceability - the location and origin of materials, and type of processes used by suppliers – and how this affected performance, Tachizawa et al. (2015) refers to this as a 'monitoring' approach – arguing that this helps firms reduce risk and manage compliance to standards. Thus, our findings provide further empirical support to the proposed Tachizawa et al. (2015) framework. Moreover, we find that investing in high levels of supply chain traceability has a positive effect on the association between GSCM practices and operating cost improvement. As with supply chain ecocentricity, supply chain traceability provides the data and transparency needed to identify cost improvement opportunities.

Second, and contrary to expectations, we found that supply chain traceability (H3a) had a negative moderating effect on the relationship between GSCM practices and environmental performance. We show that as a firm's investment in GSCM practices moves from low to high levels, the rate of environmental performance improvement increases; however, it does so at a negative rate as greater levels of supply chain traceability are developed. That is, firms with low levels of supply chain traceability had a significantly more positive rate of environmental performance improvement, relative to firms who already had high levels of supply chain traceability. We also note that supply chain traceability, as our hypothesized moderator variable, has no direct effect on environmental performance improvement. This surprising finding is counter-intuitive to our conceptual model. However, the experience of many firms implementing traceability systems for environmental monitoring and compliance purposes may provide a potential explanation. Low levels of transparency may indicate that the firm has only limited insight into the environmental compliance of tier 1 suppliers, with whom they work directly and often have coercive power to encourage supplier compliance and adoption of environmental initiative. On the other hand, firms with high levels of supply chain traceability in place have a very different situation – they can trace the sources of their raw materials, often back to their origin as well as being able to track and trace product and processes throughout their supply chain networks. This level of traceability provides firms with a clearer picture of the challenges they face in achieving supplier compliance to environmental requirements throughout their entire supply chain, from source to customer; and let alone achieving improvements in environmental performance. For firms in this latter case, they may be aware of the broader set of improvement opportunities in their supply chain; yet their ability to achieve these sustainability improvements is more limited in sub-suppliers (Meinlschmidt, et al., 2018; Wilhelm, Blome, Bhakoo and Paulraj, 2016).

Finally, our results advance understanding of the GSCM-performance relationship. Research investigating this relationship has suggested that the meaning underlying this association is complicated and that future research should explore more contextual factors that may well explain the nature of this association more fully (e.g., Jacobs, et al., 2010; Zhu, et al., 2005). Our findings showed such an interaction effect, such that high levels of ecocentricity and supply chain traceability could act as key strategic resources when trying to improve cost performance by adopting GSCM practices.

5.2 Managerial Implications

From a managerial point of view, our findings provide insights into making a case for GSCM initiatives within their organization, as well as how to be more effective with said initiatives. First, the finding of a positive relationship between GSCM and operating cost improvement suggests that managers seeking to enhance GSCM or propose GSCM initiatives to senior management team could craft their message around such synergistic effects on financial performance. This implication is also consistent with recent research showing GSCM practices are related to superior financial and market-related performance (Schmidt, et al., 2017). Second, our research provides managers with a better understanding of how to carry out GSCM practices by promoting ecocentricity and supply chain traceability more appropriately. For instance, the development of supply chain ecocentricity should be approached as a longer-term initiative that may not provide direct, immediate effects on environmental performance. It is possible that larger systems-level gains may, however, be achieved via collaboration with these non-traditional partners.

Also, managers should seek opportunities to increase their supply chain traceability through more comprehensive monitoring systems (Bititci, Garengo, Dörfler and Nudurupati, 2012; Hervani, Helms and Sarkis, 2005). Organizations that have robust monitoring systems could use this a strategic resource, contributing to reduced supply chain risk and improved pollution prevention strategies. Overall, our findings suggest that managers may consider high levels of collaboration with non-traditional partners and active monitoring to achieve supply chain traceability as key capabilities when trying to achieve cost performance by improving GSCM practices.

6. Future Research & Limitations

Our research design was survey-based and cross-sectional. Future research should explore the opportunities for using longitudinal data, particularly as the effects of GSCM initiatives may influence performance differentially over time. Testing and extending this theoretical framework beyond United Kingdom manufacturing firms into other contexts, such as the role of public sector procurement requirements (Amann, Roehrich, Esig and Harland, 2014), as well as to an examination of social responsibility in supply chains may be beneficial. Our data was collected using perceptual scales. While past research has found that managerial assessments are consistent with objective internal performance (Dess and Robinson Jr, 1984; Pearce, Robbins and Robinson, 1987) and with external secondary data (Venkatraman and Ramanujam, 1986), future research should incorporate secondary data, for example, on dependent variables like environmental performance. Finally, while the ecocentricity construct was developed in a way that was driven by the literature (Chavez, et al., 2016; Gladwin, et al., 1995; Gold, et al., 2013; Pagell and Wu, 2009; Seuring, 2004), we feel compelled to agree with Pagell and Wu (2009) that this construct has not received little empirical attention, which is both a limitation of the development of this scale as it is an opportunity for further research.

Moreover, future research could explore additional practices as moderators to the GSCM practice-performance relationship, such as technology or innovation. A few highly practical and relevant practices in this area could be, for example, blockchain, internet-of-things, and standards (such as GS1). Finally, given the results of our research, we suggest that future studies could also examine the critical impact of these practices on GSCM's ability to deliver operating cost performance.

7. Conclusions

Capturing the value from sustainability-related activities directed at their supply chains represents a significant challenge for most firms. Our study contributes to this area via an examination of the contingent effects of GSCM practices on environmental and operating cost performance, in particular by validating and testing two new moderating constructs: ecocentricity and supply chain traceability. Consistent with prior literature, we show that GSCM practices help to improve both environment and cost performance; with supercharged benefits for operating cost improvement where the firm has high levels of supply chain traceability and adopts a broader view of their supply chains which incorporates non-traditional actors. We highlight the importance to managers of focusing on both monitoring and collaboration activities in their supply chains to extract the benefits from their sustainability activities.

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Figure 1: Theoretical Framework

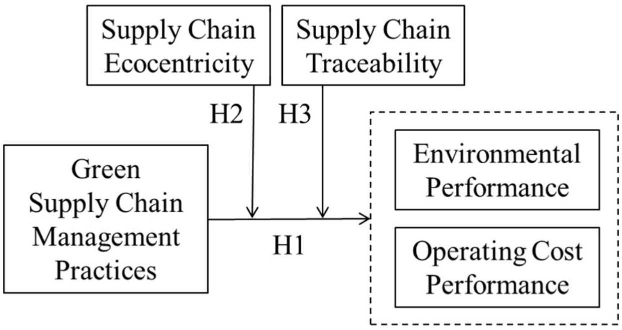

Figure 2: Moderation effect of supply chain traceability on GSCM practices and environmental performance improvement

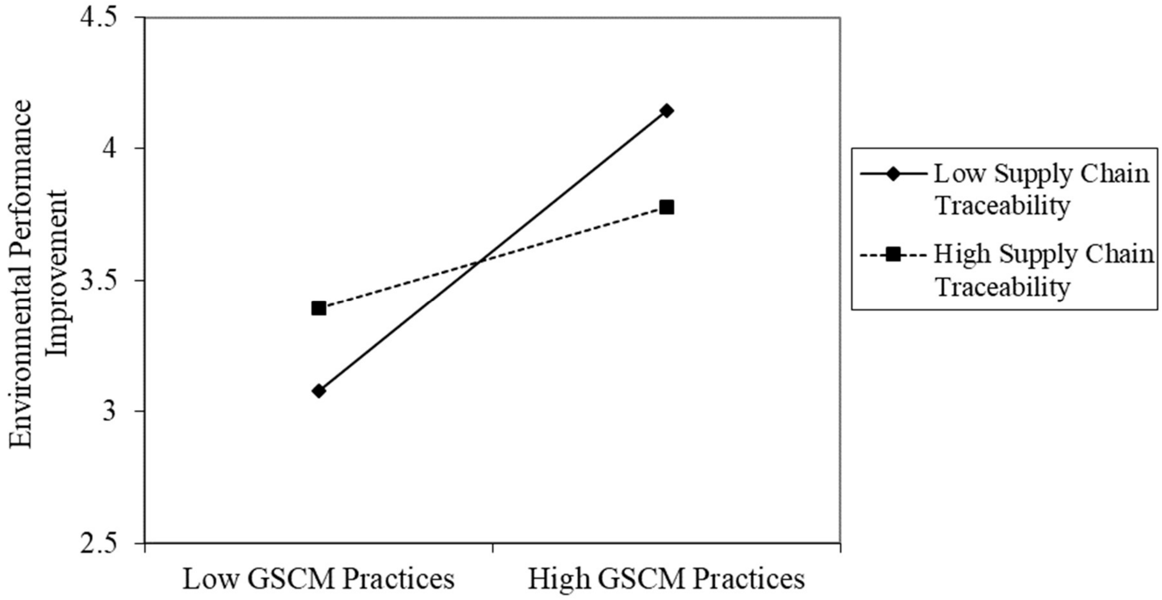

Figure 3: Moderation of supply chain traceability on GSCM practices and operating cost improvement

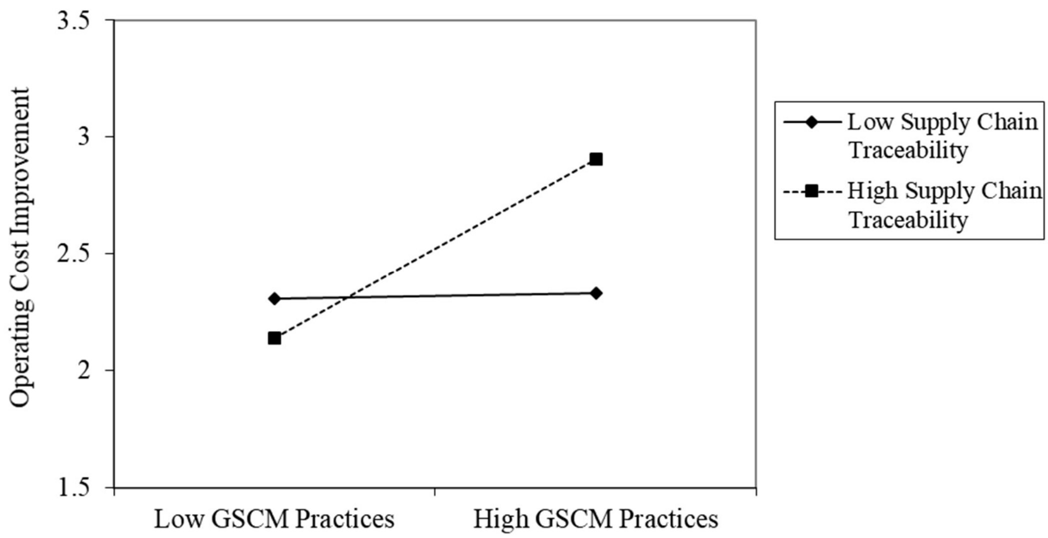

Figure 4: Moderation of supply chain ecocentricity on GSCM practices and operating cost improvement

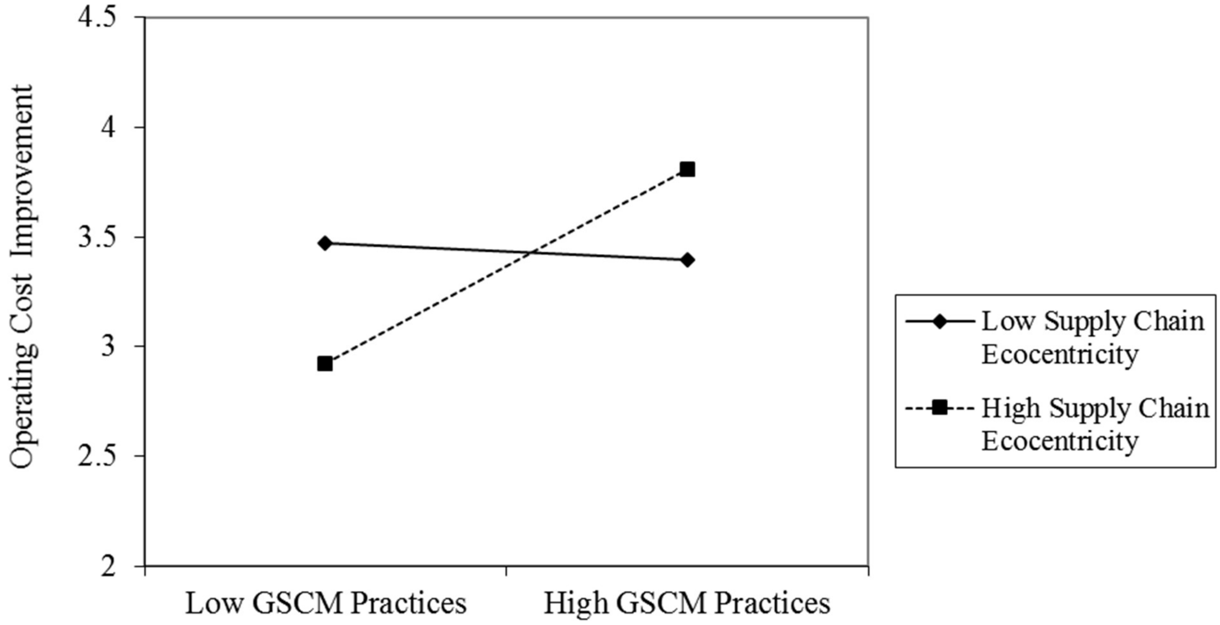

Table 1: Sample Characteristics

Industry	**Number**	**Percentage**
Machinery & Equipment	45	18.3
Packaging	24	9.8
Furniture	20	8.1
Automotive	27	11.0
Aerospace	15	6.1
Fabricated Metal Products	33	13.4
Computer & Electronics	27	11.0
Chemical & Plastics	31	12.6
Food	7	2.8
Missing	19	7.8
Total	248	100

Position	**Number**	**Percentage**
Director of Purchasing/Head of Supply Chain	30	12.1
Head of Operations	10	4.0
Purchasing/Supply Chain Manager	80	32.3
Senior Buyer / Buyer	23	9.3
Materials/Logistics Manager	46	18.5
Operations/Quality Manager	33	13.3
Environmental Manager	13	5.2
Missing	13	5.2
Total	248	100

Organisation Size (employees)	**Number**	**Percentage**
50 - 99	68	27.4
100 -149	32	12.9
150 - 199	18	7.3
200 - 499	76	30.6
500 - 999	21	8.5
Over 1000	25	10.1
Missing	8	3.2
Total	248	100

Table 2: Exploratory Factor Analysis

Items	Component					
	1	2	3	4	5	6
Environmental Performance Improvement						
… Diverted solid waste from landfills	0.76					
… Recycling of solid waste (not incineration)	0.76					
… Reduced solid waste disposal	0.73					
… Reduced raw materials usage	0.71					
… Reduced emissions into the atmosphere	0.70					
… Reduced waste water usage	0.66					
… Reduced energy usage	0.63					
… Recycling of product (not incineration)	0.62					
… Decrease use of hazardous/harmful/toxic materials	0.55					
Green Supply Chain Management Practices						
… ecological materials for primary packaging		0.79				
… recyclable or reusable packaging/containers in logistics		0.77				
… selection of cleaner transportation methods		0.70				
… a preference for green products in purchasing		0.69				
… recuperation and recycling systems		0.64				
… environmental criteria in supplier selection		0.61				
… consolidation of shipments		0.53				
Supply Chain Traceability						
… We know the sources of our raw materials			0.87			
… We track the processes involved in producing product throughout our complete supply chain			0.84			
… We trace the origins of our purchases through the entire supply chain			0.83			
… We track the environmental performance of our complete supply			0.74			
… We know what chemicals or elements are in our purchased			0.63			
Financial Performance						
… Profit growth				0.90		
… Return on total assets				0.88		
… Return on sales				0.85		
… Return on investment				0.79		
Operating Cost Improvement						
… Total product costs					0.88	
… Production costs					0.88	
… Labour productivity					0.78	
Supply Chain Ecocentricity						
… We incorporate external feedback (e.g. from trade associations) to help improve the sustainability of our supply chain						0.80
… We partner with NGO's and not-for-profit organisations to learn about potential solutions to environmental problems						0.72
… We actively engage external parties (e.g. customers, suppliers) in seeking to improve environmental performance						0.61
… We incorporate input from regulators (e.g. UK Environment Agency, DEFRA) into our supply chain policy and practices						0.60

Table 3: Descriptive Statistics

	Variable [a, b]	1	2	3	4	5	6	7	8	9	10	11	12
1	Operating cost improvement	**.89**											
2	Environment performance improvement	.26	**.88**										
3	GSCM practices	.30	.54	**.90**									
4	Supply chain ecocentricity	.16	.52	.58	**.78**								
5	Supply chain traceability	.20	.32	.54	.42	**.89**							
6	Industry - machinery/equipment	.00	-.18	-.05	-.16	.01	-						
7	Industry - automotive/aerospace	.00	-.02	-.02	-.03	.05	-.21	-					
8	Industry - fabricated metal	-.02	-.03	-.11	-.04	-.19	-.18	-.18	-				
9	Industry - chemical / plastics	.01	.06	.02	.06	-.04	-.17	-.16	-.14	-			
10	Industry - computer hardware / electronics	-.06	.11	.03	.16	.11	-.18	-.17	-.15	-.13	-		
11	Organization size (employees)	.15	.12	.14	.16	.08	-.16	.16	.01	-.04	.05	-	
12	Financial performance	.50	.31	.32	.24	.24	-.06	.04	-.07	-.01	.04	.16	**.93**
	Mean	4.61	5.11	4.57	4.24	4.32	.18	.17	.13	.11	.13	785.90	0.61
	Standard Deviation	1.04	1.04	1.26	1.36	1.51	.39	.38	.34	.31	.33	3510.13	1.07

[a] Signifcant at .05 (two-tailed) when r > .125

[b] Cronbach alpha shown in bold on diagonal

n=248

Table 4: Results of Multiple Regression Analysis [a, b]

Variables	Environmental Performance Improvement			Cost Performance Improvement		
	Mod 1	Mod 2a	Mod 2b	Mod 1	Mod 2a	Mod 2b
Block 1: Controls						
Industry – machinery/equipment	-.12[†]	-.12[†]	-.11[†]	.00	-.02	-.02
Industry – automotive/aerospace	-.04	-.04	-.03	-.07	-.06	-.07
Industry – fabricated metal	.01	.01	.01	-.01	-.02	-.01
Industry – chemical/plastics	.02	.02	.03	-.01	-.01	-.03
Industry – computer/electronics	.03	.03	.02	-.11[†]	-.10	-.10
Organization size (log employee)	.00	.00	.01	.07	.07	.06
Financial performance	.13*	.13*	.14*	.44***	.42***	.43***
Block 2: Main effects						
GSCM practices	.34***	.33***	.32***	.12[†]	.17*	.17*
Supply chain ecocentricity	.26***	.25***	.24***	-.04	-.01	-.03
Supply chain traceability	.00	-.01	.00	.05	.06	.05
Block 3: Two-way interactions						
GSCM practices x Supply chain ecocentricity		-.02			.18**	
GSCM practices x Supply chain traceability			-0.11*			.15**
Adjusted R^2	0.35	0.35	0.36	0.26	0.28	0.28
F	13.72	12.44	13.06	9.27	9.55	9.23
ΔR^2 [b]		0.00	0.01		0.03	0.02
F for ΔR^2 [b]		0.18	4.46*		9.08**	6.62*

[a] Standardized regression coefficients are shown

[b] Changes in R^2 are from Mod 1 within the same model

[†] p<.10, * p<.05, ** p<.01, *** p<.001